ADB TA 6357: Central Asian Countries Initiative for Land Management Multi-country Support Project

CACILM Multicountry Partnership Framework Support Project on

Sustainable Land Management Research

ADB TA 6357

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1. Executive Summary

Land degradation represents diminished ability of ecosystems or landscapes to support and sustain livelihoods functions and services attributed to these ecosystems. Land degradation takes many forms. Areas with greatest potential for land and water degradation are those with highly weathered soils, steep slopes, areas denuded of vegetation, inadequate or excess rainfall, and high temperatures. Land degradation results in declining total factor productivity of inputs such as to increase production costs. It adversely affects the livelihoods of farmers. The main cause of land degradation is inappropriate use of agricultural lands. Land degradation is driven by a complex interplay of bio-physico-chemical, socio-political and techno-economic factors. Policy and livelihood decisions that fail to take into account longer-term consequences on resource quality often result in land degradation. In order to tackle land degradation problems, different NRM technology options appropriate to site specific situations were field validated at 10 locations in the five Central Asian countries.

The SLMR activities can be broadly grouped into namely, (i) the Regional activities of ICARDA- SLMR (GIS and Socio-economic& policy research), and (ii) the National program research activities. Salient research outputs have been listed here by countries

A. Regional activities of ICARDA- SLMR (GIS and SEP Research):

1. Central Asia with a geographical area of 393 Mha in five countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) is comprised of 187 agro-ecological zones. Five largest zones cover nearly 48% and the top twenty larger zones cover 80% of Central Asia.

2. Based on the UNESCO classification of arid zones, Central Asia is covered by twenty-one (21) agro-climatic zones. It was estimated that 68 per cent of the total geographical area is occupied by just two zones (sparsely vegetated deserts and grass-/shrub lands), and another 30 percent by 10 zones. The other zones although discernable but they are very minor zones.

3. The SLMR research conducted over ten sites in five countries represent nearly one-fourth (24%) of all the agro-climatic conditions in Central Asia.

4. Central Asia, with 3% of the world's land mass (excluding Antarctica), accounts for only around 1.4 % of CO_2 fossil fuel emissions. About half of this comes from Kazakhstan, which occupies 70% of the land mass of the 5 countries. The total CO_2 emissions combined amounts to 55 million tons per year. Conversion from virgin land to cultivation led to soil carbon losses from 9 to 21 percent depending upon the climatic conditions and organic carbon contents of the soils.

5. Socio-economic survey templates were pre-tested in all the countries to map rural livelihoods to create baseline data. During the pre-surveys it was observed that low fodder availability is serious concern for the survival and productivity of the livestock - the main stay of the people in the range and pasture lands.

6. It was observed that *In-season Yield* (INSEY) for wheat can be estimated at 140 days after sowing with Optical sensor based 'GreenSeeker' technology with nearly 70 % reliability (Uzbekistan, Turkmenistan, Kyrgyzstan). With more rigorous and better experimentation (Yield data for spring / winter planted wheat for few years and for different cultivars and locations) the reliability can be significantly improved.

7. Results of the field trials point out that farmers use more N fertilizers. With appropriate techniques the same yields can be obtained with use of 12-20% less amounts of nitrogen.

8. In SLMR Project, a number of hands-on training programs, project initiation and planning meetings were organized regionally and also in participating countries. Details are given in the table below for the one year period beginning July 2007-08.

Meetings, Workshops, and Training programs organized (July 2007-July, 2008)

Workshops and Trainings organized	**Countries Involved**	#Participants
A. Workshops/ Meetings organized		
1. Project Initiation workshop	All countries , NSEC, UNCCD, UND, FAO and Zef-UNESCO and other stakeholders	**57**
2. Training on CA machines and their uses and repairs	Kyrgyzstan	**10**
3. In-country Meetings for Planning SLMR activities	All countries	**50**
4. Collegiate Discussions on SLMR Research Prospectus	All countries, NSEC, UNCCD	**43**
B. Training programs organized		
5. Laser land leveling	Kyrgyzstan, Turkmenistan and Uzbekistan	21
6. Direct dry seeding rice technology	Uzbekistan and Kazakhstan	12
7. Multi-crop raised-bed/Zero till-ferti-seed planters	All countries	31
8. Optical Sensors for In-Season Yield Estimates (INSEY) and N management	All	23
9. Scientific equipments: - Electromagnetic probes for salinity - Soil moisture probes (Diviner) - Progress 1T probe- Temp. & salinity	All	17
10. English language (3 months)	All	20
11. On job Livelihood surveys	Kyrgyzstan, Tajikistan, Uzbekistan	7
Total		**131**

B. National research program activities:

Kazakhstan:

1. Soil surveys in Kaptagai farm, Kyzylorda have indicated that 34% soils have medium to high salinity and another 50% soils are weakly salinized.
2. Soil organic matter content in Kaptagai steppes ranges up to 4% or little more. Conversion of these virgin soils to crop production has led to loss in soil organic carbon by 50% (SOC content now just 2%). Most of the soils are N hungry and rich in available K and P.
3. In Kaptagai farm, irrigation norms were found to be higher than those prescribed for rice cultivation but reverse was true for other crops. Excessive irrigation in rice fields increases the water table in just two consequent years leading to secondary salinization. Appropriate water management practices can reduce water requirements for rice cultivation up to 15%. Through laser land leveling and use herbicides, irrigation water savings can be further improved. Rice cultivars Marjan, Aral 202 and a Russian variety Ayntar had good germination even under conditions of continuous submergence.
4. *Echinochloa* and *Phragmites communis* were predominant weeds of rice culture and to a lesser extent *Bolboschoenus*. Weed population can be significantly reduced if the pre-emergence herbicide molecules such as 'Pendimethylene', followed by post-emergence molecule 'Gullivar' are used at appropriate times.
5. Fuel, tillage, seed and fertilizer costs constitute the major cost in rice production. With direct dry seeded rice technology, seed and tillage costs can be significantly reduced. Preparations such as MERS and Hymat sodium (growth promoters) positively influenced germination of dry seeded rice.
6. In the Janatas desertic region, soils are generally sandy sierozems, gray-brown and takyr-like soils. Surveys revealed that natural vegetation primarily included only three desert plants, namely the *Safora*, *Artemisia diffucia* and *Ceratocarpus erenarius*- the fodder life line for the livestock. Preliminary results indicate that introduction of drought and cold tolerant plant species such as *Kochia prostrata, Agropyron fragile, Calligonum caputmedusae, Calligonum eriopodum, Eurotia ceratoides* and *Salsola richteri* may prove useful for this region.

Kyrgyzstan:

1. For the RCT platforms (surface seeding, zero-till and raised bed planting systems) both inter and intra-specie genotypic variations exist in wheat. It is only prudent to evaluate the performance of the improved cultivars for zero till / raised bed planting of crops.
2. Zero till advances the sowing of winter wheat by 10 days. Until a large area in all the neighborhood is sown in one go, early sowing will result in serious bird damages to emerging young seedlings.
3. Results of one season trial suggest that fertilizer doses of N in wheat can be reduced to 120kg N/ ha in many parts of the Chu Valley.
4. Use of saline drainage water (EC 2-3dS/m) alone or in cyclic /mixing modes did not show any reduction in growth of corn (a salt sensitive crop). Preliminary results suggest low saline drainage waters (<3dS/m) can be safely used to meet crop water demands in later growth stages of most crops.

5. Application of Stomp @ 5 L/ha (pre-emergence molecule) and Dialen @ 1 L/ha (post emergence) controlled the weeds in maize. This information is likely to greatly facilitate expansion of maize area.

6. Farmers have adopted bed planting of maize and other crops using the multicrop raised bed / zerotill planter.

7. Initial results suggests that controlled-irrigation in sloping lands using plastic portable chutes not only saves water, improving application uniformity but also helps in minimizing irrigation-induced soil erosion. The trial is catching the attention of the farmers and is still in progress.

Tajikistan (Based on the monitoring trip)

1. Inward-sloping terraces (to catch snow melts) and mulching seems to have a significant effect on the growth and productivity of grapes. Mulching is also likely to reduce erosion hazards and promote *in situ* soil moisture conservation. Erosion data will be collected after the drought year.
2. Vegetative gully plugs combined with mechanical check bunds proved very effective in control of soil erosion by water.
3. Inter-cultivation of beans, red beets with summer maize planted on 60 cm wide raised beds can significantly improve the total system productivity.
4. Alternate furrow irrigation can save 30-40 water in cotton planted on the 90cm wide raised beds. Under saline situations, it seems that cycles of alternate furrow irrigation may not be a good strategy for effective leaching of the salts accumulated in the raised beds. Additional research will be required..

Turkmenistan:

1. The optimal window for planting winter wheat was observed as from October 6-22 in 2008 . It was observed that productivity of very early and very late planted winter crop can be reduced up to 2.5 tons /ha.
2. New RCTs have the potential of reducing the production costs of winter wheat by nearly 23 percent. The new RCTs qualitatively promotes water saving, reduces water and wind erosion hazards.
3. Soil erosion on sloping lands can be reduced by maximizing the surface cover. Extra-short duration pigeonpea fast growing cultivars can be used to develop surface cover in tree plantations to reduce soil erosion, improve soil fertility and to provide fuel wood for the rural poor during winter.

Uzbekistan

1. Results of the lysimetric and field trials have indicated that it would be an excellent strategy to have low initial salinity at germination, and slow salinization rates in initial growth stages. High final salinity towards end of wheat season does not have any adverse effect on crop yields.
2. Saline irrigation to fill the soil pores (improve antecedent soil moisture contents) followed by fresh water saves canal supplies and improve leaching efficiency and similar crop yields.
3. Compared to traditional wheat planting on the flat, raised bed planting of winter wheat, improved its yield (up to 14%) and water productivity (6-7%). Net income of the farmers improved by 10-12 percent.

4. With changes in planting geometry, it is possible to introduce mungbean in 90cm wide cotton raised beds. This opens new opportunities for diversification of cotton-wheat systems in Central Asia and hence improved livelihoods.
5. Initial results suggest that Apricot *[Armeniaca vulgaris*- 103cm*];* Ailanto*[Ailanthus aitissima- 23 cm];* Poplar *[Populus puramidalis- 40cm]and* Peach *[Persica vulgaris- 15cm] may prove* promising in the Kyzylkum desert.
6. Livestock remain on survival rations (2-3kg/ day/ animal) during harsh winter season (3-4 months). Initial results suggest that fodder availability can be substantially improved by growing Pearl millet cultivar (Aip 13150). *Kochia scoparia,* highly tolerant to drought and salt stresses can also be used as fodder for gelded rams with good results.

Technical Progress Report on SLMR-ICARDA Component

1.0 Time schedules of SLMR Project activities 2007-09

Activities	2007		2008				Status
	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Output 1. CA countries through the application of integrated systems analysis will have greater understanding of the policy, institutional, environmental drivers of land degradation, , and, will develop a comprehensive research							
1.1 Coordination and monitoring of regional and national research activities in all the five countries through the establishment of multi-disciplinary teams of national and international scientists							
1.2 Common methodology and research approaches for data collection, factor analysis and system modeling developed for the diagnostic activities							
1.3 Orientation workshop for national scientists and enumerators organized							
1.4 Analyses of driving forces, causes, impacts of land degradation in CA countries through participatory diagnosis and integrated system analysis							
1.5 Ex-ante bio-economic modeling combined with extensive stakeholder consultation							
1.6 Mechanisms for local participation in SLM activities researched and established							
Output 2. Research prospectus for SLM research and donor-support for the duration of the CMPF Support Project developed including development pathways, research hypotheses and links with NPFs							
2.1 Integrative research hypotheses formulized by CA countries and research findings for identification of major factors determining comparative advantages of development pathways synthesized							
2.2. Existing development pathways identified using cross-country analysis and incorporated into NPFs							
2.3 Development pathways that are strongly associated with land management options (mainly resource conservation practices) identified							
2.4 Major development domains using GIS tools and potential benchmark sites identified in each CA country							
2.5 Ex-ante analysis of potential trade-offs between competing interests and the implications for different options							
2.6 A draft research prospectus developed based on the results of activities 2.1 – 2.6. through multi-stakeholder workshops							
2.7 National scientists trained through on-the-job and specialized courses							
2.8 Simple tools for local assessment and monitoring of land degradation developed.							

2. SLMR Benchmark sites characterization and out-scaling through GIS

2.1 Introduction

During the SLMR Inception Workshop in July 2007 the need for characterization of the SLMR research sites was recognized and formalized through the inclusion of GIS and agro-ecological characterization activities in the SLMR project. A budget of US$ 25,000 was allocated for characterization of the SLMR research sites to allow the out-scaling of the new agricultural practices, packages, technologies to areas that are similar in environments and farming/production systems to the research sites. The characterization is not only confined to the sites themselves, but includes also (although at a lower level of detail and resolution) the entire Central Asia region.

The GIS component of the SLMR project is implemented by the GIS Unit of ICARDA, assisted by a National Professional Officer, based at the ICARDA Tashkent Office. The following outputs were envisaged:

- Agro-ecological characterization of the SLMR research sites
- Defining the out-scaling domains of the tested technologies
- Making available ICARDA's spatial data holdings related to Central Asia
  This report summarizes progress made in the implementation o these activities.

Achievements in 2007

- Preliminary data collection
  - compiling site locations, collected from NARS collaborators
  - some thematic maps pertaining to sites, provinces.
- GIS training for a National Professional Officer to be based in SLMR Tashkent Office for assisting the GIS work module
- GIS project with large-scale data layers compiled at ICARDA

2.1.1 Progress on regional database development

A comprehensive agro-ecological database on Central Asia has been developed at ICARDA in the course of a regional study of its mandate area. The layers it contains are at 1 km resolution (roughly at 1:1,000,000 scale) and include the following themes:

- Climate surfaces (see further)
- Land use/land cover map 1993 1 km resolution
- Landforms
- Agro-ecological zones 1-km resolution

This database, although remaining the intellectual property of ICARDA, will be shared with the SLM Information System component of the SLMR Project, in the form of a CD with maps and documentation.

A list of the themes included in the database is provided in Table 2.1, as well as samples from these maps (Figures 2.1-2.5). In Table 2.1 showed list of Central Asia maps at 1 km resolution in the database. The level of detail of the soil map of Figure 2.4 is not commensurate with that of the other maps. This is due to the fact that there is no consolidated soil map at the same (1:1,000,000), or similar scale, for Central Asia. If it exists, it would probably need to be purchased. For the time being, and at the level of Central Asia, there is only the FAO Digital Soil Map of the World at 1:5,000,000 scale. Despite its low resolution, some useful information on soil management properties can be derived from this dataset, which is also available at ICARDA.

Table 2.1 ICARDA Central Asia data holdings

Theme	Resolution	Description
Climate	1 km	Monthly precipitation Seasonal precipitation as a % of the annual Monthly mean temperature Monthly maximum temperature Monthly minimum temperature Monthly number of frost days Monthly accumulated heat units Monthly accumulated cold units Monthly potential evapotranspiration Aridity index Agroclimatic zones Duration, onset and end of the temperature-limited growing period Duration, onset and end of the moisture-limited growing period Duration, onset and end of the moisture- and temperature-limited growing period
Land use/ land cover	1 km	Land use/land cover 1993
	8 km	Land use/land cover change classes 1982-1999 Land use/land cover change trends 1982-1999 Stable land use classes 1982-1999 Vulnerability to drought 1982-1999
Topography	1 km	Landforms
Soils	5 km	Distribution of indurated soils with petric phase Distribution of stony soils Distribution of shallow soils Distribution of soils with excessive wetness Distribution of fine-textured soils Distribution of medium-textured soils Distribution of coarse-textured soils Distribution of soils with high organic matter content Distribution of soils with moderate organic matter content Distribution of soils with low organic matter content Distribution of soils with high sodium content Distribution of saline soils Distribution of calcareous soils Distribution of acid soils
Integrated	1 km	Agro-ecological zones

Some of the methods used in generating the climatic layers are described in the following paper:
De Pauw, E., F. Pertziger and L. Lebed. 2004. *Agroclimatic mapping as a tool for crop diversification in Central Asia and the Caucasus*. In J. Ryan, P. Vlek, and R. Paroda (Eds.). Agriculture in Central Asia: Research for Development. ICARDA, Aleppo, pp. 21-43.

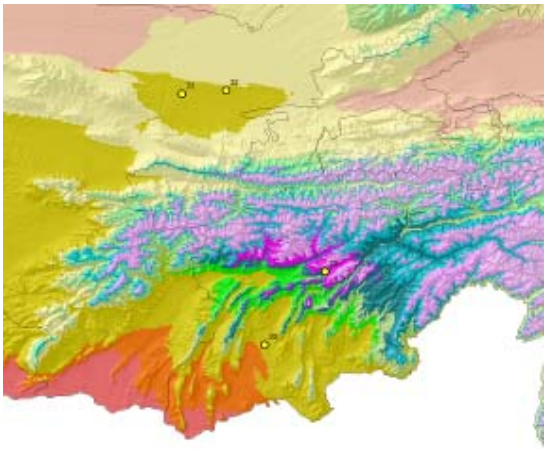


Figure 2.1 Sample from map 'Agroclimatic Cover

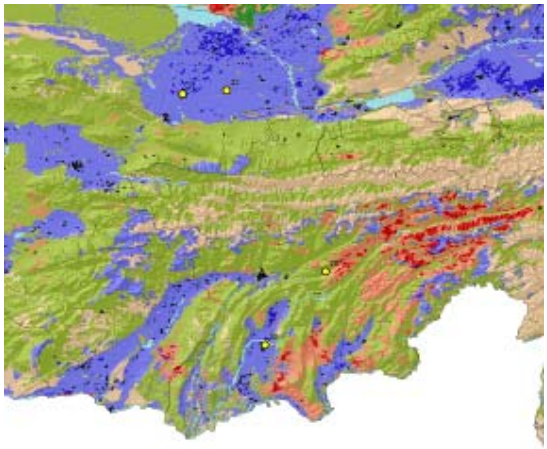


Figure 2.2 Sample from map 'Land Use/Land

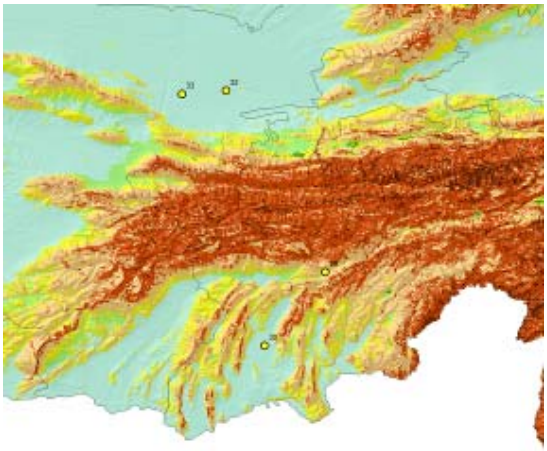


Figure 2.3 Sample from map 'Landforms'

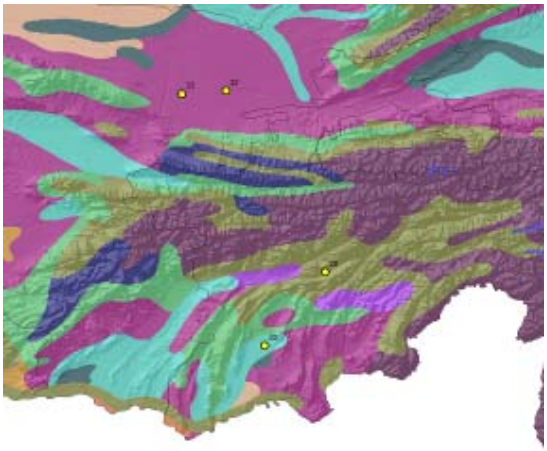


Figure 2.4 Sample from map 'Soil Management Domains

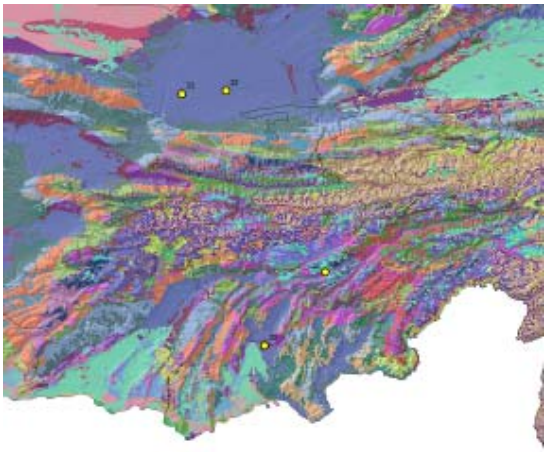


Figure 2.5 Sample from map 'Agro-ecological Zones

In addition, an overview of the agricultural environments of Central Asia can be found in the following paper:

De Pauw, E. 2007. *Principal Biomes of Central Asia*. In R. Lal, M. Suleimenov, B.A. Stewart, D.O. Hansen, P. Doraiswamy (Eds). Climate Change and Terrestrial Carbon Sequestration in Central Asia. pp.3-24. Taylor & Francis, ISBN 978-0-415-42235-2

2.1.2 Progress on data collection at the level of the benchmark sites

Coordinates of all SLMR sites have been obtained from the National Coordinators (see Table 2.2 and Figure 2.6).

Table 2.2 Locations of the SLMR research sites

COUNTRY	Site No.	Site name	LAT (dd)	LONG (dd)
Kazakhstan	25	Abylay	43.91667	69.83333
Kazakhstan	26	Kaptagay	44.33333	66.75000
Kyrgyzstan	27	Daniyar	42.90861	74.36306
Kyrgyzstan	28	Kenenbay	42.73556	74.50056
Tajikistan	29	Faizabad	38.58218	69.37572
Tajikistan	30	Vakhsh	37.85703	68.77853
Turkmenistan	31	Bugdaily	37.83878	58.75688
Uzbekistan	32	Sherzod Samandar Birlig	40.36667	68.40000
Uzbekistan	33	Esanboi-ota	40.33333	67.96667
Uzbekistan	34	Kyzylkum	41.04937	64.87753

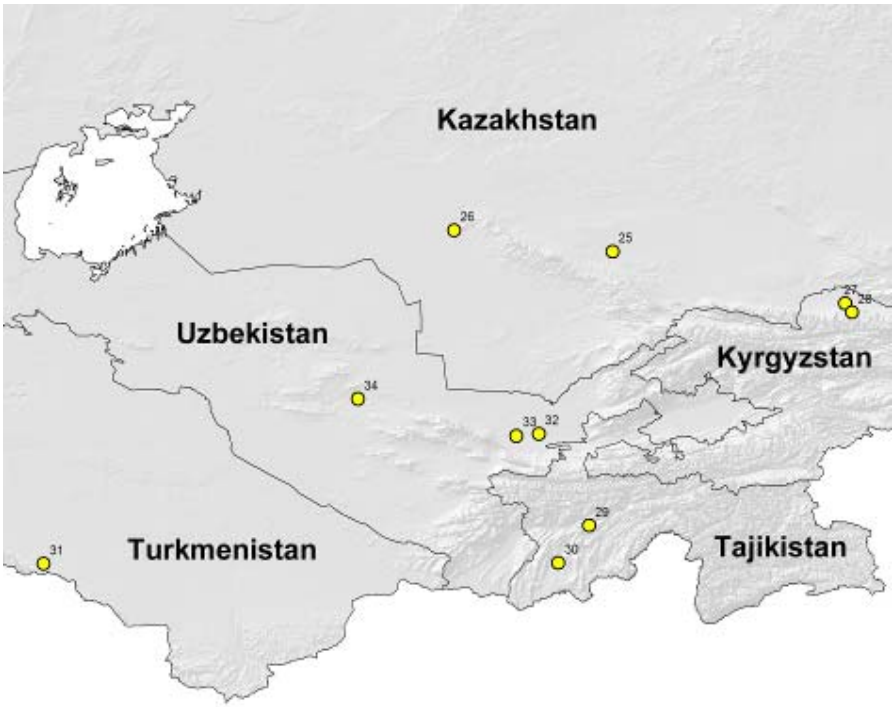


Figure 2.6 Location of the SLMR research sites

In addition some site descriptions are now available, as well as descriptions of the experiments. These are summarized in 2 section. It has to be noted that, in the light of the early stage of the project, these descriptions are incomplete, and will be updated as more information becomes available.

2.1.3 General environments of the SLMR sites

From the general maps available, it is possible to form a broad picture of the environments of the SLMR sites. This is summarized in Table 2.3 under the themes agroclimatic zones, land use/land cover, landforms and agro-ecological zones.

ICARDA uses its own system for mapping and classifying Agro-ecological Zones. At a regional scale and 1-km resolution, it is based on the integration in GIS of the following thematic layers:

- Agroclimatic zones
- Land use/land cover
- Landforms
- Soil patterns

The specific methods used in generating these layers, and the Agro-ecological Zones map, will be explained in the final report of the GIS component.

Central Asia contains 187 agro-ecological zones, of which the five largest cover nearly 48% of Central Asia, whereas the 20 largest cover 80% of the region. On the other hand, 50% of all AEZ in Central Asia cover a total of only 1%, evidencing that virtually all of them constitute 'niche' agro-ecologies, the vast majority located in mountain areas (De Pauw, 2007).

The agro-ecological zones of the SLMR benchmark sites are listed in Table 2.4. They cover about 34% of Central Asia. Their spatial distribution is shown in Figure 2.7. The general characteristics of these zones are summarized in Table 2.5.

Table 2.4. Agro-ecological zones of the benchmark sites

Site No.	Site name	AEZ	% C Asia	(AEZ2)	% Casia	(AEZ3)	% Casia
25	Abylay	**53170**	0.73				
26	Kaptagay	**31000**	3.22	**33170**	5.61		
27	Daniyar	**51000**	1.51				
28	Kenenbay	**83250**	0.39	**81000**	0.46	**82100**	2.41
29	Faizabad	**103200**	0.16				
30	Vakhsh	**51000**	1.51				
31	Bugdaily	**31000**	3.22	**33160**	3.03		
	Sherzod Samandar						
32	Birlig	**51000**	1.51				
33	Esanboi-ota	**51000**	1.51				
34	Kyzylkum	**33100**	16.89	**33170**	5.61		

Table 2.3 Summary table for agricultural environments of the SLMR sites

Site No.	Site name	Agro-climatic Zone	Landform	Land Use 1	Land Use 2	AEZ 1	AEZ2	AEZ3
25	Abylay	SA-K-W	Plain	Barren/sparse		53170		
26	Kaptagay	A-K-W	Plain	Irrigated	Barren/sparse	31000	33170	
27	Daniyar	SA-K-W	Plain	Irrigated		51000		
28	Kenenbay	SH-K-W (SH-K-M)	Hills	Irrigated	Rangelands	83250	81000	82100
29	Faizabad	H-K-W	Hills	Rainfed crops	Rangelands	103200		
30	Vakhsh	SA-C-W	Plain	Irrigated		51000		
31	Bugdaily	A-C-VW (A-C-W)	Plain	Irrigated	Rangelands	31000	33160	
32	Sherzod Samandar Birligi	SA-C-W (SA-K-W)	Plain	Irrigated		51000		
33	Esanboi-ota	SA-C-W	Plain	Irrigated		51000		
34	Kyzylkum	A-K-VW	Plain	Barren/sparse	Rangelands	33100	33170	

Notes:
1. Codes for Agroclimatic zones:
SA-K-W : semi-arid moisture regime, with cold winters and warm summers
SA-C-W : semi-arid moisture regime, with cool winters and warm summers
A-K-W : arid moisture regime, with cold winters and warm summers
A-K-VW : arid moisture regime, with cold winters and very warm summers
A-C-VW : arid moisture regime, with cool winters and very warm summers
A-C-W : arid moisture regime, with cool winters and warm summers
SH-K-W : sub-humid moisture regime, with cold winters and warm summers
SH-K-M : sub-humid moisture regime, with cold winters and mild summers
H-K-W : humid moisture regime, with cold winters and warm summers
2. Codes for Agro-ecological zones: see Table 2.3

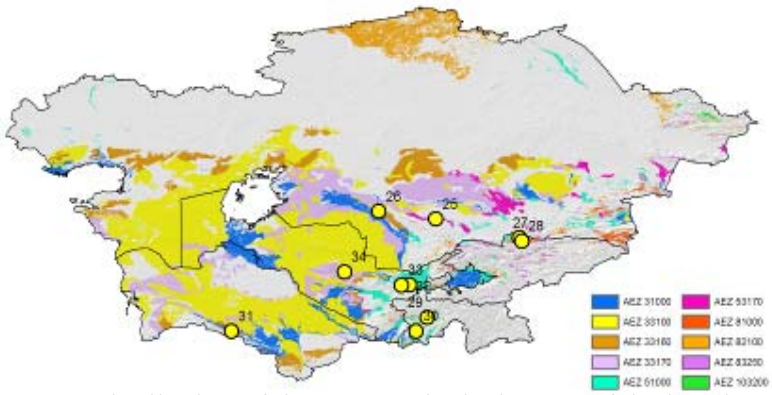


Figure 2.7 Distribution of the agro-ecological zones of the benchmark sites

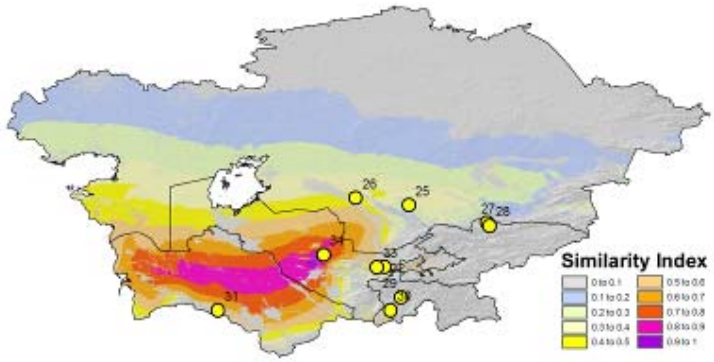


Figure 2.8 Similarity in climate, landforms and land use/land cover with Kyzylkum site

2.1.4 Similarity in environments with the SLMR sites

Provided the necessary data are available, it is quite easy to assess where similar environments occur, and it is also true that where environments are very different, the technologies tested at the benchmark sites may not be appropriate. Agroecological zones can be used to assess, as a first step, where similar environments occur as in the benchmark sites. However, since the AEZ are wide classes, containing much internal variability, that would lead to an overoptimistic interpretation of similarity.

The key question is where a similar response to a new technology can be expected if the environments are similar. First, it is obvious that different socioeconomic conditions can be sufficient ground for the non-adoption of a successful technology in a different area with similar biophysical environments. Perhaps equally important is that each technology has a different 'elasticity' to a change in environments. When testing shrubs for the rehabilitation of degraded rangelands, one plant might be suitable for a wide precipitation or temperature range, another might only be successful in a more narrow range. Similarly, a fertilizer recommendation package may work in a fairly narrow precipitation range, but be inappropriate outside that range.

For this reason an approach is needed that allows to set the range for defining 'similarity' depending on the particular technology. This can be done using the concept of elasticities to differences in environment, but would then require (i) good knowledge of the environment-technology interaction, and (ii) good site characterizations.

For the SLMR project the approach to mapping similarity in its biophysical and socioeconomic dimensions is only starting. At this moment of methodology development, and with the data available, it is confined to similarity in biophysical environment using a 3-step approach:

- Step 1: Climatic similarity (precipitation and temperature)
- Step 2: Similarity in landforms

- Step 3: Similarity in land use/land cover

Table 2.5 General characteristics of the agroecological zones of the SLMR sites

AEZ	Climate	Land use	Landform	Soil Management Domain
31000	Arid climates with cool or cold winters and warm or very warm summers; winter coldness is an ecological constraint	Irrigated crops	Plains	Soils suitable for agricultural use
33100	Arid climates with cool or cold winters and warm or very warm summers; winter coldness is an ecological constraint	Non-agricultural land use	Plains	Undifferentiated soils
33160	Arid climates with cool or cold winters and warm or very warm summers; winter coldness is an ecological constraint	Non-agricultural land use	Plains	Predominantly semi-desert soils
33170	Arid climates with cool or cold winters and warm or very warm summers; winter coldness is an ecological constraint	Non-agricultural land use	Plains	Predominantly desert soils
51000	Semi-arid climates with cool or cold winters and mostly warm summers; winter coldness is an ecological constraint	Irrigated crops	Plains	Soils suitable for agricultural use
53170	Semi-arid climates with cool or cold winters and mostly warm summers; winter coldness is an ecological constraint	Non-agricultural land use	Plains	Predominantly desert soils
81000	Sub-humid climates with cool or cold winters and mild or warm summers; winter coldness is an ecological constraint	Irrigated crops	Plains	Soils suitable for agricultural use
82100	Sub-humid climates with cool or cold winters and mild or warm summers; winter coldness is an ecological constraint	Rainfed crops	Plains	Soils suitable for agricultural use
83250	Sub-humid climates with cool or cold winters and mild or warm summers; winter coldness is an ecological constraint	Non-agricultural land use	Hills	Predominantly rocky outcrops and shallow soils
103200	Humid climates with cool or cold winters and mild or warm summers; winter coldness is an ecological constraint	Non-agricultural land use	Hills	Undifferentiated soils

The similarity domains have been mapped for all SLMR sites. Details of the methodology are provided in 3rd section. Figure 2.8 provides a good example of a benchmark site (Kyzylkum) with wide potential outscaling domain. Table 2.5 provides the similarity maps for all SLMR benchmark sites based on climatic conditions, land use/land cover and landforms.

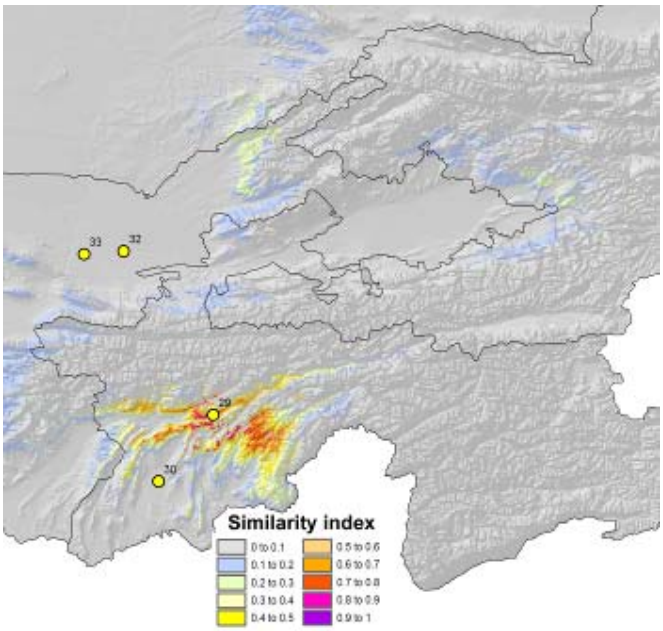


Figure 2.9 Similarity in climate, landforms and land use/land cover with Faizabad site

Figure 2.9 provides a good example of a benchmark site (Faizabad) with a fairly narrow potential outscaling domain. This by no means can be interpreted as that the site has been less well selected than the previous one, only that the particular environments similar to the Kyzylkum site are more widespread in Central Asia than the ones that Faizabad represents.

2.1.5 Site characterization

Sites are selected to be representative for particular agroecological conditions (climate, soils, land degradation characteristics), farming or production systems, or common problems related to the interactions between systems and environments. That sites are representative is a key requirement for their suitability for testing of new agricultural practices, packages, technologies etc. At the same time, it should be obvious that if the sites are not properly characterized, there is no way of knowing what they represent.

Within the SLMR sites, it is necessary to distinguish two levels of sites and corresponding levels of characterization

- Type A: small areas, of the order of hectares (plot/field/farm level) in which the actual experiments are undertaken
- Type B: larger areas, at the level of a landscape, of the order of several km^2 to hundreds of km^2 , for which the included experimental sites are very representative, or in which multi-disciplinary research is conducted. These can be watersheds, cover one or few communities, and be representative for one or more agroecological zones or production systems.

The difference between a Type A and Type B site is illustrated in Figure 2.10.

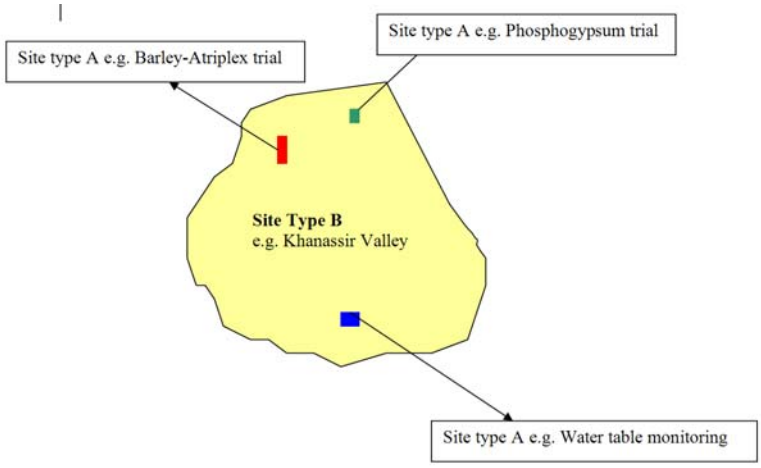


Figure 2.10 Relationship between Type A and Type B sites

At a Type-A site the actual experiments take place and data collection focuses entirely on the technology being tested. It is assumed that the environment of a Type-A site is homogeneous and that any possible soil heterogeneity can be controlled through plot replication and randomization. A Type-B site is the real benchmark site. It encompasses all the Type-A sites and therefore is much more likely to be affected by a degree of internal heterogeneity that will need to be assessed in order to correctly assess the outscaling domain for the tested technology. To outscale successfully to the level of Central Asia, it is essential that both Level A and level B characterizations are undertaken. This is an exercise that can be done in a very thorough (and expensive) way involving new surveys, or a more practical approach, making the best use of available data, supplemented by targeted field observations and acquisition of new but essential information.

It will be necessary to develop a simple protocol for Type-A site and Type-B site characterizations. Kinds of observations and level of detail will be different between Type A and Type B sites.
For a Type-A site the focus will be on understanding the experimental design. This will give a good handle on the requirements and elasticity of the tested technologies that should be incorporated into the outscaling model.
For a Type-B site the focus will be on understanding the biophysical, and in a later stage, the socioeconomic environments. It will require the collection of basic data related to the environments (climate, soils, erosion features, land use, terrain, water resources etc.), the production systems (crops, livestock, poverty, tenure, use of inputs etc.) as well as poverty and livelihoods.

Besides data collection at the level of the SLMR benchmark sites, which might include purchase of climatic data from nearby stations, there will be a need for further data acquisition at the level of Central Asia and data conversion in GIS-compatible formats. In the light of the absence of a regional soil map, the compilation of a 1:1,000,000 soil map is a top priority.

2.2 Preliminary description of the SLMR research sites

2.2.1 Kazakhstan research sites

Abylay site (No. 25)

By administrative division the site is located in Abylay farm, Sarisuysk district of Jambul Province. Selected plots for experiments occupy three different types of agroecosystems: (1)

piedmont plain, (2) sandy massif and (3) sandy area (with application irrigation from artesian flow well).
Sarisuysk district is located in the transition zone between the desert and steppe. The weather is characterized by cold winter and hot summer, fast change from winter to summer and short spring period, instability and small amount of precipitations, dryness of air and intensive evaporation. The nearby Baikadam weather station indicates an average annual air temperature of 9.8^{o}C, with a minimum in January of –7.3^{o}, and a maximum in July of 25.8^{o}C, an average annual amount of precipitation of 198 mm, including 95 mm during the cold season (between November and March) and 103 mm during the warm season (between April and October).
According to the ICARDA map of Agroclimatic Zones the site belongs to the class SA-K-W (semi-arid, with cold winters and warm summers). The ICARDA Land Use/Land Cover map of 1993 indicates 'barren/sparse vegetation' as main land use/ land cover class.

The experiments undertaken at the Abylay site are related to rangeland management and are summarized in Table 2.6.

Table 2.6 Research at the Abylay site

Experiment	Treatment
#1	1. Pastel Buasye – Sameriaria (ephemeris)
	2. Sandy Sainfoin – Onobrychis arenaria (perennial grasses)
	3. Khorasan Sainfoin – Onobrychis chorasanica (perennial grasses)
	4. Pectinated – Agropyron cristatum (perennial grasses)
	5.Kochia prostrata (subshrub)
	6. Krascheninnikovia ceratoides (subshrub)
	7. Camphorasma lessingii (subshrub)
	8. Black Saxaul – Haloxylon aphyllum (arborescent shrubs)
#2	1. Agropuron fragile (perennial grasses)
	2. Kochia prostrata (subshrub)
	3. Krascheninnikovia ceratoides (subshrub)
	4. Calligonum aphyllum (shrubs)
	5. Black Saxaul – Haloxylon aphyllum (arborescent shrubs)
#3	Fodder crops: Millet (Panicum, Sorghum), Sweet Clover (Melilotus), melons and gourds (Water Melon - Citrullus)

Kaptagay site (No. 26)
By administrative division the site is located in Kaptagay and K LLC Shiely district of Kzyl-Orda Province, physiographically in the Syr Darya delta-front (357 thousand ha). According to national classification system (Selyaninov, et al., 1979) the site belongs to the Prisyrgarya agroclimatic district. The period with temperature above 10°C is 180-200 days. Mean temperature in July is 26-28°C, in January -6.5°C. During season with temperature above 10°C amount precipitation is 35-75 mm. Temperature conditions are favorable for growing crops such as rice, grapes, alfalfa, melons, but only under irrigation from Syr-Darya River.
The nearest weather station is Kzyl-Orda, located at 120 km from the site.
According to the ICARDA map of Agroclimatic Zones the site belongs to the class A-K-W (arid, with cold winters and warm summers). The ICARDA Land Use/Land Cover map of 1993 indicates 'irrigated field crops' as main land use/ land cover class.

The experiments undertaken at the Kaptagay site are related to irrigation management and are summarized in Table 2.7.

Table 2.7 Research at the Kaptagay site

#1	1. Short flooding. Support water in rice check with TDS of 2.5 g/L during germination, shoots and flowering stages and 3.5 g/L – during the rest.
#2	2. Permanent flooding. Support water in rice check with TDS of 2.5 g/L during germination, shoots and flowering stages and 3.5 g/L – during the rest.

2.2.2 Kyrgyzstan research sites

Daniyar site (No. 27)
By administrative division the site is located in Daniyar farm, Sokuluk district of Chu Province, physiographically in the Chu valley.
The nearest weather station is Bishkek (Frunze). According to the ICARDA map of Agroclimatic Zones the site belongs to the class SA-K-W (semi-arid, with cold winters and warm summers). The ICARDA Land Use/Land Cover map of 1993 indicates 'irrigated field crops' as main land use/ land cover class.

Kenenbay site (No. 28)
By administrative division the territory is located in Sokuluk district of Chu Province. Physiographically the site is located on the northern slope of sub-montane plain of Kyrgyz ridge.
The nearest weather station is Bajt`k. According to the ICARDA map of Agroclimatic Zones the site belongs to the class SH-K-W (sub-humid, with cold winters and warm summers). At higher elevations the agroclimatic zone changes to class SH-K-M with cooler summers (sub-humid, with cold winters and mild summers). The ICARDA Land Use/Land Cover map of 1993 indicates a mixture of rangelands, rainfed and irrigated crops as main categories.

2.2.3 Tajikistan research sites

Faizabad site (No. 29)
By administrative division the site is located in Faizabad district, in the Region of Republican Subordinateion. Physiographically it is located in the medium-elevation piedmont zone. The landscape is mainly hilly.
The nearest weather station is Faizabad. According to the ICARDA map of Agroclimatic Zones the site belongs to the class H-K-W (humid, with cold winters and warm summers). The ICARDA Land Use/Land Cover map of 1993 indicates a mixture of rangelands and rainfed crops as main categories.

Vakhsh site (No. 30)
By administrative division the site is located in Bokhtar district of Khatlon province. Physiographically it is located in the Vakhsh valley.
The nearest weather station is Kurgan-Tyube. According to the ICARDA map of Agroclimatic Zones the site belongs to the class SA-C-W (semi-arid, with cool winters and warm summers). The ICARDA Land Use/Land Cover map of 1993 indicates 'irrigated field crops' as main land use/ land cover class.

2.2.4 Turkmenistan research sites

Bugdaily site (No. 31)

By administrative division the site is located in Ak bugdai District of Akhalsky province. Physiographically it is located in the Gyaursk valley of the Kopet Dagh piedmont plain. The nearest weather stations are Geok-Tepe and Kaakhka. According to the ICARDA map of Agroclimatic Zones the site belongs to the class A-C-VW (arid, with cool winters and very warm summers). At higher elevations the agroclimatic zone changes to class A-C-W (arid, with cool winters and warm summers).The ICARDA Land Use/Land Cover map of 1993 indicates a mixture of rangelands and irrigated crops as main categories.

2.2.5 Uzbekistan research sites

Sherzod Samandar Birligi site (No. 32)
By administrative division the site is located in Sardoba district of Syrdarya Province. Physiographically it is located in the piedmont plain.
The nearest weather station is Djyzakh. According to the ICARDA map of Agroclimatic Zones the site belongs to the class SA-C-W (semi-arid, with cool winters and warm summers). A few km northward the agroclimatic zone changes to class SA-K-W (semi-arid, with cold winters and warm summers), becoming colder in winter. The ICARDA Land Use/Land Cover map of 1993 indicates 'irrigated field crops' as main land use/ land cover class.

Esanboi-ota site (No. 33)
By administrative division the site is located in Pakhtakor district of Djizakh Province. Physiographically it is located in the submountain plain. The nearest weather station is Djyzakh. According to the ICARDA map of Agroclimatic Zones the site belongs to the class SA-C-W (semi-arid, with cool winters and warm summers). The ICARDA Land Use/Land Cover map of 1993 indicates 'irrigated field crops' as main land use/ land cover class.

Kyzylkum site (No. 34)
By administrative division the site is located in Kenimekh district of Navoi Province. Physiographically it is located in the Kyzylkum desert.
The nearest weather station is Navoi. According to the ICARDA map of Agroclimatic Zones the site belongs to the class A-K-VW (arid, with cold winters and very warm summers). The ICARDA Land Use/Land Cover map of 1993 indicates 'barren/sparse vegetation' as main land use/ land cover class.

2.3 Methodology for similarity mapping

2.3.1 Climatic similarity
In climatic similarity analysis, the value of a climatic parameter or index at one location (the 'match' location) is compared with other ('target') locations in order to quantify the degree of similarity in climatic conditions. In this particular case the climatic pattern of each one of the four KRB benchmark sites has been used as representing the match location. The target areas are KRB, Iran and the CWANA region.

The model used to assess similarity is a very simple distance function:

$$S = I_{1(\Delta_t)} * I_{2(\Delta_p)} \qquad (2.1)$$

The functions I_1 and I_2 are *similarity indices* for respectively air temperature and precipitation. They model the drop in similarity under increasing dissimilarity for air temperature Δ_t and precipitation Δ_p , respectively, as

$$I_1 = e^{\left(-\frac{\Delta_t}{\sigma_t}\right)} \text{ and } I_2 = e^{\left(-\frac{\Delta_p}{10\times\sigma_p}\right)} \qquad (2.2)$$

with σ_t [$^{O}C^{-1}$]and σ_p [mm^{-1}]user-defined calibration constants (Fig. 2.11).

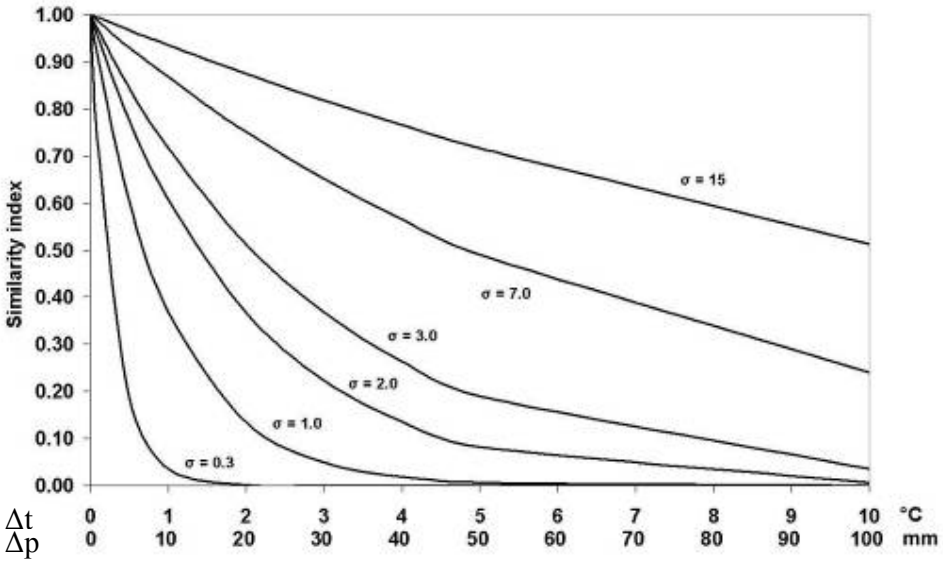


Figure 2.11 Use of calibration factors to adjust sensitivity to a climatic parameter

In this study the calibration factor for air temperature σ_t is set to 7.0, which corresponds to a drop in similarity by 20% under $\Delta_t = 2^{O}C$ and of about 50% under $\Delta_t = 5^{O}C$. The calibration factor for precipitation σ_p is set to 3.0, which corresponds to a drop in similarity of 50% under Δ_p = 20 mm and of about 80% under Δ_p = 50 mm.

Data input was in the form of climatic grids (12 mean monthly precipitation and average temperature surfaces). To assess similarity within Central Asia, grids were used with GTOPO30-DEM resolution (30 arc-second; 1 km).
The dissimilarity in temperature Δ_t was computed as follows (De Pauw et al., 2004):

$$\Delta_t = \sqrt{\frac{\sum_{i=1}^{12}\left(t_{i+s} - T_i\right)^2}{12}}, \qquad (2.3)$$

where i is month number, *t* is mean monthly air temperature in the target point, *T* is mean monthly air temperature in the matching point (^{O}C), *s* is a phase shift in month numbering.

The phase minimizes the deviation in temperature between match and target location and is obtained by shifting the temperature array until the covariance:

$$Cov(\overline{Tm}, \overline{T}) = \sum_{i=1}^{12}(Tm_i - \overline{Tm})\cdot(T_i - \overline{T}) \qquad (2.4)$$

reaches a maximum. This way the seasonal pattern in different geographic locations can be synchronized. In a climatically homogeneous region the phase is 0. The maximum possible phase is 11.

The same phase (s) is then applied to calculate the dissimilarity in precipitation pattern (Δ_p):

$$\Delta_p = \sqrt{\frac{\sum_{i=1}^{12}(p_{i+s} - P_i)^2}{12}}, \qquad (2.5)$$

where p is monthly precipitation in each target point, P monthly precipitation in the match point.

The above formulas apply for a similarity assessment based on a point to point comparison. However, within a benchmark site a range of precipitation and temperature conditions may exist. To ensure that the internal climatic variations do not exaggerate the dissimilarity that may arise by taking only one point inside the benchmark site, it might be necessary for large benchmark sites to consider the precipitation and temperature conditions in two points that represent a minimum and maximum. These points can be seen as end points of transects across the major temperature and/or precipitation gradients that represent 80-90% of the climatic conditions inside the benchmark site. For temperature or precipitation between these two values, 100% similarity is assumed. An example is shown in Figure 2.12 of a benchmark site containing plains, hills and mountains, in which the two end points of the transect cover about 90% of the temperature and precipitation conditions inside the benchmark site.

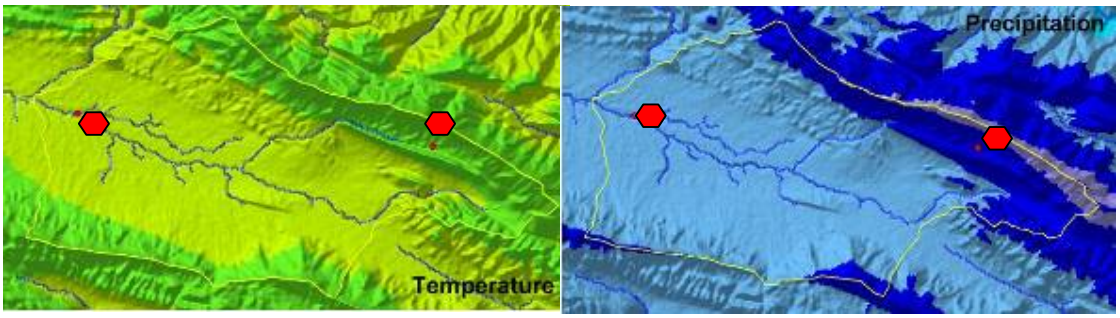


Figure 2.12 Assessing area similarity using two points along a gradient of temperature (left) and precipitation (right)

2.3.2 Similarity in landforms and land use/land cover

Whereas climatic similarity is assessed through a *continuous* variable, the climatic similarity index, similarity in landforms and land use/land cover is assessed as a *crisp* feature, which can have only two states, either *similar* or *non-similar*. This simplification is necessary in view of the fact that landforms or land use are usually characterized through a classification, rather than a continuous variable. To make the similarity assessment work using classifications, it is important that (i) the classifications used are adapted to the level of out-scaling envisaged and to the detail of the available datasets, and (ii) are used in a way to avoid exclusion of transitional classes.

To assess similarity of landforms, a simplified 3-class system is used, based on the concept of 'relief intensity' and applied to the GTOPO30 DEM[1] dataset. 'Relief intensity' is derived from the maximum elevation difference between two neighbouring pixels and classified as follows:

- Plains: relief intensity 0-50 m
- Hills: relief intensity 50-300 m
- Mountains: relief intensity >300 m

In contrast to the climatic factors used in the similarity mapping, which are continuous variables, landforms are classified variables and similarity is thus expressed by two states only, 'similar' if the landform has the same class as in the benchmark site, and 'non-similar' if it has a different class. The landform similarity index is 1 if similar, and 0 if non-similar.

As in the case of landforms, similarity in land use/land cover is expressed by two states, 'similar' if the land use/land cover has the same class as in the benchmark site, and 'non-similar' if it has a different class, and the land use/land cover similarity index is 1 if similar, and 0 if non-similar. As mentioned in the main report, the ICARDA Land Use/Land Cover map was used for the assessment.

2.3.3 Similarity in all evaluated factors

The total similarity is calculated as the product for all three evaluated factors

$$S_{total} = S_{climate} * S_{LF} * S_{LULC} \qquad (2.6)$$

with $S_{climate}$ the climatic similarity index, S_{LF} the landform similarity index, and S_{LULC} the land use/land cover similarity index.
Samples of these maps showed in Figures 2.13-2.23.

[1] Documentation: http://edc.usgs.gov/products/elevation/gtopo30/README.html

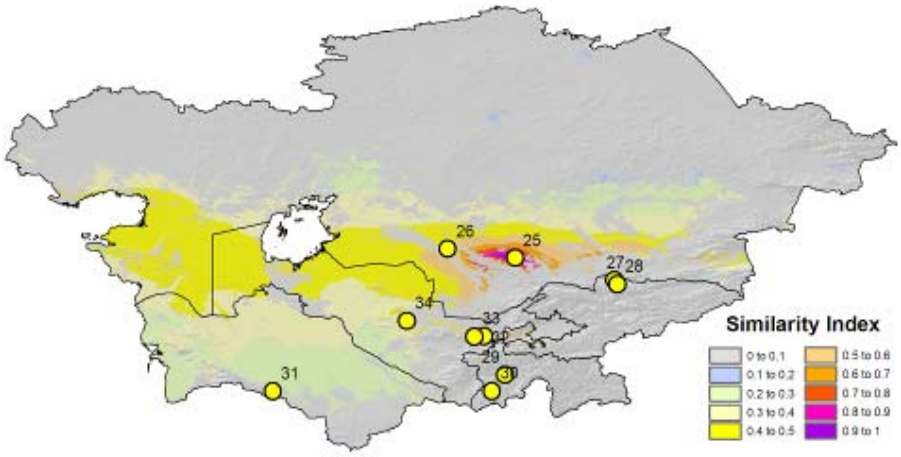


Figure 2.13 Similarity in climate, landform and land use/land cover with the Abylay benchmark site

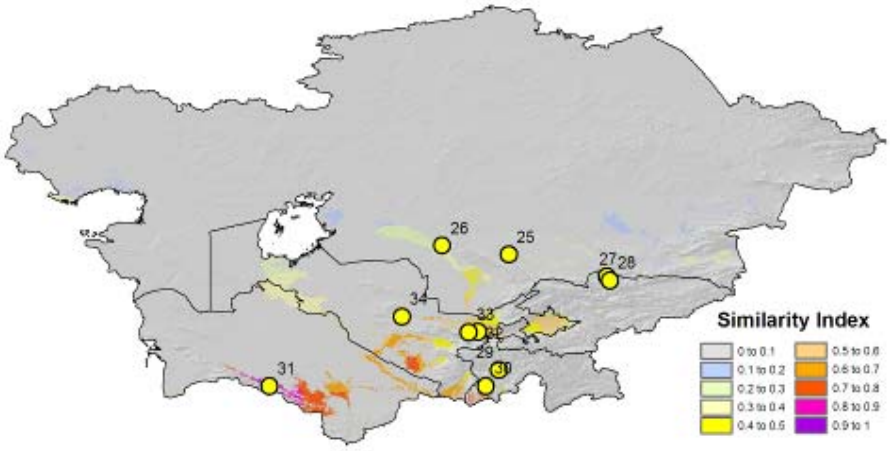


Figure 2.14 Similarity in climate, landform and land use/land cover with the Bugdaily benchmark site

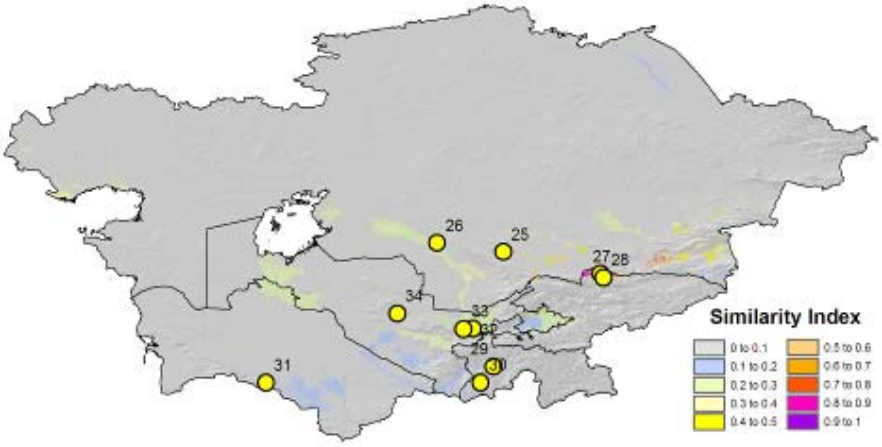


Figure 2.15 Similarity in climate, landform and land use/land cover with the Daniya benchmark site

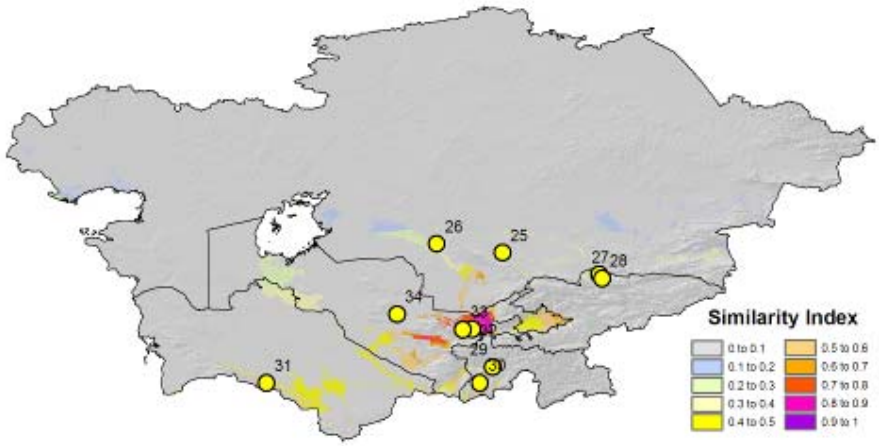


Figure 2.16 Similarity in climate, landform and land use/land cover with the Esanboi benchmark site

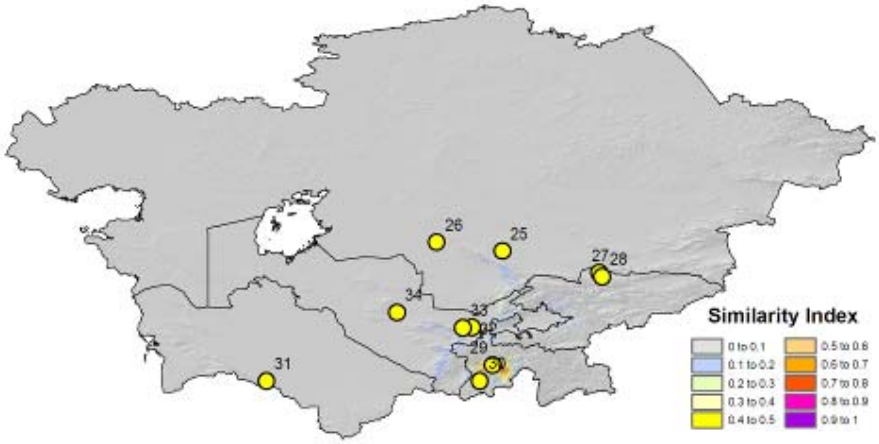


Figure 2.17 Similarity in climate, landform and land use/land cover with the Faizabad benchmark site

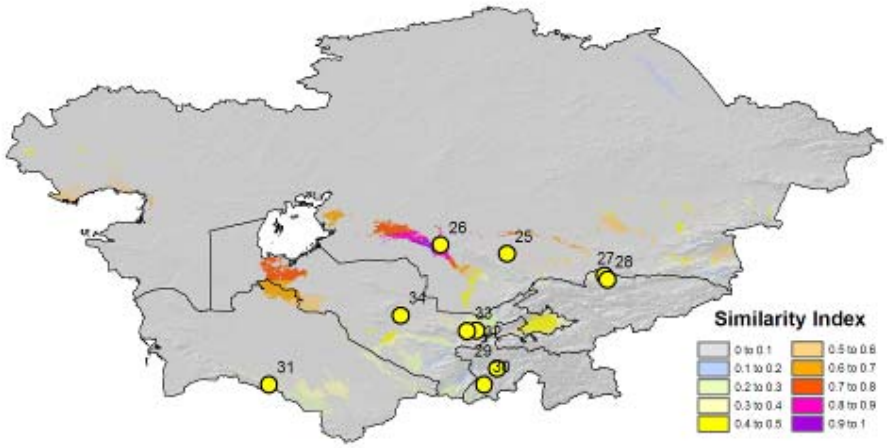


Figure 2.18 Similarity in climate, landform and land use/land cover with the Kaptagay benchmark site

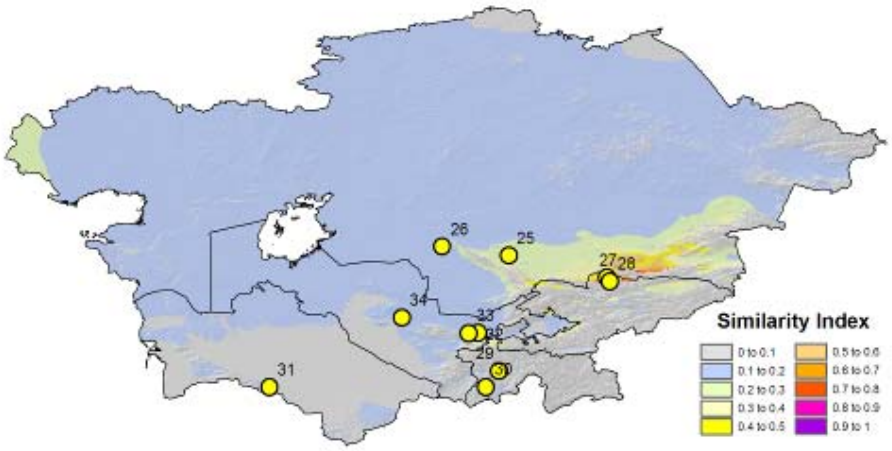


Figure 2.19 Similarity in climate, landform and land use/land cover with the Kenenbay benchmark site

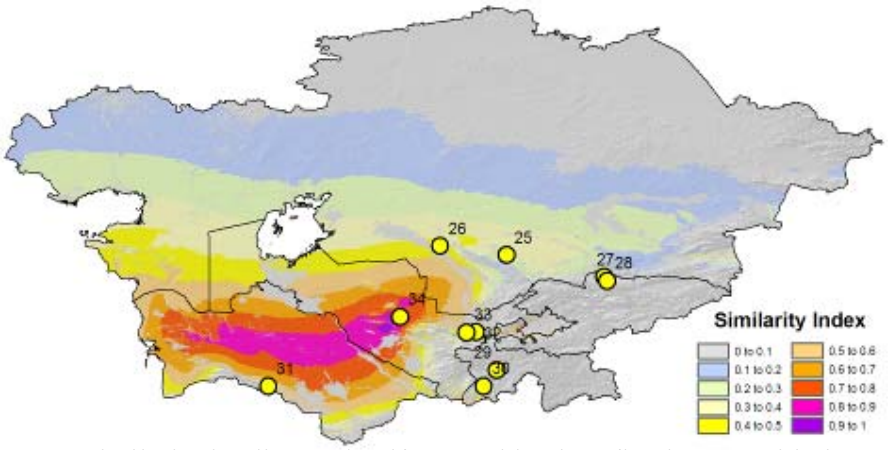


Figure 2.20 Similarity in climate, landform and land use/land cover with the Kyzylkum benchmark site

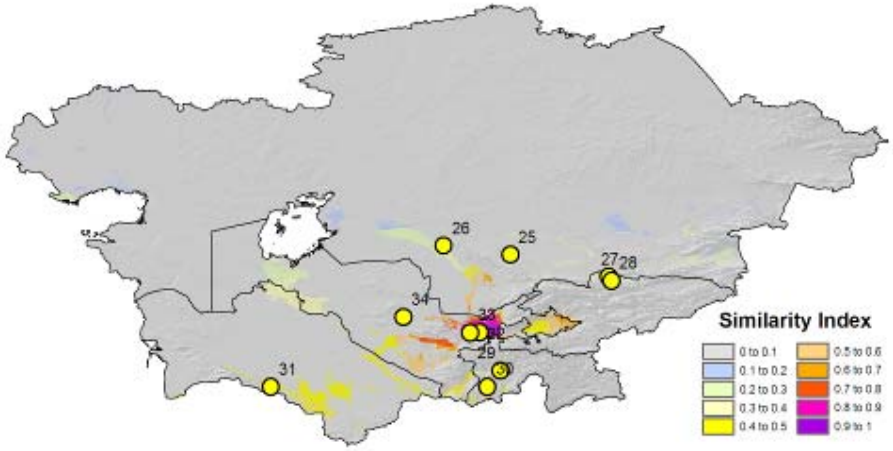


Figure 2.21 Similarity in climate, landform and land use/land cover with the Sherzod benchmark site

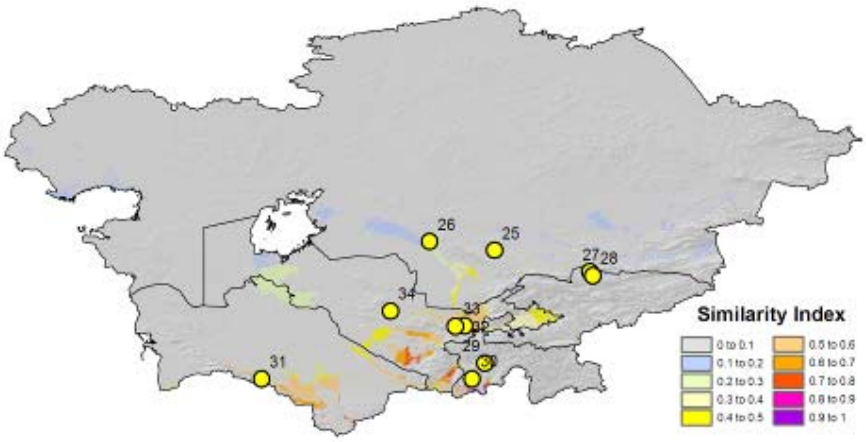


Figure 2.22 Similarity in climate, landform and land use/land cover with the Vakhsh benchmark site

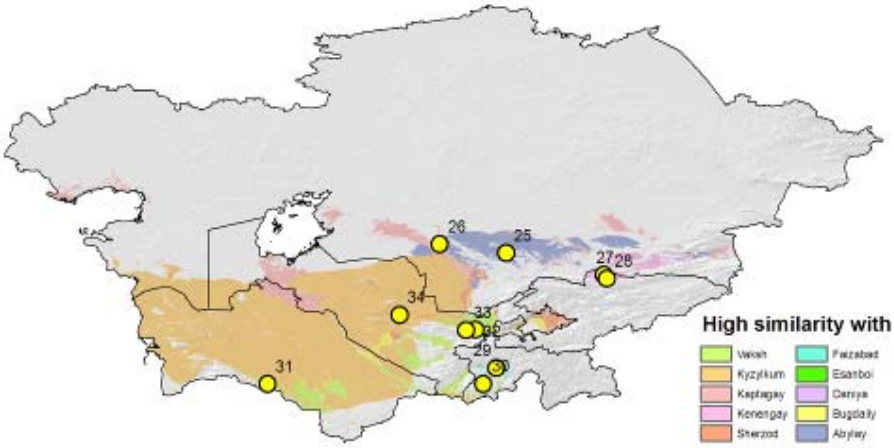


Figure 2.23 High similarity (index >0.5) with different SLMR benchmark sites

2.3.3 Progress and constraints

As anticipated by the work plan, the reporting period is mainly one of data collection and transformation into digital layers that can be processed in GIS. In this respect good progress has been made, especially in the compilation of topographical maps and national soil maps using the Country Atlases.

Topographical maps at scale 1:100,000 and 1:200,000 have been compiled for the areas in which all SLMR research sites are located. The maps have been scanned and georeferenced and will be used as base maps.

From the National Country Atlases 4 country soil maps (Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan) have been extracted through scanning, and have been successfully geo-referenced. They are now being digitized at ICARDA. The Country Atlas for Tajikistan was graciously lent out by Dr. Sanginov, for which many thanks. The legends for the 4 soil maps were translated into English, which will allow to correlate them across countries and to develop a single soil map for Central Asia, which will be more detailed than the FAO Soil Map of the World. We have not been able to get a copy of the national soil map of Turkmenistan published in the Turkmenistan Country Atlas and we hope Dr. Nepesov will be able to locate this important document so that adequate arrangements can be made for scanning and further processing.

At the SLMR sites data compilation is ongoing. Some climatic data from meteorological stations that can be considered representative for the SLMR sites are being processed.
However, as a general comment, the flow of information from the research sites is inadequate. No data have as yet been received related to the specifics of the experiments carried out in the sites. Although coordinates have been provided for the sites (see earlier Technical Progress Report), these represent points, but not the areas of the sites. This lack of basic knowledge about the technologies being tested in the SLMR sites is going to make extrapolation to Central Asia, due for the end of 2008, very difficult. Moreover, due to the limited funds allocated to the GIS component, it will not be possible for the GIS unit to undertake a mission to the SLMR sites for ground truthing. Hence the input from the site coordinators is crucial for a successful implementation of the GIS component, and there is still time to address this problem.

2.4. Other activities related to the SLMR project

A small study has been carried out as a follow-up to the carbon sequestration studies published by Lal et al. (2007), which will be published in the forthcoming issue of the ICARDA Caravan series. By combining a land use/land cover map, established knowledge on the sequestration potential of Central Asian soils under natural conditions and under agricultural use in different agroclimatic conditions, and the FAO Soil Map of the World data, the study provides a new estimate of the maximum sequestration potential in Central Asia. By making a difference map between the estimated carbon pools between natural conditions and current land use. The draft article is included in this report (section 5). The layers generated will be added to those already compiled for Central Asia.
The study will be updated when the new soil map for Central Asia is ready.

2.4.1 Carbon Sequestration: in the Soils of Central Asia

Studies in Central Asia try to make sense of carbon sequestration – and lead to some surprising conclusions.

As we look for ways to stop global warming, one term is often heard: carbon sequestration. Carbon enters the atmosphere as carbon dioxide when fossil fuels are burnt. In theory, a significant proportion of this carbon could be sequestered by soils, i.e. captured and stored as organic matter or carbonate minerals, taking it out of the global warming equation. In practice, there are doubts about whether the gains would be meaningful in the context of global CO_2 emissions. Recent research in Central Asia, where the soils and agro-ecosystems are believed to have considerable potential for carbon sequestration, puts these issues in perspective.

The five countries of Central Asia – Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan and Turkmenistan with a total land mass of nearly 4 million km^2– have large expanses of uncultivated steppe, which is often used to graze sheep. These areas are generally unsuited for agriculture. But could they potentially serve as carbon sinks, sequestering carbon for the world's benefit and generating income for the country through international carbon-trading agreements?

Central Asia, with 3% of the world's land mass (excluding Antarctica), accounts for only around 1.4 % of CO_2 that is set free worldwide by fossil fuel burning. About half of this comes from Kazakhstan, which occupies 70% of the land mass of the 5 countries combined,

with emissions of 55 million tons per year.

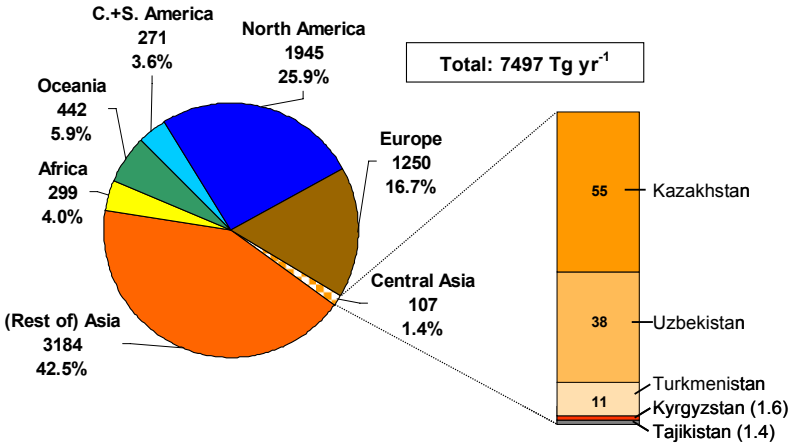


Figure 2.24: CO_2 emissions (Tg C yr^{-1}; % of total) from fossil fuel burning in 2004 worldwide as well as in detail for Central Asia (adapted from various sources provided by the Carbon Dioxide Information Analysis Center, 2008, http://cdiac.ornl.gov/)

1 Tg = 1 tera gram = 10^{12} g = 1 million tons
Central and South America' also includes the Caribbean countries; 'Oceania' comprises Japan, Australia and New Zealand as major emitters (99.6 % of Oceania's total) and twelve other states in the Pacific Ocean

2.4.2 Sources and sinks

Where is carbon found? Pretty much everywhere, from underground coal deposits to dissolved compounds in sea water to plant and animal tissue. The world's oceans are by far the largest carbon pool, containing nearly 40 trillion tons. Soils are the next largest, containing about three times the amount of carbon bound in living plants and animals (Table 2.7). In terms of climate change, buried or 'bound' carbon does no harm – but carbon in the atmosphere (mainly as CO_2) is a major factor in global warming.
Fortunately, the capacity of the oceans to act as carbon 'sinks' has not been severely damaged. But human activity is reducing the effectiveness of other sinks. Conversion of pastures and forests into fields, causes heavy losses of soil organic carbon, partly because inappropriate practices such as heavy tillage exposes buried organic matter to air and sunlight, accelerating the release of carbon. The biggest culprit is deforestation, which often involves clear-burning of large swathes of forest. By some estimates, all these changes in land use have released 156 billion tons of carbon into the atmosphere over the past 150 years. The rate of emissions is increasing – currently 2 billion tons per year.
That is just from changes in land use. Burning of fossil fuels (coal, gas, oil) is far more serious, releasing 7.5 billion tons of carbon per year.

2.4.3 How land use affects carbon stocks

In recent years, scientists from several institutions (including Mikhail Suleimenov and Richard Thomas, both land management specialists at ICARDA) have been studying the potential for carbon sequestration in the steppes of northern Kazakhstan, which cover 126 million hectares, or 43% of the country's area.
The amount of carbon in steppe soils depends heavily on climate as well as land use. Soils in

warmer, drier, and lower-latitude areas contain less carbon.

Table 2.8 Carbon pools

	Carbon (billion ton)
Ocean	38 – 39000
Atmosphere	785
Plant and animal tissue	466-835
Geologic (coal, gas, oil)	4 – 5000
Soil organic carbon	1220-1550
Soil inorganic carbon	750-950
Soil, total (1 meter depth)	2000-2500

Conversion from virgin land to cultivation led to losses of 9% to 21% in soil carbon levels – with one caveat. Especially in arid areas, conversion to irrigated (as opposed to rainfed) farming actually increases organic matter, because irrigated farmland produces more biomass, and therefore potentially more soil carbon, than virgin land.
To better understand the influence of land use on soil carbon stocks, ICARDA scientists used GIS analysis. Data from various studies were compiled, standardized, and overlaid onto soil and land-use maps. Consider the two maps shown below. Figure 2.25 shows land-use categories in Central Asia: open grasslands and rainfed crops in the north, barren or sparsely vegetated land in the south, and a few patches where high-yielding irrigated crops are grown. Figure 2.26 shows how crop production reduces the amount of soil organic carbon (SOC).

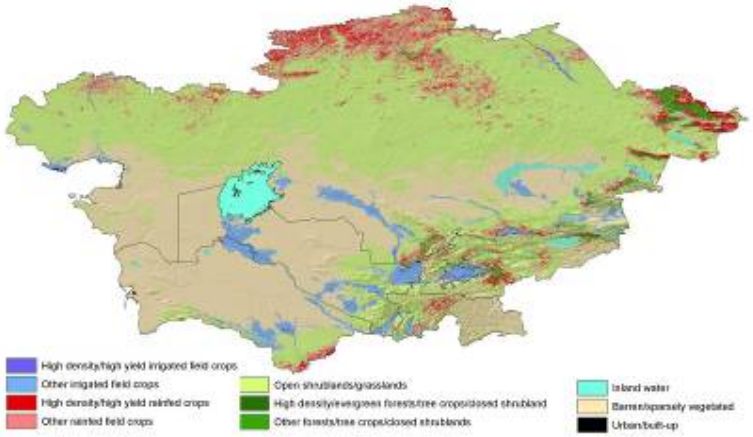


Figure 2.25 Land use categories in Central Asia

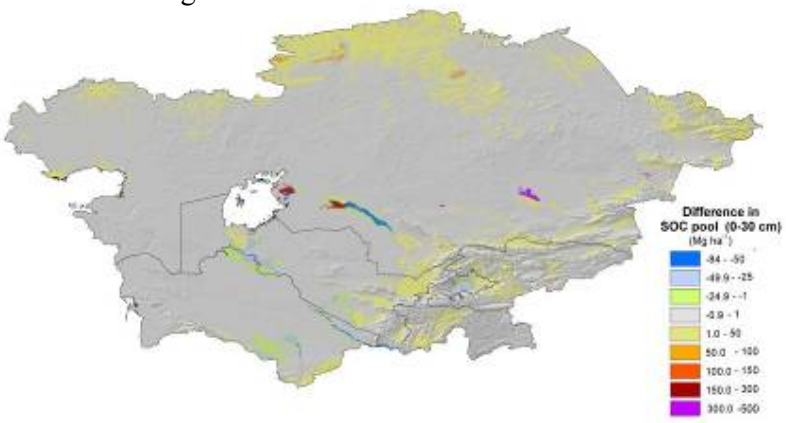


Figure 2.26: Losses of soil organic carbon in Central Asia due to crop production
At first glance, this map shows grey, hence 'no problem', but let us not forget that the total

area of Central Asia is nearly half of Brazil, hence the colored 'patches' represent very large areas.

The red areas in Figure 2.26 are 'hot-spots' of high SOC depletion. These include, for instance, wetlands with SOC-rich soils, which were drained for cultivation. On the other hand, SOC has increased substantially in some areas along the Amu Darya and Syr Darya rivers (blue), where desert areas were converted to intensive irrigated agriculture. Most of Central Asia still remains uncultivated. But the limited conversion to farmland has already reduced SOC levels by 3 to 4%. Degradation of rangeland due to over-grazing has caused further losses, but these are hard to quantify. An ongoing study by ICARDA and partner institutions in Kazakhstan and Uzbekistan is examining the scale and level of rangeland degradation, and the impact on SOC stocks.

2.4.4 The benefits of sequestration

Organic matter levels, and therefore capacity for carbon sequestration, have declined in large parts of Central Asia. Solutions are available – different crop rotations, better management practices (in particular, reduced tillage), improved grazing management – that can increase SOC back to its original levels, or even higher. But implementing these solutions will be hard, for two reasons, First, the potential for improvement is variable, being dependent on local conditions such as soil type, availability of irrigation etc. Second, and more important, can these solutions be widely promoted in a region where rural communities are poor and widely scattered, and government infrastructure is lacking?

But let's take an optimistic view. Assume that SOC levels in all of Central Asia's farmland can be brought back to native levels in the next 50 years. This means 15.7 million tons of carbon can be sequestered each year, assuming a linear increase in SOC.

Will this make a dent in atmospheric CO_2 levels? This 15.7 million tons represents nearly 15% of Central Asia's annual anthropogenic carbon emissions – but only 0.2% of global emissions. One view is, of course, that every bit helps. But more importantly, sequestration would represent a huge income opportunity in a region with very high poverty levels and severe under-investment.

The Clean Development Mechanism under Kyoto protocol offers opportunities for countries to sell carbon sinks on the international carbon market. Sequestering 15.7 million tons of carbon per year, at the current price of €25.75 per ton, will be worth approximately 403 Million Euro, and this does not even take into consideration the potential for sequestering C in currently degraded rangelands. However, so far no Central Asian country is eligible to participate in these markets.

The economies of Central Asia are heavily dependent on agriculture, oil and gas. Higher SOC levels would improve soil fertility, food production, ecosystem sustainability, and livelihoods of the rural poor, who form the majority of the population. Soil carbon sequestration would be a positive side-effect: not so much in terms of reducing climate change, but as a potential source of income for national governments.

References:

R. Lal, M. Suleimenov, B.A. Stewart, D.O. Hansen, P. Doraiswamy (Eds). 2007. Climate Change and Terrestrial Carbon Sequestration in Central Asia. Taylor & Francis, ISBN 978-0-415-42235-2

2.5. Socio-economic analysis of policy, livelihoods and SLM options and their effect on land degradation

During the reporting period, the socio-economic activities under the project were focused on two major objectives:

1. Review of literature on drivers of land degradation and their systemic interactions
2. Livelihoods analysis at the benchmark sites

Presently, a substantial database of secondary information on the state and dynamics of land degradation has been collected for all the five countries in order to identify the systemic interactions between different bio-physical, socioeconomic, policy and institutional causes of land degradation. In addition, relevant information from other regions of the world facing similar problems has also been studied. The collected information database is in both English and Russian languages and contains more than 800 publications, articles, and brochures, both in electronic and printed formats. Efforts have been initiated at developing Review Documents for all the five countries by homogenizing the collected information around three components:

i) Situational analysis: land and water resources and their use, and agricultural production both crop and livestock,

ii) Trends in land degradation, including extent, drivers, and forms of land degradation in various agro-ecologies in Central Asia,

iii) Systemic interactions of causes, pathways and consequences of land degradation.

To illustrate, a working draft of the Review Document for Uzbekistan (now only in Russian language) is given in Annex 1[2]. In addition, the technologies developed under previous RETA projects in the region conducted by ICARDA, as well as other agricultural research projects under the CGIAR Consortium for Central Asia and the Caucasus have been studied for their up-scaling potential. It was found that more than 60 various technologies of soil an water management, crop diversification, integrated pest management, rangeland management and livestock production, etc have been researched under various agro-ecologies of Central Asia and are available for uptake and dissemination. It is planned to publish a handbook containing a compilation of best of these SLM practices for the benefit of policymakers, farmers, and extension/advisory agencies in 2008.

The livelihoods survey of land users and other stakeholders is being conducted to identify the impact of land degradation on rural livelihoods at the project research sites. The secondary information mentioned above also served as the basis for developing the **livelihoods survey instrument**: survey questionnaire. The survey questionnaire was pre-tested and fine-tuned during January – June, 2008, for the specificities of the major agro-ecologies and production systems represented by the benchmark sites as well as in order to better integrate the questions and issues of land degradation most important for the livelihoods of farmers as seen by the farmers themselves.
During the pre-testing of the questionnaire it became clear that the research sites represent a wide range of variability not only in terms of their agro-ecologies and dominant production systems, but also in terms of their socioeconomic and institutional contexts even within a single country. For example, in irrigated plain areas in Uzbekistan and Kyrgyzstan (Syrdarya

[2] The Annex 1 is uploaded at https://wpqp1.adb.org/QuickPlace/cacilm/PageLibrary4825729F00314446.nsf/h_Toc/620b50cbb5fd79ef48257496003ea2ae/?OpenDocument

and Daniyar sites), it was found that agricultural production is commercially oriented and farm sizes are usually more than 20 ha (reaching up to several hundred hectares in Daniyar site in Kyrgyzstan). In contrast, in Kyzylkum site in Uzbekistan which is located in the desertic area with agro-pastoral production system, as well as Kenenbay site in Kyrgyzstan represented by sloping areas, farm sizes are very little, usually with less than 1 ha for majority of farmers; the agricultural production in these areas is predominantly subsistence-oriented.

The livelihoods surveys are also expected to provide insightful information for cross-country comparisons. In irrigated areas of Daniyar site in Kyrgyzstan, average machinery ownership by farmers was estimated to be equal to 15,000-25,000 USD, while in irrigated areas of Uzbekistan (Syrdarya) and Turkmenistan this figure does not exceed, on average, 1500 USD. Even though the farmers at the Daniyar site, Kyrgyzstan, were better off financially then their counterparts in Syrdarya, Uzbekistan, they indicated their reluctance to contribute to efforts on cleaning or drainage systems in their area, while the farmers in Syrdarya site expressed their readiness to contribute either cash or in kind. **Availability of fodder** during winter seasons was reported to be the biggest constraint to livestock production in Uzbekistan and Kazakhstan. In the Kyzylkum site in Uzbekistan, the interviewed farmers indicated that they usually give to livestock unpalatable desertic grass species such as camel's thorn (*Alhagi camelorum*) as feed during winter period so that the livestock survives. Hay or alfalfa is given only to sick animals to make them recover more rapidly. The survival rate of newly born sheep was reported to be less than 50% for the last winter, mainly due to unusually cold temperatures and unpreparedness of farmers for such extreme weather conditions.

On-job and on-field trainings on survey Instruments: The pre-testing of the questionnaire was carried out together with national enumerators, which gave an excellent opportunity for imparting on-job and on-field trainings for them on the conduct of the surveys. The final survey questionnaire is given in Annex 2[3].

The basic hypothesis for the study is that land degradation in Central Asia is leading to increased vulnerability of farmers' livelihoods. All other factors being equal, there could be strong relationship between land degradation and the livelihoods of farmers. However, in reality, farmers may have various coping strategies which affect the livelihood outcomes in a manner that reduces the vulnerability caused by land degradation. Thus, the study objective is to analyze the relationship between land degradation and rural poverty and to identify the coping strategies, both agronomic and socioeconomic that farmers may adopt to reduce the negative impact of land degradation on their livelihoods.

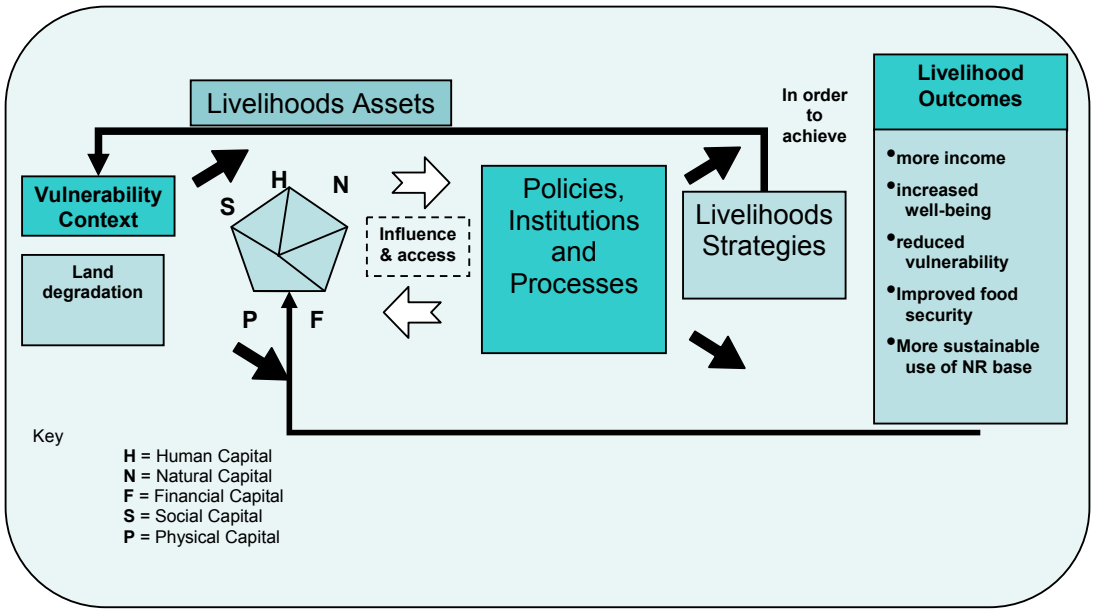
The following research questions are posed:

1. *How land degradation impacts the livelihoods of farmers in the target area?*
2. *What coping strategies farmers are adopting and can adopt against land degradation? How successful are they? How and who can facilitate the success of these coping strategies?*
3. *What actions and alternative policy and institutional options should be adopted to improve the livelihoods of farmers in the areas affected by land degradation and to ensure the sustainability of the resource base?*

[3] Uploaded at https://wpqp1.adb.org/QuickPlace/cacilm/PageLibrary4825729F00314446.nsf/h_Toc/620b50cbb5fd79ef48257496003ea2ae/?OpenDocument

The methodology for the livelihoods analysis is based on the Sustainable Livelihoods Approach Framework developed by DFID, as shown in the graph A1 below, with a focus on assessing the impact of land degradation on the livelihoods of farmers, as well as farmers' coping strategies.

Figure 2.27. Sustainable Livelihoods Approach Framework (DFID)



Sample size is determined using statistical methods. In addition to the purpose of the study and population size, three criteria usually need to be specified to determine the appropriate sample size: the level of precision, the level of confidence or risk, and the degree of variability in the attributes being measured[4]. There are several types of equations to calculate the necessary sample size for a different combination of levels of precision, confidence, and variability.

The website http://www.isixsigma.com/library/content/c000709a.asp presents sample size calculator provided by Creative Research Systems for calculating the sample size given the population size, desired confidence level and sampling error, whose statistical equation, presented below, has been used to identify the sample size for the surveys[5]:

$$n = \frac{N}{1 + N\,(e)^2} \qquad [2.7]$$

Where, n – sample size
N – Population size, i.e. total number of farmers in the area
e – The level of precision (sampling error). The confidence level is taken at 95%.

[4] Miaoulis, George, and R. D. Michener. 1976. *An Introduction to Sampling*. Dubuque, Iowa: Kendall/Hunt Publishing Company.

[5] Israel, Glenn D. 1992. *Sampling The Evidence Of Extension Program Impact*. Program Evaluation and Organizational Development, IFAS, University of Florida. PEOD-5. October.

The table below shows the sample sizes for each of the sites under the project. Considering that there is not significance difference between e = 10% and e = 15% in terms of representatives of the sample, the sample sizes are determined with e = 15% which will allow for greater cost-efficiency.

Table 2.9 Sample sizes for each site in CAC under SLMR project

Country	Site	e = 10%	e = 15%
Kazakhstan	Shieli	64	35
	Abylai	44	28
Kyrgyzstan	Daniyar	90	41
	Kenenbay	59	33
Tajikistan	Faizabad	57	33
	Vaksh	54	32
Turkmenistan	Bugdayli	75	38
Uzbekistan	Syrdarya	76	38
	Kyzylkum	28	21
Total		547	299

The corresponding numbers of farmers are being selected randomly out of the total list of farmers. Naturally, the sample sizes are increased by 5% in order to cover for farmers absent during the interview time or those who may not wish to participate in the survey. The full-scale surveys will be launched and completed during July-August, 2008. The activities under this component are being conducted in partnership with NGO "Agribusiness and Entrepreneurship" and the NARS partners in the five countries of the region.

2.6 Meetings, workshops and training programs organized (July 2007-July 2008)

Items	Countries Involved	#Participants
A. Workshops/ Meetings organized		
1. Project Initiation workshop	All countries , NSEC, UNCCD, UND, FAO and Zef-UNESCO and other stakeholders	**57**
2. Training on CA machines and their uses and repairs	Kyrgyzstan	**10**
3. In-country Meets for Planning SLMR activities	All countries	**50**
4. Collegiate Discussions on Research Prospectus	All countries, NSEC, UNCCD	**43**
B. Training programs organized		
5. Laser land leveling	Kyrgyzstan, Turkmenistan and Uzbekistan	21
6. Direct dry seeding rice technology	Uzbekistan and Kazakhstan	12
7. Multi-crop raised-bed/Zero till-ferti-seed planters	All countries	31
8. Optical Sensors for In-Season Yield Estimates (INSEY) and N management	All	23
9. Scientific equipments: - Electromagnetic probes for salinity - Soil moisture probes (Diviner) - Progress 1T probe- Temp. & salinity	All	17
10. English language (3 months)	All	20
11. On job Livelihood surveys	Kyrgyzstan, Tajikistan, Uzbekistan	7
Total		**131**

3. Kazakhstan

Program schedules of Research activities planned with monitoring indicators

Kazakhstan	Qr 3	Qr 4	Qr 1	Qr 2	Qr 3	Qr 4	Qr 1	Qr 2	Indicators	Outcomes
1. Evaluate the current status of land degradation in irrigated lands of "Kaptagay" LLC in Shielli massif of Kazakhstan.	X	X	X	X					• Annual Reports √ • Bench mark database on land degradation √ • Reports on C stocks and potential for C sequestration√ • Direct seeded dry rice (DSR) technology √ • New cultivars for yield improvement in rice √ • Methodology for assessment of the agronomic and crop management interventions on growth and land quality √ • Technologies for rehabilitation of the saline soils √	•Farmers start practicing DSR and Afforestation technologies in the neighboring areas to improve quality of natural resources •Institutions use the methodologies in comparative evaluations of the SLM interventions
2. Assessment of the existing soil organic carbon status and potential for carbon sequestration in irrigated lands of "Kaptagay" LLC in Shielli massif of Kazakhstan.	X	X	X	X						
3. Studies on the effect of irrigation schedules on rice yield, saving in irrigation water and salinity of the ponded waters and soil profile.				X	X	X				
4.Study the effect of different border dimensions on salt- water-salt balances in rice culture for saving in irrigation water and salt buildup.				X	X	X	X	X		
5. Evaluate the performance of new rice cultivars developed in Kazakhstan and Russian Federation				X	X	X	X	X		
6. Calibration and use of Optical crop canopy sensors (GreenSeekers) for measuring crop development, comparing crop management practices for SLM and efficient nitrogen management				X	X	X	X	X		
7. Evaluate the performance of different trees, shrubs, grasses and fodder crops in submontane plains, sand massifs, and sands in Abylai area.	X	X	X	X	X	X	X	X		
8.Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options			X	X	X	X	X	X		

Activity 3.1 Evaluate the current status of land degradation in irrigated lands of "Kaptagay" farm in Shielli , Kazakhstan.

Sustainable Land Management of the country is such a development when the requirements of the present generation are satisfied but the opportunities of the next generations to satisfy their requirements are not threatened. For the Republic of Kazakhstan shifting to sustainable land management is the vital necessity. The economy growth at the expense of exploitation of natural resources can occur only at particular stage. In modern conditions for the development and the growth more progressive mechanisms are required.

Productivity of irrigated lands of Kazakhstan is 4-6 times higher than that of the rainfed lands. Occupying around 6% of the cropped territory, they contribute over 30% of country's

gross agricultural produce. However, extensive irrigation in the river valleys without sufficient scientific foundation has led to non-sustainable usage of water resources – salinization and water logging and desertification at the same time, and inefficient agricultural production. Out of 1.6 million ha of irrigated cropland, only 468.3 thousand hectares are covered by the drainage network (Diussembekov, 1998). In Kyzyl-orda region alone 58.8 thousand ha or over 20% of improved land are not used (Zubairov, 2002). In Almata region, the area of the rice massifs comes to over 5.0 thousand ha (Tolepbaev, 2002). The disturbance of earlier rice-alfalfa crop rotations area of alfalfa-the main preceding crop of rice, has decreased drastically. Humus content in the soil of Akdalinskiy massif of rice growing has decreased by 19.3-24.7% in comparison with initial conditions (Otarov, Ibraeva, 2007). And in the soil of old irrigated rice massifs of Kyzyl-Orda region the loss of humus is around 30-40 % in last 30 years. At present on 60% of arable land area, humus content is less than 1 % (Zubairov, 2002). By means of research it is established, that in non-favourable ecological conditions, the loss of the available water soluble humus form reaches 12-36 % (Otarov, Ibraeva, 2007).

Low fertility of the soils often result in deficiency of even the major nutrients. While in 1986, farmers used 1919 thousand tons of mineral fertilizers in the republic, but only 28.7 thousand tons was applied on the crop of 1996, which signifies a stable declining tendency in the content of mineral and organic nutrients (Yeleshev, 1998). This contributed to further aggravation of the long-existing problem of soil fertility. The reduction of irrigated lands area due to soil cover degradation also causes alarm. While in the late 1997 the area of irrigated lands was 1.6 million hectares, by the end of 1998 it reduced by 161.3 thousand hectares (Diusembekov, 1998).At the present time, the relevance of these issues is particularly high in the salinized deltal and old deltal alluvial plains of the Aral Sea basin and Balkhash Lake.

In the major rice-growing region of Kazakhstan – Kyzyl-Orda, where irrigated lands are salinized to a variable extent, over 80 % of rice crop area is occupied with the varieties, released 20-30 years ago. These varieties (Marjan and Kuban 3) are mostly adapted to local soil-climate conditions but are susceptible to biotic stresses. The productivity losses in agricultural crops has led to reduction in share of agriculture in the Gross Domestic Product (GDP) from 34% in 1990 to 8% in 2000 (Conception ….2005). Above description of the irrigated croplands of southern and south-eastern Kazakhstan suggest that land degradation is hampering socio-economic development of the whole region therefore the study was conducted to assess the status of soil degradation.

Activity 3.2. Evaluation of existing condition of degradation of soils on irrigated territory of Kaptagai farm, Shieli

Main aim of research was to evaluate existing condition of land degradation in the massif and developing a list of activities for their reclamation and sustainable management of land resources. For implementation of this work, in fall 2007, a salinity survey was conducted to map saline soils (Figure 3.1) and in ambience MapInfo professional is formed corresponding to card (Figure 3.2).

Figure 3.1 – Studies on land degradation in Kaptagai.

As a result of surveys it has been identified that on "Kaptagai" farm almost all soils have some salinity problems. A large area (88.5%) is affected by secondary salinization (Figure 3.3) (Table 3.1).

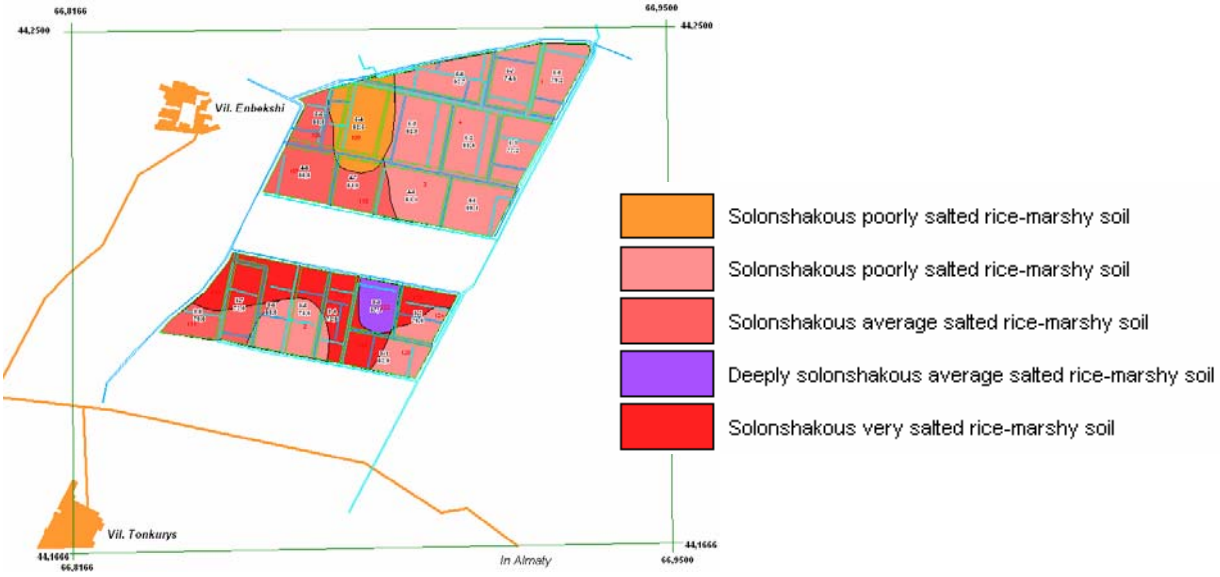


Figure 3.2 – Soil salinity map of "Kaptagai and K" company

Table 3.1 Distribution of salt –affected soil in Kaptagai

Soil a contour	Salinity affected area and Percentage (%)	
	Area, ha	(%)
Solonchak mildly salted	998.0	54.5
Solonchak medium salted	312.0	17.0
Solonchak highly salted	311.0	17.0
Solonchakous mildly salted	155.0	8.5
Deeply solonchakous medium salted	55.0	3.0
Total	1831.0	100.0

As a result of conducted evaluation of existing condition of level and chemical features of saline soils and depth of saline horizon on the territory of "Kaptagai" farm the critical territories on soil salinization have been identified. Such territories are edges of all fields of 3-d rotation adjoining to collector that takes drainage waters of 3-d and 4th rotations. It shows that technical condition of this collector doesn't fit with project norms i.e. collector angles are bloated, brake depth and cutting don't provide flow of drainage waters. As a result the lifting of the level of ground waters to critical point and soil salinization takes place.

But average salted soils occupy the area 7-go and 8-go flap 4-go crop rotation and 5-go field 5-go crop rotation. On these floor also necessary to conduct the melioration of the action, on-ruled on reduction water table on desalinization and increasing of the fertility of soils. Developing a final soil-reclamation map with appropriate activities on improvement of reclamation condition of soils is closely linked with these hydro-geological data.

Activity 3.2.1 Evaluation of humus condition and availability of basic nutrient elements in soils on irrigated lands of Kaptagai farm, Shieli

Main aim of research was to evaluate the current status of humus in soils and availability with main nutrition elements. For implementation of this work in fall 2007 on the territory of the research object agro chemical shooting on the area 712.0 ha has been conducted and appropriate cartographic maps have been developed.

According to the results of agro chemical investigation the soil of this farm can be classified as a category of very exhausted and degraded soils. Soils of all investigated territory have low humus content and K" company on 42% of the area and very low on 95.8% of area (Table 3.2) (Figure 3.3).

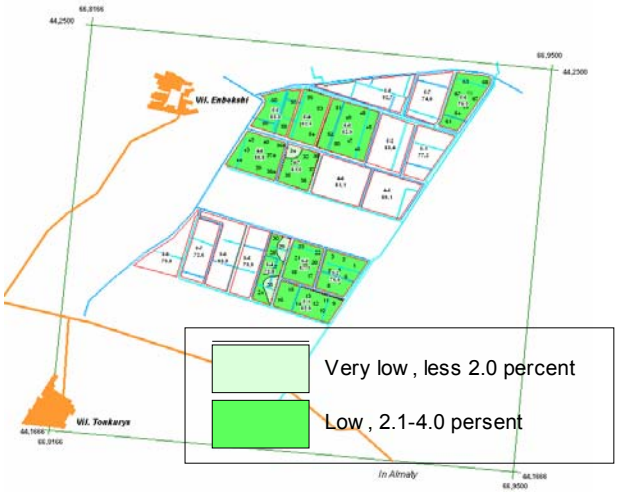


Figure 3.3 – Soil fertility map of "Kaptagai and K" company

Table 3.2 Soil organic matter status of Kaptagai site

Groups	The categories of humus content	Humus (SOM) content, %	Area, ha	% from the total area
1	Very low	< 2.0	682.0	95.8
2	Low	2.1 – 4.0	30.0	4.2
3	Mean	4.1 – 6.0	-	-
4	Raised	6.1 – 8.0	-	-
5	High	> 8.0	-	-
Total	-	-	712.0	100.0

Figure 3.4 Map showing availability of easy hydrolyzed forms of nitrogen N (mg/kg) in Kaptagai soils

Soils of this farm also are very exhausted and one of the main nutrition elements of easy hydrolyzed form of nitrogen are insufficient. According to nitrogen content almost whole investigated farm territory (98.5%) belongs to very low grade (Table 3.3). Soils with higher nitrogen content are missing.

Table 3.3 – Nitrogen availability status in the Kaptagay soils

No groups	the substance of nitrogen	Nitrogen, mg/kg	Area, ha	% from the areas
1	Very low	100	702.0	98.5
2	Low	101 – 150	10.0	1.5
3	Mean	151 – 200	-	-
4	Raised	200	-	-
Total	-	-	712.0	100.0

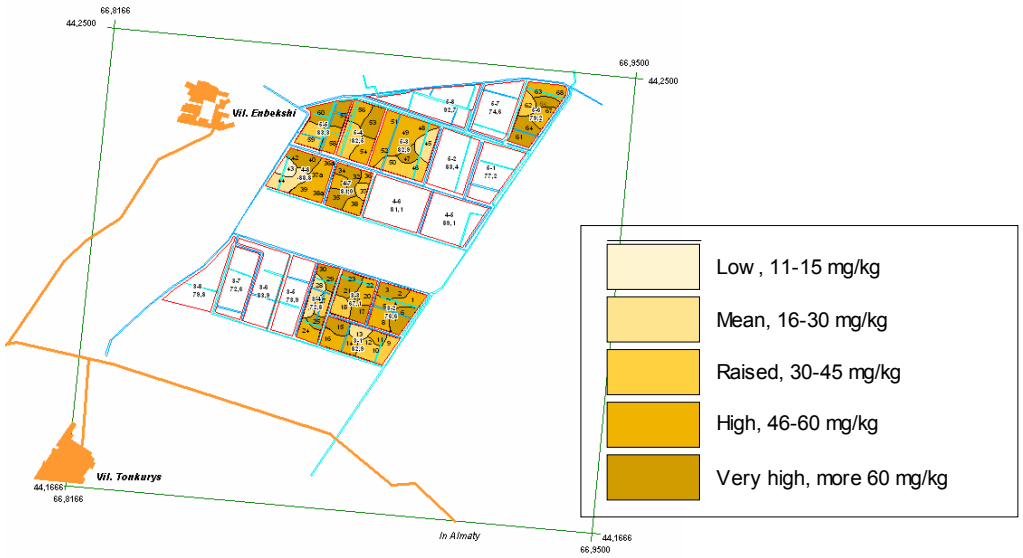


Figure 3.5 – Map showing distribution of available P in “Kaptagai” soils.

As we can see from data of Table 3.4 in the soils of investigated farm territory, phosphorus availability are very diverse and have all groups on mobile phosphorus: very low, low, average, increased, high and very high level. For getting high yield 45.2% of areas need application of phosphorus fertilizers. Also it is necessary to note that such high range requires even foundation except for phosphorus availability for the plants.

Table 3.4 Available P status contents of the Kaptagai soils

Group	Available P categories	P_2O_5, mg/kg soils	Area, ha	% from the areas
1	Very low	< 10	-	-
2	Low	11-15	10.0	1.4
3	Mean	16-30	60.0	8.4
4	Raised	31-45	252.0	35.4
5	High	46-60	280.0	39.4
6	Very high	> 60	110.0	15.4
Total			712.0	100.0

Figure 3.6 – Map showing available exchange potassium K status in Kaptagai soils

Potassium reserve of investigated soils is also very diverse, more 90% of the area of investigated soils have average and increased level of availability (Table 3.5). Alongside with this there are soils with both low and high level of potassium.

Table 3.5 Status of exchange potassium in Kaptagai soils

Groups	The potassium content	K_2O, mg/kg	Area, ha	% from the areas
1	Very low	< 100	-	-
2	Low	101 – 200	50.0	7.0
3	Mean	201 – 300	350.0	49.2
4	Raised	301 – 400	292.0	41.0
5	High	401 – 600	20.0	2.8
6	Very high	> 600	-	-
Total		-	712.0	100.0

Figure 3.7 – Map showing alkalinity problems (soil pH) in Kaptagai soils

Soil reaction is one of the important factors of soil formation processes and has significant impact on growth and development of plants and soil microorganisms, speed and direction of chemical, physical-chemical and biological processes and also determines the efficiency of fertilizers application. Data in Table 3.5 indicate that soils are alkaline to strongly alkali in their reaction. High soil pH is invariably associated with high exchangeable Na^+ which reduces the permeability of the soil water, increases mechanical resistance to root penetration adversely affecting growth of plants, sensitive to sodicity/ salinity.

Detailed soil survey report on the physical-chemical properties of the Kaptagay soils titled as "Sustainable management of irrigated land resources in Republic of Kazakhstan" has been passed on to the farmers in the beginning of spring 2008 to implement the salt test based fertililiser recommendations.

Activity 3.3. Studies on the effect of irrigation schedules on rice yield, saving in irrigation water and salinity of the ponded waters and soil profile. Direct seeded rice technology.

Rice is an important crop generally cultivated in irrigated lands of SyrDarya river basin. It significantly contributes to economy of Kyzylorda oblast. Annually rice is planted in more than 70 thousands ha of the total 175 thousands ha of irrigated lands. The objective of the trial was to develop and test DSR Technology to economize on irrigation water to prevent waterlogging and secondary salinization and to reduce the costs of rice cultivation. Traditional agronomic and crop management practices had resulted in excessive use of

irrigation water in rice cultivation causing land degradation due to waterlogging and salinity. In “Kaptagai” rice systems cover nearly 9200ha out of the total area 33407 ha. Perennial herbs of alfalfa, corn, wheat, watermelon, melon, potato occupy the rest of the area.

The research was conducted on the rice systems on “Kaptagai” farms. The climate is sharply continental, with average temperatures during rice (May-September) ranging from 22-32 C, Precipitation is 220mm a year. Soils are loam to fine loam, with bulk density ranging from 1.44-1.53 g/cm^3 , soil porosity (47-58%) and have infiltration rate between 0.014-0.02 m/day. Groundwater in autumn-winter period is at a depth between 300-350 cm, in the summer irrigation cycle of rice season water table is within surface 2 cm. In alfalfa fields water table is generally at a depth of 100-150cm. The land is heavily salinized with sulfate-chloride type salinity in surface -10 cm soil layer.

An experiment was initiated on 28 ha area in April 2008 after field preparation (plowing, 18-20 cm. depth, disking and leveling) and mineral fertilizing of the field – 3 quintals per ha. Marjan rice variety was seeded on 10-12 May and fields were flooded with water to a depth of 10-15 cm. To study the optimal methods of water management in rice, five weirs Chipoletti (photo 3.1,3.2) were installed on the experimental field to measure water level in rice field. Two water dumps and two piezometers were also installed to monitor salinity of the drainage water and the groundwater table. Evaporation, infiltration and evapotranspiration during the vegetative period are also being monitored at the experimental site.

Treatments included two irrigation regimes beside a traditional irrigation method as control.

- Short flooding- in the period of rice growing till 2-3 leaves periodic flooding is conducted (moistening of the soil with water to full saturation), then the permanent water layer of 5 to 15 cm. is created on the field depending on crop growth stages.
- Permanent flooding – the water layer of 5 to 15 sm., depending on the vegetative phase of crop, is created starting from planting to ripening stage.

Measurements on water are taken daily in the experimental field.

Photo 3.1 Weir Chipoletti, the wooden part of the shield is buried in a ground.

Photo 3.2 Installed weir Chipoletti behind the water dumping concrete anchorage to prevent water erosion.

Results presented in Table 3.7 indicate that rice was grown on 9200 ha in Shieliisk district in 2007 year. Average rice yield was 4.37 t/ha, irrigation norm was 23.62 thousands m^3/ha, water consumption per 1 ton of rice was 5405 m^3. The water consumption for other crops is given in (Table 3.6)

Table 3.6 Irrigation norms and crop yield on irrigated lands of Shieliisk district in 2007 year.

Name of the crop	Irrigated area, ha	Irrigation norms, thousands m^3/ha	Average yield, t/ha	Water productivity, m^3/t
Rice	9200	23.62	4.37	5405
Alfalfa (previous years)	4050	2.15	3.5	610
Alfalfa (current years)	2360	2.05	0.07	2920
Corn	190	4.11	3.3	1240
Grain	2700	2.6	1.5	1740
Vegetables	810	10.3	15	680
(water-) melon plantation	1470	10.05	15.2	690
Potato	1340	9.95	13	760
Household plots	1810	13.64	-	-
District	23930	11.96	-	-

The irrigated sown area of “Kaptagai” farm in 2008 year constitutes 1817 ha, rice – 820 ha, alfalfa – 693 ha, watermelon, melon, potato – 4 ha. Irrigation of the crops started in April month. Water supply for the rice field in April was 1910, in May 3470, in June 4100 m^3/ha, for alfalfa of previous years 620, 1120 and 1190 m^3/ha accordingly; alfalfa of current year 390, 890, 1050 m^3/ha. (Table 3.7)

Table 3.7 Irrigation area, volume of water supply and irrigation norms for crops at the experimental site "Kaptagai" in 2008 year.

Name of the crop	Area, Ha	Volume of water supply, mln.m^3			Irrigation norm, m^3/ha		
		April	May	June	April	May	June
Rice	820	1566	2845	3362	1910	3470	4100
Alfalfa (previous years)	393	244	441	468	620	1120	1190
Alfalfa (current years)	300	117	267	315	390	890	1050
Grain	300	-	150	210	-	500	700
Vegetables & (water-)melons	4	30	47	52	742	1187	1311
Total	1817	2689	5015	7232	1480	2760	3980

The water supply on the experimental field of KazNau institute, 28 hectares of rice was 1620 m^3/ha in the first decade (10days) of May, in the second decade – 2007 m^3/ha, and in the third decade – 1761 m^3/ha. In June due to decrease of the water scarcity at tillering, irrigation norm was decreased to 481 m^3/ha. The water supply on alfalfa fields changed from 337 to 415 m^3/ha during May-June months. The water dump level on the rice fields in May month is between 135 to 362 m^3/ha. (photo 3.3, Table 3.8) .

Table 3.8 The water supply and consumption on the experimental fields of LLP "Kaptagai".

Months	Decades (10 days)	Fields watercourse			Water dump		
		Water flows m^3/s	Water supply volume, m^3	m^3/ha	Water flows, m^3/s	Water dump volume m^3	m^3/ha
May	1	0.406	350784	1620.4	0.033	28512	135.7
	2	0.488	421632	2007.7	0.042	36288	172.8
	3	0.428	369792	1761.0	0.051	44064	209.8
June	1	0.260	224640	1070.0	0.088	76032	362.0
	2	0.117	101088	481.3	0.056	48384	230.4

Photo 3.3 Wwater consumption measurement in the canal by GR-21M rotator flow meter.

Water supply to rice planted traditionally was 9480 m^3/ha and in the improved irrigation regime variants till end of June were 8838-8267 m^3/ha for permanent flooding, 7594-7698

m^3/ha for short flooding. (Table 3.9). Data in Table 3.10 indicate that water requirement for rice cultivation can be reduced up to 15%. Large volumes of water supply to commercial traditional rice crop is only causing unjustified water dumps from the rice fields leading to congestion of the drainage networks. The results also indicate that water conveyance losses in the channels and water course vary between 7-19% in different irrigated sections. Flooding of rice fields is also causing mineralization of the irrigation water supplies.

Whereas the salinity of the irrigation water was 1.037 g/l, the salt load of water in drainage channel and collector water was 3.260 and 3.001 g/l, respectively.

Table 3.9 Water supply for rice irrigation on the experimental and industrial fields of LLP "Kaptagai" in 2008.

Irrigation regime	Rice area, ha	April m^3/ha	May m^3/ha	June m^3/ha	Total m^3/ha	changes Δ ±	Water supply coeff.
Rice irrigation regime on the industrial sowings of LLP "Kaptagai" (Traditional)	820	1910	3470	4100	9480	—	1
Rice irrigation regime on the experimental field of 28 ha	Map 44, rice field area 3,1 ha,dump1	—	4173	4665	8838	-642	0.93
Permanent flooding	Map 39, rice field area 2 ha, dump3	—	3991	4276	8267	-1213	0.87
Short flooding	Map 42, rice field area 4,3 ha, dump2	—	3447	4147	7594	-1886	0.80
	Map 38, rice field area 3 ha, dump4	—	3810	3888	7698	-1782	0.81

Activity 3.4 Investigations of the impact of various boundary conditions on water-salt balance on growing rice for conservation of irrigation water and reduction of salt accumulation

Research was conducted to study the impact of irrigation regimes on soil salinity development. For detailed analyses a 28 ha field was selected. For this purpose in spring 2008, soil salinity survey was conducted on 1:2000 scale and initial salinity map was developed (Figure 3.8). It was found that a large area of experimental plot (80.7%) field "Kaptagai" farm. Research was affected by salinity to different level (Figure 3.8, 3d; Table 3.10). Typically, surface layers had higher salinity, which decreased with soil depth. Such salinity profiles are typical of secondary salinization. On this 28ha plot seasonal dynamics and salt –water balance study was initiated to assess salinization rates from the ground water table and also from the applied irrigation water (to compute concentration factor – how ET concentrates salt solutions under prevailing climatic conditions in soils). The study was

considered important for developing appropriate recommendations for sustainable land management .

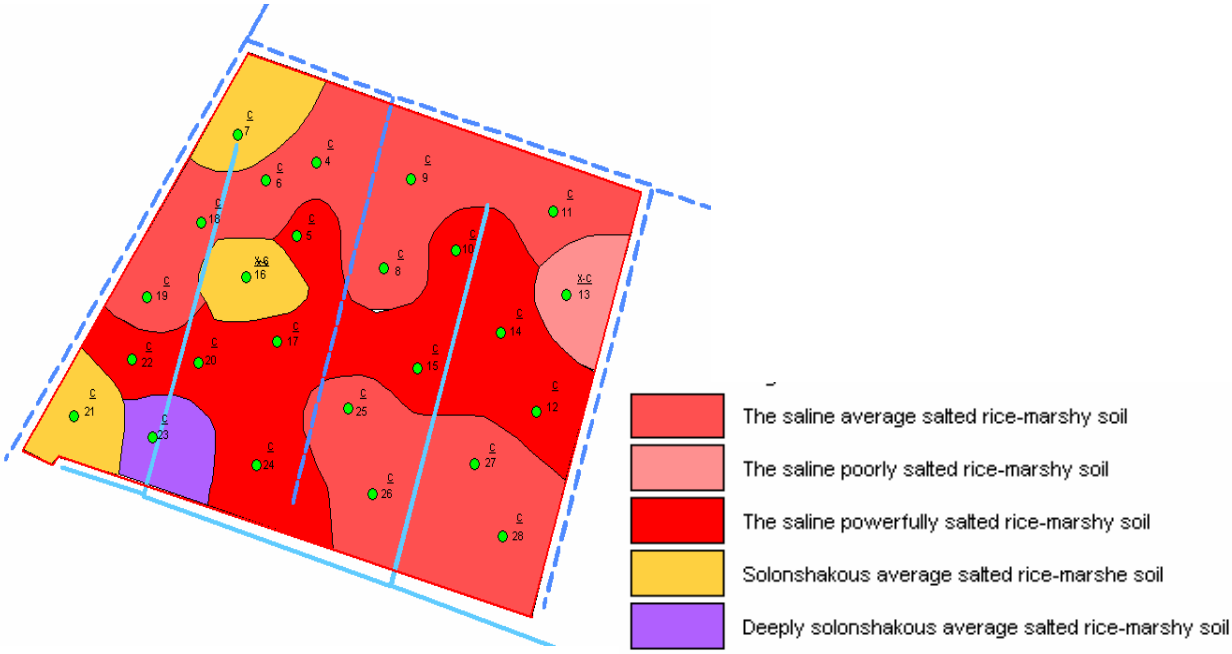


Figure 3.8 Detailed soil salinity map (1;2000 scale) of plot 3d (28ha size) in Kaptagai farms

Table 3.10 The areas salted soils of an experimental plot

Soil of contour	Area	
	ha	%
Saline poorly salted	1.1	3.9
Saline average salted	13	45.8
Saline very salted	9.9	34.9
Solonshakous poorly salted	3.3	11.5
Deeply solonshakous average salted	1.1	3.9
Total	28.4	100.0

Activity 3.4.1 Production costs of traditional rice culture

The production costs of the traditional rice crop was studied and the break up of the products are given in Figure 3.9

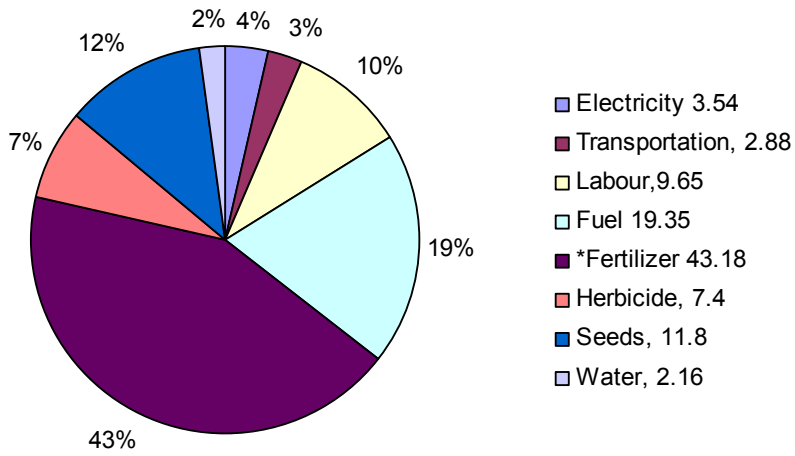


Figure 3.9 Break up production costs of traditional rice culture in Kyzylorda

Results brings out that tillage (labor, fuel), seed and fertilizer costs constitute about 29.11 and 43 percent, respectively. High fertilizer costs seems mainly due to aerial application methods and scarcity of the fertilizer nutrients. With DSR rice technology there are significant opportunities to reduce tillage costs and to save costly seeds.

Summary of the results -conclusions

Based on the research conducted in 2007-2008 years on the topic "Management of land and water resources of the degraded irrigated lands Kaptagai farm the following inferences can easily be deduced.

1. Rice cultivation, in farms Kaptagai farm irrigation norms are higher than those prescribed and lower for the other crops. It is observed that excessive irrigation in rice fields in two consequent years brings the water table closer to surface, which significantly contributes to meet the water requirements of the other crops grown in rice based systems.
2. Over use of irrigation water in "Kaptagai" farms result in secondary salinity, and has degraded more than 25%s lands due to poorly maintained drainage canals allowing the groundwater level to rise. Effective use of land and water resources on the irrigation systems of Kyzylorda oblast can be attained only as a result of the water saving technology introduction, effective work of the drainage system and maintenance service.
3. Rice sowing farms of Shieliisk district had rice irrigation norm in 2007 year 23620 m^3/ha, 4.73 t/ha rice yield, water consumption 5405 m^3/t. Water supply on the rice fields of Kaptagai farm before July 2008 constituted 9480 m^3/ha, on researched variants of irrigation- short flooding 7594 to 7698 m^3/ha, permanent flooding 8838 to 8267 m^3/ha. Water saving during the irrigation period was nearly 15%. Conveyance losses of water in channel/water courses varied up to 20% .

4. On rice irrigation system of Kyzylorda irrigation array drainage is performed in form of open earth channels with a depth from 1.5 to 3 meters. A group of primary drains, collecting drains and drum creates collecting drum-drainage network, ameliorative effectiveness of which due to several specific reasons is not satisfactory. Deterioration of ameliorative effect of the irrigated land appears due to the fact that channel back slopes are slipping, canal section is deformed, canals are silting and overgrown by grass, depth of the open drains and collecting drums is decreasing what results in increased level of ground water and salinity of irrigated lands. Crop yield data will become available on harvest at the end of September 2008.

Activity 3.5. Evaluate the performance of new rice cultivars developed in Kazakhstan and by the Russian Federation

In Kyzylorda area of Kazakhstan where irrigated rice is grown, many fields have become salinized within a short span of 2 decades. The Marjan and Kuban 3 rice varieties are adapted to local agro-climatic conditions. These cultivars are not stable especially against fungal diseases. Therefore, the present investigation was taken up to screen short duration cultivars which meet international standards of grain quality, require less water, tolerant to salinity and have high genetic yield potential. In Kyzylorda farmer grow cultivars differing in maturity group, early group matures in 85-90 days (variety- Ary). Cultivars Aral-202 and Madina mature in 110-120 days. Prospective varieties Togusken-1 and Aral-4 are not catching up because of weak seed system. A total of eight cultivars including those from the Russian Federation were evaluated in a field experiment for their yield, grain quality and input use efficiency. The trial is in progress on Kaptagai farm in Shieliyskyi rayon in Kyzylorda province. The experiment in progress was conducted together with Incorporated Open Company "Kaptagai" in Shieliyskyi rayon in Kyzylorda province who provided a plant growth substance developed as by-product of the coal industry.

Before dry seeding of rice, field was plowed to a depth of 22-24 cm. Fertilizer nutrients (sulfate of ammonium - 300 kg/hectares, ammophos with the contents of nitrogen-11 % and phosphorus - 44 % of 100 kg/hectares) were applied after two harrows. Crop was seeded in dry soil and rolled with a light roller and irrigated on May, 10-12, 2008. Eight varieties of rice- 4 from Kazakhstan (Marjan, Aral 202, Ary and Togusken 1) and 4 from Russian Fedration (Novator, Leader, Rapan and Ayntar -Amber) were line-planted in (5 m x 10m) plot, replicated thrice. Seeding rate was 7.5 million of germinating seed grains/ha. Post-emergence herbicide- Gulliver was applied at the dose of 25 g/ha to control weeds.

Results – crop is in vegetative phase (crop is in field)

Table 3.11 Density of standing of plants of varieties during full shoots

Rice Cultivars	The Origin	Number of Rice Seedlings	
		Nos/ m^2	% germinations of seeds
Marjan– St.	Kazakhstan	103	13.7
Aral 202	Kazakhstan	89	11.9
Ary	Kazakhstan	30	4.0
Togusken 1	Kazakhstan	3	0.4
Novator	Russia	10	1.3
Lider	Russia	41	5.5
Rapan	Russia	40	5.3
Ayntar	Russia	66	8.8

It was observed that manual seeding increased the seeding depth and resulted in reduced plant density of rice. Field germination of all the rice cultivars was very low ranging between 0.4-13.7 %. However, germination counts were higher for the Kazakhstan varieties: Marjan (13.7 %) and Aral 202 (11.9 %). Russian variety Ayntar (8.8 %) had relatively a little more germination.

It may be mentioned here that low germination count in cultivars under a deep layer of water, is a desirable trait of seeds- feature required for knocking down weeds by submergence. The trait facilitate Yield stability against weeds which otherwise can easily reduce crop yields. The experiment is in progress and yield data will be available in September/October, 2008.

Tillage requirements for rice cultivation

In order to benefits the farmers, it is crucial that either (i) crops yields are improved, and or (ii) production costs are reduced. The later can be achieved through establishment of the rice crop under conditions of reduced or minimal tillage. In the traditional method of rice crop establishment, field preparations (Tillage costs) constitute almost close to 30% of the total production costs. Conservation agriculture platforms such as surface seeding and zero-tillage and residue management can reduce the later costs substantially. In order to evaluate this, a field experiment was conducted.

1. **Traditional planting method** of rice: Spring plowing to a depth of 22-24 cm followed by disking + roll up ridge skating rolls, a few times to remove grass/ Alfa Alfa **(control).**
2. **Reduced tillage (A)** by disking + roll up ridge skating rolls - **is reduced tillage (no spring plowing)**
3. **Reduced tillage (B) by** harrows + roll up ridge skating rolls - **second variant of (A)**

The field experiment was laid out in «Kaptagai» where the previous crop was two-year-old lucerne with low plant density because of salinity problems. Disking was not possible because of non-availability disk harrows. Attempt was made to prepare the field for rice seeding with reduced tillage without plowing by a rotary till machine (Italian) in presence of the residues of the Lucerne (alfalfa). Rice crop was seeded direct in dry soil in a 2 hectare field with minimal soil disturbance using a multi-crop Indian zero till/ raised bed planting machine.

The following treatments were established:

1. Zero till dry seeding of rice in undisturbed soil.
2. Dry seeding in a reduced till field.

The field plot was highly salinised with salt encrustations on the surface. Before crop planting, soil was fertilized with 300 kg/hectares of sulfate of ammonium and 100 kg/hectares ammophos. Crop was seeded on May, 11 and field was flooded on May, 13, 2008. Unfortunately, surface salt encrustation could not be flushed out of the field which led to poor germination of the rice. Presence of the brown coloration of the in standing water was indicative of the solonetzic nature of the soluble salts – dissolution of the organic matter in alkaline water. The learning was that alkali soluble salts must be flushed out of the fields (surface washing) before ponding with fresh water. In absence of initial surface washing of salts, replacement of 'brownish water' 4 times, did not help. Intensive processes of decomposition of organic substances of lucerne under anaerobic conditions led to production of hydrogen sulphide, which also caused high mortality. The experiment will be repeated in 2009 in presence of residues of the previous crops (rice / wheat etc.).

Experiment on Seed Rate of direct dry seeded rice on beds

Traditionally farmer plant rice by broadcasting as much 250 Kg/ ha of rice seed on the flat surface and mixing it by using a nail-board. A non-saline field was chosen for the purpose. Field was plowed and fertilizers were applied as basal (sulfate of ammonium - 300 kg/hectares in physical weight, ammophos with the contents of nitrogen-11 % and phosphorus - 44 % of 100 kg/hectares). Nail board was used to level the field and to remove the stubbles of the previous alfalfa crop.
Rice cultivar – Marjan was seeded in raised bed –furrow system using a multicrop zerotill/ raised bed planting machine of Indian make on May 12, 08. The treatment included the following:

1. Raised bed planting- 4 Rows on 90cm width with 18-20cm crest, distance between lines was 20 cm, norm of seeding of seeds - 90 kg/hectares.
2. The same as above , norm of seeding @ 110 kg/hectares
3. The same as above , norm of seeding @ 130 kg/hectares
4. The same as above , norm of seeding @ 150 kg/hectares.
5. Traditional Planting: norm of seeding of 250 kg/hectares - the control.

The crop was planted in reduced till plots. During vegetation period, crop phenology data was collected on plant density and weeds: Phragmites communis Trin, Echinochloa and Bolboschoenus. Post-emergence herbicide Gulliver @ 25 g/ha was used to control weeds. During germination period, weeds were controlled by submergence to a depth of (at crest) no more than 3-5 cm. As rice plants emerged and put up growth, depth of water was increased upto10-12 cm.

Data on plant attributes and weeds etc is presented in table (3.12). Plant density of on the raised beds with different seeding rates ranged from 130 to 70 plants / m^2. Distinctions between variants on density of standing of plants are statistically significant at 5 % and 1 % level.

Table 3.12 Plant density of rice and of weeds as affected by varying seed rates, 2008

Variants of experience	Quantity of plants of rice and weeds, No/m^2				
		Phragmites communis	Bolbosc·hoenus	Echino-chloa	всего
Crop of seeds by grain seeder of spread way with norm of seeding of 250 kg/hectares - the control	178.20[x]	8.0	-	13.30	21.30
Crop on the raised bed with norm of seeding of 90 kg/hectares	70.70[x]	-	-	13.30	13.30
Crop on the raised bed with norm of seeding of 110 kg/hectares	126.20	-	-	11.10	11.10
Crop on the raised bed with norm of seeding of 130 kg/hectares	130.20	28.90	1.80	20.90	51.60
Crop on the raised bed with norm of seeding of 150 kg/hectares	79.10[x]	4.90	-	104.90	109.80
LSD at $_{05\%}$	37.86				

The seed test weight of *Marjan equals 33 g ;* *Plants with only 25% germination

On the control plot (250 kg/hectares) the plant density was 178.2 plants/m^2. Highest germination was observed at seed rate of 110 kg/ha (38.2 %) and 130 kg/ha (33.4 %). Rather

low germination of seeds was observed in variants with seeding norm of 90 kg/ha (19.1 %) and 150 kg/ha (17.5 %).
It was observed that weeds at norm of seeding of 90 kg/hectares (13,3 pieces/m^2) and 110 kg/hectares (11,1 pieces/m^2). Among weeds, Echinochloa and Phragmites communis were predominant and to a lesser extent Bolboschoenus. Weed population was little affected by seed rate. However weeds can be significantly reduced if the pre-emergence herbicide molecule such as 'Pendimethylene', followed by post-emergence molecule 'Gullivar' becomes available. It will also obviate the need for continuous submergence resulting in further saving of the fresh irrigation water supplies.

Use of regulators of growth for increase of productivity and quality of a crop of rice

Bio-regulators are used world over to improve plant vigor by accelerating the growth processes. These exogenous chemical substances stimulate germination of seeds, photosynthesis, solute transport, improve weight and the size of grain and also help stability to natural stresses. Several leading manufacturers (BAYER, BASF, etc.) are engaged in search of new, ecologically pure preparations for agricultural usage. In Kazakhstan such physiologically active chemical molecules are being synthesized in Institute of Chemical Sciences, and Karaganda Institute For Synthesis of Organic Molecules. Two such new molecules produced indigenously (MERS and Hymat sodium) were tested in a field trial conducted with rice as the test crop.

MERS is a preparation of a phytogenesis in which Cu and Zn are introduced. Whereas MERS of Almaty is developed by Open Company " Scientifically a production association " Ana Zher", the other molecule -Hymat sodium is a byproduct of coal wastes. The manufacturer is a Open Company " Coal synthesis ", Karaganda. Rice seeds were treated with preparations of MERS and Hymat sodium and planted in the in a experiment conducted on the "Kaptagai" farm, Chiiliyskyi rayon, Kyzylorda province.

Table 3.13 Rice plant density/m^2 as affected by treatment of the growth factors

PGS Treatment	Quantity of plants of rice and weeds, pieces/m^2					
	Frequency		Average	Phragmites communis Trin	Bolboschoenus	Echinochloa cruss-galli, Echinochloa phyllopogon
The control, over processing seeds by preparations	R1.	40	45.3	-	-	16
	R2.	60		-	-	20
	R3.	36		-	-	4
Seeds, processed by growth factor MERS	R1.	100	106.7	-	-	-
	R2.	140		-	-	8
	R3.	80		-	-	-
Seeds, processed by Hymat sodium	R1.	120	106.7	-	-	-
	R2.	80		-	-	-
	R3.	120		-	-	8
LSD at 0.05%	39.4					

The total experimental area was 16380 м^2. The three treatments were replicated thrice. Rice variety Marjan harvested on 5/11/2008 for the trial. The seed was treated with MERS @ 100 ml/hectares, diluted with 25 litres of water and it processed 250 kg of seeds of rice. Rice seed

were treated with Hymat sodium – 2.5 %, i.e. Hymat sodium dissolved 25 gram in 1 litre of water. The solution prepared in volume of 30 litres to treat 250 kg seeds of rice.

Results of calculation of plants of rice and weed plants show, that preparations MERS and Hymat sodium positively influenced seed germination quantity of shoots positively and at an identical level (106.7 pieces/m^2). It may be mentioned here that the plant population is sufficient to provide a grain yield of 7-8 ton/ ha. On a variant where seeds were not processed by preparations, plants density was statistically significantly less and was only 45.3 pieces/m^2 (42.5 % less than the treated seeds).

Preliminary conclusions of researches

1. The method of DSR rice cultivation on raised-beds using Indian planter has been unique in the sense that it allowed line seeding at lower seed rate varying from 90,110,130,150 Kg/ha with no loss in plant population per square meter. This will reduce the cost of precious seed and facilitate accelerated spread of newly released cultivars.
2. Number of plants per square meter were higher at seed rate of 110 and 130 kg/hectares (126, and 130,2 pieces/m^2 respectively) as against 45 plants / m^2 with control (250kg/ha). The planter thus greatly improves the plant stand.
3. Field germination of all rice cultivars (Russian and Kazakhstan varieties) was very low in general. However Kazakhstan varieties Marjan (13,7 %) and Aral 202 (11,9 %) and Russian variety Amber (8,8 %) performed better in field germination test. Low field germination of seeds is high-quality feature which shows stability of the given variety to a deep layer of water a practice used to control weeds.
4. Results show that seed treatment with MERS and Hymat sodium significantly improved germination of seeds of rice, plant density. crop stand.
5. The yield data will be available after harvest of the crop.

Activity 3.6 Calibration and use of the optical sensor "Green Seeker"

The experiment was initiated but due to some technical issues due to faulty operation of the software in IPAQ (Palm) computer, NDVI data could not be collected. Efforts are being made to reload the software and make the system fully operational. Pl see the combined report of the GS experiment on page of 111-115

Activity 3.7. Evaluate the performance of different trees, shrubs, grasses and fodder crops in submontane plains, sand massifs, and sands in Abylai area.

Abilay farm organized in 1993 allocated on the territory of Sarisuysk district in Jambilskaya rayon of the Republic of Kazakhstan. It has 3880 ha of lands, including 5.4 ha irrigated land and the rest (3800 ha) as pasture. There are 800 sheep and goats, 30 cows, 120 horses and 80 camels on the farm. The farmer has 2 MTZ-80, GAZ-53, 2 carriages, 1 raker, 1 field baler, 1 feed cutter. For implementation of the project SLM-R «Pastures management and fodder production» three sites were selected.

The first site (600 ha) is representative for foothill plain of Karatau mountain. The area of light serozem is about 30,000ha and administratively situated on the territory of Sarisuysk, Talassk districts and Jambilsk and Sozaks South-Kazakhstan regions. Climate is strongly continental. It is very dry and hot area according to agroclimatological zoning.

Second and third sites are representative of Moyinkum sands with the area of 5.2 million ha. This territory is administratively located in Sarisuysk, Talassk, Moyinkum district of Jambilsk and Sozaks South-Kazakhstan regions. These sites are in Moyinkum sands, 70 km from Janatas town. The area comes to 2300 ha. These sites have also very dry and hot agroclimatological conditions. The relief is hilly. According to the data of Baykadam and Kamkali-Kol weather station (table 3.14) annual precipitation amounts to 138-198 mm. The main part of precipitation falls in XI-VI months of the year. Average temperature of the hottest month (July) 25.8-27.2^0, the coldest month (January) -7.3-11.8^0. Effective temperatures amount is 3400-3900^0, depth of soil freezing is about 80 cm in winter months

Table 3.14 Average air temperature and average precipitation

Agroclimatic zone	Station	Parameters	Months												Year
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Very dry hot	Bayka-dam	Temperature , C^0	-7.3	-5	3	12	18	23	26	24	18	10	1	-5	9.8
		Precipitation, mm	14	16	26	29	24	16	6	4	5	19	22	17	198
	Kamkal Kol	Temperature, C^0	-12	-8	1	12	19	25	27	25	18	9	0	-7	9.1
		Precipitation, mm	10	12	22	22	20	15	5	3	2	8	12	8	139

Activity 3.7.1 Soil physical and chemical characteristics

Soils in the region are generally sandy sierozems, gray-brown and takyr-like soil. They are formed on the thin eluvial detritus loams. The depth of groundwater is 12-15 m. Overall these soils are low in humus content 0.5-1.1 % (Table 3.15) in top 50 cm layer. Carbonate content is 4.5-5.6% in topsoil, increasing gradually with the depth. Calcium predominates the exchange complex (86-100 %). Soil Ph water suspensions is alkaline to highly alkaline. The security of available phosphor is poor, K is medium to high. soil texture is pulverescent. Fractions of the size of 3 mm and larger are at the depth 150-160 cm – 4.6 %, and fractions 3-1 mm gathered on the horizon 45-55 cm – 43.4 %. The massifs of these soils are used as low-yielding pastures. As a result of overgrazing, these soils have been partially degraded.

The soils of second and third sites are in Moyinkum sands and characterized by low humus content 0.4% and total nitrogen 0.03 % in the shallow horizon, which is reducing notably with the depth (Table 3.17). Carbonate content is not high 2.5-45%. Reaction of water suspensions is from alkaline to high alkaline. The security of available phosphor is very poor, and K level is satisfactory. As one can see from the Table 3.19, fine-grained sand is 75.9-82.8 %, the share of thin fractions of the size of < 0.001 mm is 0.7-1.6 %, a < 0.01 2.2-5.5 %. Large massifs of desert sands are used as pastures. Earlier they were used as winter pastures. In recent years they are used almost round the year, causing sand deflation, especially near the wells and settlements. To prevent from further degradation of serozems and desert sands, it is crucial that

pasture rotations and reseeding of grass, semi-shrubs and shrubs is practiced.

Table 3.15 Chemical and physical-chemical properties of serozem light north

Depth (cm)	Organic matter (%)	Total N (%)	CaCO 3(%)	$CaCO_3$ (%)	Exchangeable cation, me/100 g soil					pH	Available (mg/100 g)	
					Ca″	Mg″	Total	%Ca	%Mg″		P_2O_5	K_2O
0-10	1.1	0.08	4.5	10.2	6.7	x	6.7	100	0	8.6	3.0	55.5
10-20	0.7	0.05	5.0	11.4	-5.0	0.8	5.8	86	14	8.4	1.2	46.1
25-35	0.6	0.04	5.6	12.7	5.0	-	5.0	100	0	8.6	0.8	45.0
45-55	0.6	0.04	6.9	15.7	-	-				8.6		
60-70	0.5	-	7.7	17.5	-	-				8.7		
90-100	-	-	7.9	18.0	-	-				8.7		
150-160	-	-	7.9	18.0	-	-				9.0		

Table 3.16 Granulometric and micro-aggregate composition of serozem light north soils

Depth (cm)	Hygroscopic water (%)	Percentage of particle with size (%)							
		> 3	3-1	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	< 0.001
0-10	1.4	-	-	-	10.8	37.3	5.8	12.6	17.7
10-20	1.8	0.4	-	-	13.7	32.8	7.3	10.6	18.7
45-55	1.8	1.2	43.4	-	4.4	19.9	2.8	6.6	10.7
90-100	1.8	-	0.1	-	21.7	24.5	5.0	9.2	14.9
150-160	1.4	4.6	2.0	0.1	9.5	37.9	5.8	8.8	13.2

Table 3.17 Chemical and physical-chemical properties of deserted sand soils

Depth (cm)	Org. matter (%)	Total N (%)	$CaCO_3$ (%)	Exchangeable cation (me/100 g of soil)			pH	Available (mg/100 g)	
				Ca″	Mg″	P_2O_5		P_2O_5	K_2O
0-5	0.4	0.03	6.4	2.1	x	2.1	8.7	2.5	14.2
5-15	0.3	0.02	5.7	2.1	x	2.1	8.7	1.5	16.2
25-35	0.2	0.07	10.1	6.0	x	6.0	9.0	-	25.2
50-60	0.1		7.1	0.3	x	0.3	8.6	-	-
110-120			7.1	-	-	-	9.2	-	-
200-210			10.1	-	-	-	9.3	-	-

Table 3.18 Granulometric and micro-aggregate composition of desert sand soils

Depth (cm)	Percentage of particle with size (%)							
	> 3	3-1	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	< 0.001
0-5	0.4	6.5	3.0	77.8	10.5	1.0	0.5	2.9
5-15	0.1	4.5	2.8	81.8	6.4	2.2	1.6	5.2
50-60	0.7	7.0	2.8	75.9	8.8	2.4	1.9	6.7
110-120	2.1	11.0	3.9	76.8	4.1	0.9	1.7	5.8
200-210	0.3	6.5	4.9	82.8	2.5	1.5	0.7	4.4

Activity 3.7.2 Seed collection missions

For reseeding the grasses, shrubs and semi-shrubs, seed collection missions were organized to Moiynkum and Kyzylkum as well as Karatau and West Tien Shan foothills. The seeds of the following species were collected: pastel, Agropyron fragile and karatau (perennial grasses), sainfoin fergansky and khoracansky, Kochia prostrata (subshrub) sandy and stony, Krascheninnikovia ceratoides (subshrub) and eversmannian, Salsola vermiculata, Camphorosma lessingii, Astragalus, Calligonum, Sherkez, Salsola richteri, saxaul. As well, the seeds of Atriplex and Haloxylon have been provided by ICARDA. The laboratory experiments for estimation seed attributes were established and given in Table 3.19.

Table 3.19 Seed test weight and seed viability of the arid zone species

Species	Seed Test weight , g/1000 seeds	Lab. Seed germination, %
1. Sameriaria boissieriana	22.20	96
2. Agropyron fragile	1.90	83
3. Agropyron cristatum	2.30	68
4. Onobrychis ferganica	14.90	93
5. Onobrychis chorazanica	11.20	87
6. Astragalus alopecias	10.20	94
7. Atriplex nummubria	8.70	82
8. Atriplex policarpa	2.30	98
9. Salsola vermiculata	4.50	14
10. Camphorosma lessingii	0.90	47
11. Kohia prostrata	2.10	66
12. Krascheninnikovia ceratoides	3.70	73
13. Krascheninnikovia eversmanniana	3.90	87
14. Salsola richteri	9.70	59
15. Halothamnus subapyllus	12.80	81
16. Calligonum kzyl-kumi	47.00	49
17. Calligonum aphyllum	21.80	27
18. Calligonum microcarpum	27.70	43
19. Calligonum eriopodum	40.00	61
20. Haloxylon aphyllum	5.40	23

In the Janatas desert, it was observed that natural vegetation included primarily three desert plants, namely Safora, Artemisia diffucia and Ceratocarpus erenarius. Farmers reported that during the summer season animals (from Janatas) are shifted for grazing to Bekbakdala region. During the winter season, livestock are maintained on stored hay. Usually the animals are provided with around 2.5 kg per day hay/animal/ day during the winter season which is barely sufficient for their survival. It was pointed out that farmer generally store 250-300kg hays for one animal for 3-4 winter months. Farmers were receptive about growing dual purpose wheat, barley, Triticale etc. to improve the fodder availability at least near the watering point. The area has a large water body near the experimental site where additional fodder can be grown but currently the lake water (fed by a canal) is not used for agricultural crop production. Farmers are installing new tubewells in the area to grow agricultural crops. Dual purpose winter wheat can substantially improve fodder and grain availability if grown over larger area to avoid bird damages. Farmer pointed out that winter wheat can be useful as winter fodder for horses because of their ability to remove snow cover over wheat plants during winter season. The reason receives 100-150mm of snow during winter season. Triticale could be an option as its seen growing very well in Kyzylkum desert (Uzbekistan) under almost similar ecology. To this argument the suggestion has been made to feed horses with the winter wheat and the portion of hay which is usually allocated for horses should be given to other animals as this strategy increases the portion of fodder consumed by each animal.

Farmer also informed that they are planning to install wind power station to use generated energy for pumping ground water. It appears that farmers can use a smaller diameter (10-12cm) tube instead or 20-25 cm dia pipe in tube installation. The smaller tube should be sufficient to pump water for irrigating 5-10ha field plots.

The SLMR experiments have been laid out at 3 sites to cover the variants as under:

(i) Flat uneven sandy range lands with no provision of external water supplies
(ii) Sloping sandy rangelands with no provision of water supplies.
(iii) Sandy rangelands with no provision of ground or surface water supplies.

In view of the above characteristics the technical program has been little different for each of the three experimental sites located in Janatas sand deserts. Natural vegetation included the Safora, Artemisia diffucia and Ceratocarpus erenarius.

Site situation (i) above, in addition to three above 3 fodder species, following exotic fats growing grass species have been introduced on the site after one disking to knockdown the natural vegetation to remove competition for water. The newly introduced species are in four strips, some 100-150m long and 5 m wide strips. The newly introduced species include the following in 4 strips (replicates) with species allocated in some random design. .

1. - Aellenia subaphylla,
   - Kochia prostrata,
   - Agropyron fragile,
   - Calligonum caput-medusae,
   - Calligonum Eriopodum
   - Eurotia ceratoides.
   - Salsola richteri (5 cm height).

   Besides the above following species were also planted

   1. Camphorosma lessingii
   2. Atriplex nummubria
   3. Atriplex policarpa

4. Salsola vermiculata
5. Kochia grey (stony) – Kochia prostrate var.canessens
6. Kochia grey K-118 – Kochia prostrate var.villossima
7. Kochia grey P-2 – Kochia prostrate var.villossima
8. Kochia grey P -28 – Kochia prostrate var.villossima
9. Kochia grey K -5 – Kochia prostrate var.villossima
10. Kochia grey – Kochia prostrate var.villossima
11. Kochia grey K -121 – Kochia prostrate var. villossima
12. Kochia grey K -822 – Kochia prostrate var. villossima
13. Kochia grey P -30 – Kochia prostrate var. villossima
14. Kochia grey K -131 – Kochia prostrate var. villossima
15. Kochia grey K -735 – Kochia prostrate var. villossima
16. Kochia grey K -831 – Kochia prostrate var. villossima
17. Kochia grey K -820 – Kochia prostrate var. villossima
18. Eurotia grey – Krascheninnikovia ceratoides
19. Krascheninnikovia eversmanniana
12. Shrubs and trees:
20. Salsola richteri
21. Halothamnus subapliyllus
22. Calligonum kzyl-kumi
23. Haloxylon aphyllum

Site situation (ii)

On the Second site- the problem is strong wind erosion. A small sand/ debris hillock is located away from where wind generally comes (leeward side). These 5 strips are nearly 5-6 m wide and 100-150 m long, located between the two small hillocks. These strips are planted with the same grass species as listed above to control sand drifts. The lay out was discussed with site coordinator and it was observed that in order to measure sand loads in the air, possibly the better thing would have been to place the strips parallel to the wind direction and then collect air borne materials in glass containers every 50 m distance from the distal end of the vegetation strip. Dr. Setkerim was of the opinion that the strip for such work should be 10 meter wide and join the the wind corridor with the leeward side hillock basement, The particulate material can be collected in vessels mounted on sticks of variable heights (depending on the plant canopy) to measure the wind blown material and isolate canopy effects if any to this area. Vessels could be 20-30 cm above the ground. When canopy / shrubs grow further, height can be increased by putting additional vessels.

On the second site following relatively-irrigated crops were included for fodder.

1st strip:
1 plot –safflower *[Cazthamus]* Nurlan
2 plot –safflower *[Cazthamus]*Akmay
3 plot – safflower *[Cazthamus]* HUVBC Tale
4 plot – safflower *[Cazthamus]* Ras-171
5 plot – safflower *[Cazthamus]*Br-25/R-2007
6 plot – millet *[Paicum miliaceum]*: J sms-7704, Jp-19581, Jp-22269, Jp-13150
2nd strip
1 plot –Maize *[Zea maus]*
2 plot –Alfalfa *[???]*
3 plot – Pea *[Pisum saficum]*
4 plot – Pea *[Pisum saficum]*
5 plot – Melon *[Melo orienfalis]*

6 plot – Water melon *[Citrullus vulgaris]*
Mixed species was as following: Sameriaria boissieriana + Onobrychis + Agropyron + Camphorosma + Kochia + Krascheninnikovia + Halothamnus + Calligonum.
At this site black saxaul *[Haloxylon sown]* was also sown.

Site Situation (III)

The third site area is very close to a watering point – a new tube well has been installed in an artisan aquifer to provide watering point for livestock and also use it for irrigation of high value crops. Farmers want to improve their livelihoods and resolve their fodder problems during the lean and harsh winter season.
The level of the water in the tube was just above the ground level (artisan situation). A preliminary field trials has been laid out near the tube well to explore possibilities of growing cereals, oilseeds and vegetable crops in the Janatas desert area. It was suggested that the strategy should be to double the productivity of the livestock by growing Triticale/ barley etc. and have the twin benefits of additional cereal grains and straws for the small and large ruminants to do away with the survival strategy which end up in very weak and fragile animals by end of the winter and at time high mortality particularly of the young ones. It was suggested to compare the benefits accruing from cereal-livestock system vis-a-vis sole vegetable system.

Third site included four strips with the following species:
1st strip and 2nd strip included mixed species: Sameriaria boissieriana + Onobrychis chorasanica + Agropyron + Kochia + Krascheninnikovia + Halothamnus + Calligonum.
3rd strip included 3 plots with the following: Aellenia, Agropyron, Kochia.
4th strip included 3 plots with the following: Salsola, Calligonum and Calligonum

The results of the trials are given in the table 3.20 below. Due to serious drought conditions in 2008, survival of the seedlings was low to very low. The trail will have to repeated in following winter/ spring .

Table 3.20 Plant density (plants/m^2) of halophytes species at Zhetykyrka and Bilal sites

Site	Species		Density, p./м^2			
			25.IV	8.V	22.V	30.VI
Zhetykyrka	Sameriaria boissieriana		71	-	-	-
	Onobrychis ferganica		29	2	-	-
	Onobrychis chorazanica		13	7	3	3
	Agropyron fragile		133	56	-	-
	Agropyron cristatum		150	31	-	-
	Astragalus alopecias		3	1	-	-
	Atriplex nummubria		43	21	-	-
	Atriplex policarpa		21	7	-	-
	Kohia prostrata subsp. grisea	БТ-1	48	33	23	12
	K-118		31	13	11	3
	P-2		57	18	10	3
	P-28		13	10	7	3
	K-5		36	11	9	2
	BT-6		29	17	13	7
	K-121		67	28	11	7
	K-822		43	14	8	2
	P-30		21	7	3	3

	K-131	23	11	7	3
	K-735	41	28	13	5
	K-831	36	21	17	3
	K-820	61	31	19	7
	Krascheninnikovia ceratoides	43	18	11	7
	Krascheninnikovia eversmanniana	34	24	13	5
	Salsola richteri	7	3	-	-
	Halothamnus subapyllus	21	13	7	4
	Onobrychis ferganica	37	18		
	Sameriaria boissieriana	28	-	-	-
	Onobrychis ferganica	21	13	-	-
	Agropyron cristatum	53	21	-	-
	Kohia prostrata	27	18	7	3
	Krascheninnikovia ceratoides	18	11	5	3
	Halothamnus subapyllus	13	5	3	1
	Calligonum aphyllum	7	-	-	-
Bilal	Kohia prostrata subsp.grisea	27	17	11	5
	Agropyron fragile	117	73	59	-
	Halothamnus subapiyllus	18	11	7	3
	Salsola richteri	7	3	1	1
	Calligonum microcarpum	4	2	2	1
	Calligonum eriopodum	7	5	2	2
	Sameriaria boissieriana	11	-	-	-
	Onobrychis chorazanica	5	2	-	-
	Agropyron fragile	31	18	-	-
	Kohia prostrata	23	10	3	3
	Krascheninnikovia eversmanniana	13	7	3	2
	Halothamnus subapyllus	17	8	5	2
	Calligonum aphyllum	13	7	2	1

Activity 3.8 Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options

Dissemination activity was not reported by the National Coordinator accept that all the field trials were conducted in farmer participatory modes.

4. Kyrgyzstan

SLMR WorkPlans for 2007-08 for Kyrgyzstan

Kyrgyzstan	Qr3	Qr 4	Qr 1	Qr 2	Qr 3	Qr 4	Qr 1	Qr 2	Indicators	Outcomes
1. Evaluation of performance of new cultivars (wheat / Barley) suited to different tillage systems for improved water productivity in shallow water table conditions.	X	X	X	X	X	X	X	X		
2. Study the effect of different herbicide molecules (pre-and post-emergence) on weeds dynamics, water productivity for increased farm incomes.	X	X	X	X	X	X	X	X	• √ Reports • √ Improved cultivars and seed availability • √Technologies on use of multi-quality waters • √Methodology for assessment of the agronomic and crop management interventions on growth and land quality Methodologies	• Institutions use the methodologies for comparative evaluations of the SLM interventions. • Farmer begin custom service and SMEs initiate agribusiness • Farmers use the improved truthful seed of the diversified crops.
3. Studies on the effect of controlled irrigation methods in improving crop -water productivity, and reduce irrigation-induced soil erosion.		X	X	X	X	X	X	X		
4. Effect of the conjunctive use of fresh and drainage water on crop yields and soil quality (salinity build-up).		X	X	X	X	X	X	X		
5. Evaluate the impact of laser-assisted precision land leveling on water savings, salinity and crop yields in irrigated agro-ecologies.				X	X	X	X	X		
6. Calibration and use of Optical crop canopy sensors (Green Seekers) for measuring crop development, comparing crop management practices for SLM and efficient nitrogen management.			X	X	X	X	X	X		
7. Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options			X	X	X	X	X	X		

Kyrgyzstan Research Activities

Kyrgyzstan has nearly 1.4 million ha of arable lands which is nearly 7 % of total geographical area of the country. Productivity of these lands (70% of them) depends on irrigation. Land degradation is a major issue- annually thousands of hectares of arable land are lost from crop production due to salinity, waterlogging, soil erosion and irrigation-induced erosion on slopes upto 0.07 and more. The ecological problems intensify due to the presence of the small farmer holdings (4-6 ha size; more than 200000). Experiments on land management were laid out in a farmer holding at "Daniyar" which is situated 30 km afar from Bishkek. Soils of the experimental site represent prairie gray heavy loamy soils with some secondary salinity problems. The climate of the zone is extreme continental with cold winters and dry hot summers. Average annual temperature of the air is +9.6 ^{o}C. The duration of the inter-frost period is 170 days. Late frosts are frequently recorded in this zone within first part of May as well as early decrease in temperature up to negative values in the second half of September. Annual precipitation is around 450 mm.

Daniyar is located within the Chuy valley and representing common problems that characterizes farmer holdings in this region. Soils in the area are normally managed by multiple tillage operations which lead to deterioration in physicochemical properties Water table is generally within 2.5-3.0 meters. In irrigation cycles and snow melting water table is generally within 0.7 meters of soil surface. The poor quality of the ground water / drainage waters is often low. Where ever water table is shallow farmers are unable to practice crop rotations because of technology gaps and non availability of appropriate machinery. Farmers are often constrained to use low quality seed material. It is for these reasons, field trials were conducted to resolve some of the problems facing the farmers and to raise crop productivity as per plans

Activity 4.1 Evaluation of performance of new cultivars (wheat / Barley) suited to different tillage systems for improved water productivity under fluctuating water table conditions.

In order to evaluate the performance of new winter wheat and barley cultivars a field experiment was conducted with 3 methods of planting and two cultivars of wheat and of barley. The planting methods comprised of :

1. Plantation into unprepared stubble (zero till).
2. Raised bed planting.
3. Farmer's practice – Traditionally tilled and planting using a high seed rate (upto 240Kg/ha)

Winter wheat varieties "Intensivnaya" and B) variety "Asyl" ,developed by Kyrgyz Research Institute of Agriculture were compared. Barley cultivar 'Manas' was compared for it yield with wheat cultivars.

A soil preparatory irrigation was applied from 5 to 15 September with the rate of 1120 m^2/ha. Soil was plowed to a depth of 25-28 cm on October 28, 2007. On the direct planting (planting into stubble) soil tillage was not conducted. Due to poor germination and inexperience of the tractor operator, winter wheat crop was replanted on October 30.

In spring season, winter crops received additional portion of ammonium nitrate in the rate of 60 kg of nitrogen per hectare. After winter the condition of the crops was good. However, due to the frosts that caused temperature to fall down till – 8 ^{o}C at the booting stage on April 17-18, 2008 adversely affected the plants. Replanting (in zero till) shortened the vegetation period by 27-29 days.

The plant density after seedling emergence, after winter season and the frost period in April is given in table 4.1. Plant density was high in broadcast method due to higher seed rate. During the winter season seedling/ plant mortality was observed up to 12 percent. The region experienced severe frosting in April which adversely affected the wheat and other crops. Dat in table 4.1 indicate frost caused some additional mortality to reduce the plant population. Zero till had maximum survival as the booting stage in wheat was delayed by a week which helped it escape frost injury.

Table 4.1 Winter crops plant density as affected by tillage methods

Periods	Plant density, plant/m^2 depending on tillage							
	Winter barley «Manas»		Winter wheat «Intensive»			Winter wheat «Asyl»		
	Broad Cast	Raised bed	Broad cast	Raised bed	Zero till	Broad cast	Raised bed	Zero till
After full sprouting	462	348	480	420	206*	456	384	189*
After wintering	412	324	462	395	184	402	366	175
Survival % after winter	89.2	93.1	96.2	94.0	89.3	88.2	95.3	92.6
Survival % after frost	59.7	73.4	70.8	68.8	85.8	65.6	69.9	81.1

Note: * plant density after replanting

Table 4.2 Population of weeds (plant/m^2)as on 25 June, 08 in winter season crops

Types of weeds	Number of weeds depending on the method of planting							
	Barley «Manas»		Winter wheat «Intensive»			Winter wheat «Asyl»		
	Broad cast	Raised bed	Broad cast	Raised bed	Zero till	Broad cast	Raised bed	Zero till
Corn lily	6	2	7	3	12	6	3	9
Pink sow-thistle	2	-	3	1	5	2	1	4
Pointed reed	5	3	2	1	2	1	1	2
Cleavers	2	-	3	-	5	1	-	4
Dish mustard	2	2	6	3	7	3	3	5
Knotgrass	5	2	4	3	8	3	2	6
Дымлянка Вайяна	3	-	4	3	8	3	1	7
Pigweed	2	4	2	3	8	1	2	4
Thorny ocklebur	-	-	2	2	4	1	4	6
Redroot	1	2	2	3	5	1	3	7
Others	25	32	28	34	63	20	24	76
Total plants/m^2	53	47	63	56	127	46	44	130
Air-dry weight of the weeds, g	114,0	106,9	76,8	122,1	426,7	65,6	98,6	444,6

Results in table 4.2 indicate that air dry biomass of weeds was more wheat than barley. Zero till planted wheat crop had the maximum weed biomass. High weed density expectedly will reflect itself on the yields of the crops. It is also worth mention here that wheat cultivar Asyl suppressed the weeds more than Intensive cultivar. The results suggest that for enhancing wheat productivity it will be important to use herbicide molecules with new tillage and crop

establishment methods wherein seed rates are generally lower than the traditionally broadcast method. Longstanding rhizome weed plant thistle pink has been found in winter wheat. On the other hand reeds were found in barley crop. Creeping-rooted weed called devil's guts has been found on all of the planting methods (2-8 plants). During early springs minimal weed numbers were observed on raised beds.

It was observed that cereals had sporadic Grain Lema, Grain Carabidae and grain bedbugs. However, their quantity didn't exceed the threshold and had no economic consequences. Cereal crops have been slightly affected by blotch. Rusts and blasts have not been detected. Plant attributes and yields obtained with different planting methods are given in table 4.3 Results indicated that compared with traditional method, raised bed planting improved the yield of Manas (barley) and Asyl (wheat) cultivars. Yield of Intensive wheat cultivar was independent of the planting methods. Therefore, Asyl was found suitable for raised bed planting system and performed better than Intensive .

Table 4.3. Performance of Barley and Wheat cultivars with different planting methods in Daniyar, Bishkek, Kyrgyzstan.

Exponents	Units of measurement	Barley, Manas		Winter wheat «Intensive»			Winter wheat «Asyl»		
		Broad cast	Raised bed	Broad cast	Raised bed	Zero till	Broad cast	Raised bed	Zero till
Productive	plants/m^2	325	363	381	398	249	340	366	215
Total tillering	tillers/plant	2.9	2.4	2.2	2.2	2.1	1.7	2.0	2.2
Effective Tillers	tillers/plant	1.32	1.53	1.16	1.56	1.57	1.28	1.42	1.51
Plant's height	Cm	64	72	70	65	53	66	70	55
Ear head length	Cm	6.0	7.4	8.5	8.2	7.3	7.5	7.8	6.5
Grain Moisture	%	8.7	8.9	9.2	9.4	9.8	9.6	9.6	9.8
Grain Yield	*centner/ha*	*13.4*	*49.2*	*34.6*	*30.8*	*18.6*	*27.8*	*34.0*	*18.5*
Seed test weight	g/1000 grs	24.0	35.2	33.8	34.0	33.8	38.0	36.4	38.6

Activity 4.2 Study the effectiveness of different herbicides to improve farm incomes.

Maize crop can be grown during the period between spring and autumn. Depending on its usage (fodder, green cobs, feed/ grains), maize crop can easily fit any crop rotation. The experiment was conducted to determine the efficiency of the pre- and post-germination herbicides in weed management in maize crop.

Investigations are being carried out in maize with the following treatments.

1. Without herbicide (manual weeding, farmer practice)
2. Application of the pre-germination herbicides
3. Application of the herbicides on vegetating plants
4. Application of the pre- and after-germination herbicides

Pre-germination herbicides included (Stomp or pendimethalin and Esteron). Post-emergence herbicides included Dialen and Titus. The pre- and post- emergence herbicides were also used in different combinations.

Maize hybrid "Chui D-62" developed by Kyrgyz Research Institute of Agriculture was planted on April 25, 2008 using the multicrop planter. Seed rate was 25 kg/ha. Ammophos was applied in the ratio $N_{13}P_{57}$ kg/ha at seeding. During plantation raised bed planter was

demonstrated to the managers of the nearest farm holdings. After planting on April 28, 2008, pre-germination herbicides have been applied: Esteron @0.6 l/ha and Stomp @ 5.0 l/ha. Post-emergence herbicides Dialen and Titus were applied @ 1 L/ha and 40 g/ha respectively before the six leaves stage.

Esteron is based on the highly active etherous form 2.4 D (systematic) and can affect bi-lobate late weeds and perennial weeds such as corn lily, dandelion, thistle, Molokan tartarian. Dialen is based on dicamba + 2.4 D dimethylamil salt and can affect annual cereal and bi-lobate weeds, perennial thistle, bindweed, molokan. Titus is based on rimfulfuron that has been imported recently. The study is in progress and the effect of the herbicide molecules on weed population is given in Table 4.4.

Study on the dynamics of weed species found on the maize has shown the presence of cereal weed plants such as ***S. pumila (Poir.) Schult***, hare barley, oat grass ordinary, chicken millet and cock's-foot grass. Among the large-leaved weeds following species have been found: amaranth ordinary, frost-blite, Atriplex tatarica, Capsella bursa-pastoris (L.) Medic., *Thiaspi arvense* L., Abutilon theophrasti , *Xanthium spinosum* L.., *Portulaca oleraceae* L. Amongst perennial root rhizomatous and creeping-rooted weeds followings have been found: corn lily, couch grass, pointed reed, dindle, oxtongue the pink. Before the experiment has been laid out the supply of weed seeds on the experimental plots have been determined that turned out to be a huge seed bank for the weeds (Table 4.4).

Table 4.4 Seed stocks of weeds in surface -20 cm soil in the experimental plot

Preceding crops	Quantity of the weed plants ml plants/ha					
	Point 1	**Point 2**	**Point 3**	**point 4**	**Point 5**	**Middle point**
Alfalfa, 3 years	79.1	73.4	75.6	81.2	95.8	81.0
Cereals, 3 years	121.8	132.4	135.5	118.9	128.5	127.4
Hays /Cereals	118.4	112.5	110.8	103.8	120.2	113.1

Weed seed bank in the soils depend on the weed flora of the preceding crops. In case of alfalfa grown for 3 years seed supplies were less and comprised in average 81 ml plants/ha. In case of growing cereals for 3 years the supply of weed seeds was 127.4 ml plants/ha, in case of alternate growing of cereals and hay crops seed bank was nearly 113.1 ml plants/ha. These figures indicate that under the condition of sufficient soil moisture and or appropriate irrigation regimes weed will always infest the crops of commercial importance.

After several years of alfalfa, lower soil layers were observed to have little more bulk density (upto 1.31 g/cm^3) as compared with the wheat plots (1.18 g/cm^3 ,Table 4.5). Long presence of alfalfa and wetness of the soil layers due to shallow water table seems to facilitate soil compactions within top soil layers.

Table 4.5. Physical and chemical properties of Daniyar soil.

#	Place of sample selection	Soil layers, cm	Bulk Density, /cm^3	Humus, %	Available contents , % N	P_2O_5	K_2O
1	Wheat after wheat	0-30	1.21	1.12	0.13	0.46	3.00
		30-50	1.18	1.16	0.08	0.34	2.75
2	Wheat after alfalfa	0-30	1.26	1.19	0.14	0.45	2.75
		30-50	1.31	1.25	0.10	0.35	2.65

Data in Table 4.5 also suggest that growing alfalfa for 4 years increased humus content by 0.07% in the surface and 0.06% in the lower soil layers. Alfalfa, also seem to positively improve the N content and soil fertility. The Danyar soils have K in moderate level and rich in P due to its continuous use.

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Results indicate that in order to maintain a positive nitrogen balance in soils, Danyar soils will need application of nitrogenous fertilizers. Rates of P and K fertilizers can be determined by the crop removals of these elements (replenishment doses). Soil structure can be improved through use of organics and growing of green manure crops.

Weeds were monitored in 5 spots of each plot using the ring method. Herbicide effectiveness is calculated by comparing number of weeds before herbicide application and at every 10 days after herbicide application (Table 4.6).

Table 4.6 Relative effectiveness of herbicides for weed management in maize crop.

Treatments	#of weeds in control (farmer practice) , plants/m^2			Technical herbicide effectiveness, % Before planting	# of weeds (raised bed system) plants/m^2			Herbicide effectiveness %
	Before application	After application			Before applic.	After application		
		25/V/08	20/VI/08			25/V	20/VI	
Traditional (manual weeding)	43	49	33	-	47	64	39	-
Pre-emergence								
Stomp @5L/ha	48	34	20	58.3	43	27	20	53.5
Esteron 0,6 l/ha	39	32	21	46.2	41	29	22	46.4
Post-emergence								
@Dialen 1 l/ha	43	26	11	74.4	38	22	12	69.3
Titus @40 g/ha	41	28	12	70.7	37	24	15	59.5
Stomp+Dialen	48	22	8	83.4	41	20	8	80.5
Esteron+Titus	47	20	9	80.9	45	17	12	73.3

Observations showed that manual weeding fully eliminated the vegetative part of the plant, but under the condition of irrigation, weeds again appear and oppress development of the main crop. Application of the pre-emergence herbicides protects maize seedlings during first 15-20 days. However, late spring weeds start to grow and catch up with maize. The effectiveness of pre-germination herbicides (Stomp @5L/ha and Esteron 0,6 l/ha) was 46.2-58.3% in control plots and 46.4-53.5% in case of the raised bed planting. Under the condition of double herbicide application, maize crop was free of weeds upto 50 days. Within this period maize grows up to 30-40 cm which suppresses the growth of weed plants. Under the condition of our experiment the *best results have been achieved by double combination of pre-and post-emergence application of herbicide molecules*: before germination Stomp was

applied in the rate of 5 l/ha and during vegetation – Dialen with the rate of 1 l/ha (Table 4.5). Herbicide effectiveness under these rates of application was 80.5% for the raised-bed planting and 83.4% for ordinary planting methods. In case of double application of Esteron 0.6 l/ha + Titus 40 g/ha effectiveness for the raised bed planting was 73.3% and for the ordinary planting 80.9%.

It should be noted that herbicide effectiveness is a little low in comparison with expected level due to the absence of sufficient soil moisture (best results when molecules are used in periods of vigorous growth of weeds).On the watered fields, herbicide effectiveness (double application) could reach 90-95%.

Activity 4.3. Studies on the effect of controlled irrigation methods in improving crop - water productivity, and reduce irrigation-induced soil erosion.

(Irrigation on sloping lands) Site 2. Kenenbay

Under the conditions of increasing water resource deficit and land runoffs during irrigation/ rainfall events erosion causes soil degradation in Chuy province of Kyrgyzstan. Rationale water use and expansion of irrigation cover require protection of the sloping lands from irrigation-induced erosion based on resource conserving technologies. In order to reduce irrigation induced soil erosion and to save precious water a field study was carried out at Kennenbay farms for small scale mechanization of irrigation in the pre-mountainous zone of the Chuy region. The objective of the study was intensification of irrigation based agriculture, economical use of the water and human resources, increase, and reduce land degradation on steep sloping lands. Investigations were carried out as per workplans by the Kyrgyz Research Institute of Irrigation. "Kenenbay" farms are owned by "Orok" community are located in Sokuluk region of the Chuy province. The climatic conditions in Sokuluk is moderately hot continental and can be characterized by the data collected by meteorological station in Frunze city.Average annual temperature of air is + 9.2 ^{o}C. Annual precipitation is fluctuating between 310-490 mm. Maximum precipitation is observed during the spring months: April and May.

In "Kenenbay" farms, 3 types of soils are found: chestnut brown soils with the sub-types of light chestnut brown and ordinary gray soils (serozems). The experimental site has very shallow soils sloping in different directions and thus highly prone to water erosion. In terms of mechanical content soil belongs to heavy and moderately loamy soils. These types of soils are insufficiently supplied with nitrogen and phosphorus, however have adequate potassium content. Humus content is fluctuating between 0.88 and 1.66 % on the experimental site and on the control site SOC content varied between 0.72-1.26 (Table 4.7). It is worth mentioning here that soils are very shallow- soil depth ranges between 30cm – 75cm. Soil fertility within 0-60 cm in the experimental and control plots is given in table below (October, 2007).

Table 4.7 - Nutrient status of the different layers in Kenenbay soil

#	Layers, cm	Nutritious components, mg/kg				SOC, Humus, %
		N_{NH4}	N_{NO3}	P_2O_5	K_2O	
		Experimental plot				
1	0-20	0.34	5.47	2.75	220.26	1.66
2	20-40	1.53	1.53	1.13	146.72	0.91
3	40-60	1.86	4.56	1.68	153.5	0.88
		Control plot				
4	0-20	0.70	2.53	2.80	157.0	1.26
5	20-40	No	0.51	1.14	79.72	0.99
6	40-60	No	0.26	1.14	34.40	0.72

Ground water table is within depth of 10 m or more. All small rivulet, named river Ala Archa Tush, is fed by snow melts, flows close to the experimental site. Snow melt water from the rivulet is diverted by farmers for irrigation.. General slope of the field plots is in the northerly direction.

For assessment of the crop water requirement for targeted yields, methods of SANIIRI, TIIMSH and Kambarova were used taking into account corrections for the arid zones of the pre-mountainous lands of the Chuy region. For water transportation over the slope, portable plastic chutes (PPC-50, manufactured under directions of SANIIRI) were used. These chutes have regulatory holes in their bottom to facilitate controlled water supplies. Chutes were placed perpendicular to the raised beds-irrigation furrows prepared along the contour to further reduce irrigation-induced soil erosion. For calculating irrigation water supplies triangular and trapezoidal section sluice gates were used. In order to define the soil moisture- gravimetric method was used .Speed by which water reached the last point was measured by stop-watch timer and the length of the furrow was measured by tape-measurer. Systematization and analysis of the materials for the inter-relation of parameters of irrigation with elements of irrigational technology is being processed on computer.

Speed by which water reached the last point was measured by stop-watch and the length of the furrow was measured by tape-measurer. Systematization and analysis of the materials for the inter-relation of parameters of irrigation with elements of irrigational technology is being processed on computer.

After the pre-plant irrigation on November 15-17, 2007 applied at the rate of 1500 m^3/ha maize crop was planted following the Agro-technical recommendations issued for maize growing (Ministry of Agriculture of Kyrgyz Socialist Republic, Kyrgyz Research Institute of Farming, Frunze, 1971. 48 p). Calculated rates of fertilizers were applied using planting machine (ammophos – 250 kg, nitrate of potash – 200 kg) before tillage on 22.11.07.

In early spring soil samples before planting were collected (23.03.08) to determine soil moisture and contents of NPK in experimental plots. Soil moisture on the experimental plots (autumn ploughing) was for 70 % greater that on the control plot. Moisture supply for two plots comprised 3018 and 2110 m^3/ha. Content of NPK on the experimental plot is provided in the table 4.8 below:

Table 4.8 Soil Fertility Status of the Kenenbay soils as on 23.03.08

Layer, cm	NO_3, mg/kg	N_{NO_3}, mg/kg	NH_4, mg/kg	P_2O_5, mg/kg	K_2O, mg/kg
0 – 10	15.91	3.60	ND	15.9	204.59
10 – 20	17.52	3.96	ND	5.84	198.59
20 – 30	15.36	3.52	28.38	2.95	153.66

In spring, before planting soil was tilled on 27-28.04.08 to knock down weeds and to prepare a fine seed bed and maize crop was planted for grains either alone or in combination with beans. 'Manas' variety of maize and "Red skirt" variety of cluster beans were used. Planting was done with the Indian planting machine. Seed rate was 40 kg for maize and 10 kg for beans. Maize crop - Manas variety was planted in 0.64 ha; and Maize plus beans was planted in 0.24 ha. Basal dose of fertilizer amophous was 40 kg of fertilizer. Stomp herbicide was applied before germination on 07.05.08 to control weeds using an OVP sprayer.

Data on seedling emergence/ germination count was collected in maize and beans on 23-24.05.08. Portable chutes were assembled and regulated for regulated supplies of water to irrigation furrows. At 6-7 leaf stage mineral fertilizer Karbamid was applied @ 100 kg/ha on 25.06.08.

First irrigation, water was applied on 27-29/06/08 at the rate of 600 m^3/ha. Observations on flow rates /speed of water reaching the tail end of the furrow, furrow erosion, uniformity in water application along the furrow were collected at three water application rate (0.2 l/sec; 0.3 l/sec; 0.4 l/sec). Data is yet to be analyzed and processed. However, preliminary results indicated that Plastic chutes are very useful in control of irrigation-induced soil erosion on sloping lands, saves irrigation water per irrigation
(normal application rates are 1000-1200 m^3/ha). Slow advancement of water wets the shallow soils deeper and substantially reduces the soil erosion. After-germination application of herbicide Dialen was conducted on 30.06.08 to eliminate weeds.

Devices and equipments
Green Seeker optical sensor has been custom cleared and received to conduct researches on determining plant biomass. Laser leveler RUGBY 100 LR, scrapper bucket and Indian raised bed planter as well as set of portable plastic chutes have been have been received in Kyrgyzstan via ICARDA-CAC within the framework of Sustainable Land Management Research Project. These equipments are being successfully used on the experimental fields and studies conducted on the Daniyar and Kenenbay sites.

The experiment is still in progress and detailed results will be available after crop harvest.

Activity 4.4 Studies on effect of conjunctive use of fresh and drainage water on crop yields and soil quality (salinity build-up).

Maize planting was carried out using hybrid seeds "Chiyskiy D-62" with the seed rate of 25 kg/ha. the technician could not handle the Dasmesh planter and control the seed depth. After receiving new planting machine on May 16 maize was replanted. Maize was planted individually and with a legume jondo (bean variety) in order to intensify cereal-legume crop rotation. This bean crop is used in national cuisine. Bean crop was planted on June 15 in order to avoid the negative effect of herbicides. Seed rate was 60 kg/ha. Germination is expected after irrigating. The experiments are in progress.
On July 29, 2008 maize crop irrigated. There were three treatments in the experiment.

Treatment 1. Irrigation with the fresh water (from canal).
Treatment 2. Irrigation with the drainage water.
Treatment 3. Mixed irrigation supplies (fresh water + drainage water) in 1:1 proportion.

Plot size has the dimensions : length of the raised bed – 100 m, bed size 0.7m x 5beds .
Measured volumes of irrigation water were applied for irrigation. Before irrigation soil moisture was measured at 4 places to a depth of 100m at 20cm depth interval. In accordance with the soil moisture, irrigation rate was calculated. Chemical analysis of the water samples collected from drains, water table revealed that mineralization of the drainage water was at 1.19 g/l (~1.8 dS/m). Salinity of the water table was 1.29 g/l (~2.0 dS/m) and the nature of salinity was sulphate-hydrocarbon type.

Table 4.9 Soil moisture contents in different layers before pre-sowing irrigation on 27.10.07**.**

Soil horizons, cm	Soil moisture content (%) on 4 places/points				
	Site 1	Site 2	Site 3	Site 4	Average
0-20	8.18	7.72	9.32	9.29	8.61
20-40	12.33	12.88	12.76	14.04	13.0
40-60	15.65	16.03	13.45	16.96	15.5
60-80	17.55	17.69	14.83	18.14	17.0
80-100	18.01	20.11	18.28	20.63	19.2

Soil moisture was determined gravimetrically in 0-100 cm layers before pre-plant irrigation and on different dates are given in Table 4.9 and 4.10 respectively. Irrigation on June 28/29 got delayed due to the reconstruction works on inter-farm irrigation network. Rate of irrigation was 720 m^3/ha. To save water irrigation, skip furrow irrigation was practiced.

During October, 2007-April, 2008 weather data (air temperature, relative air humidity, speed and direction of the wind, soil temperature on the depth of 5 and 20 cm, precipitation) were received form automatic meteorological station. Meteorological parameters are being processed and evaporation during the night as well as total evaporation is being determined. On June 9, 2008 automatic meteorological station have been transported and placed on the experimental plot of the Daniar farm holding. In table 4.11 open pan evaporation data for the period of December 3, 2007 – April 16, 2008. Remaining data is being processed currently.

Table 4.10 Soil moisture contents in Daniyar soil , in June, 2008.

#	Dates	Site	Horizons, cm	Average soil moisture (% by vol.)
1	9.06.08.	Well 1	0-20	7.87
			20-40	11.45
			40-60	14.32
			60-80	17.76
			80-100	20.16
2	9.06.08.	Well2	0-20	8.68
			20-40	10.77
			40-60	13.63
			60-80	17.41
			80-100	19.36

Table 4.11 Open pan evaporation during day, night and 24 hours recorded with automatic meteorological station, Daniyar, 2007-08.

Year	Day	***Date***	***Evaporation, mm***		
			Day	***Night***	***24 hours***
2007	336	3.12.2007	0.06	0.16	0.22
2007	338	5.12.2007	0.44	0.44	0.88
2007	339	6.12.2007	0.3	0.28	0.58
2007	340	7.12.2007	0.04	0.03	0.07
2008	58	27.2.2008	1.11	0.08	1.19
2008	59	28.2.2008	0.58	0.43	1.01
2008	60	29.2.2008	0.65	0.65	1.3
2008	61	1.3.2008	0.64	0.74	1.38
2008	62	2.3.2008	0.01	0.51	0.52
2008	63	3.3.2008	0.01	0.08	0.09
2008	70	10.3.2008	0.12	0.36	0.48
2008	71	11.3.2008	0.73	0.01	0.74
2008	72	12.3.2008	1	0.04	1.04
2008	73	13.3.2008	0.82	0.15	0.97
2008	74	14.3.2008	1.18	0.17	1.35
2008	75	15.3.2008	1.64	0.2	1.84
2008	76	16.3.2008	1.57	0.25	1.82
2008	77	17.3.2008	0.33	0.31	0.64
2008	78	18.3.2008	1	0.1	1.1
2008	79	19.3.2008	1.58	0.26	1.84
2008	80	20.3.2008	0.97	0.22	1.19
2008	81	21.3.2008	1.42	0.52	1.94
2008	82	22.3.2008	1.46	0.31	1.77
2008	83	23.3.2008	1.4	1.04	2.44
2008	84	24.3.2008	1.22	1.24	2.46
2008	85	25.3.2008	2.16	0.7	2.86
2008	86	26.3.2008	1.32	1.23	2.55
2008	87	27.3.2008	2.18	1.52	3.7
2008	88	28.3.2008	1.8	1.4	3.2
2008	89	29.3.2008	0.14	0.4	0.54
2008	90	30.3.2008	2.33	0.26	2.59
2008	91	31.3.2008	2.48	0.33	2.81
2008	92	1.4.2008	2.76	0.4	3.16

2008	93	2.4.2008	2.5	0.47	2.97
2008	94	3.4.2008	2.94	1.03	3.97
2008	95	4.4.2008	2.47	1.45	3.92
2008	96	5.4.2008	1.2	0.49	1.69
2008	97	6.4.2008	2.14	0.79	2.93
2008	98	7.4.2008	3.24	1.49	4.73
2008	99	8.4.2008	2.84	0.64	3.48
2008	100	9.4.2008	3.2	1.02	4.22
2008	101	10.4.2008	2.81	1.63	4.44
2008	102	11.4.2008	3.28	0.65	3.93
2008	103	12.4.2008	3.16	0.56	3.72
2008	104	13.4.2008	3.25	0.76	4.01
2008	105	14.4.2008	2.91	1.84	4.75
2008	106	15.4.2008	2.91	0.72	3.63
2008	107	16.4.2008	1.01	3.36	4.37

Note: To make calculations only complete data was used (data collected during 34 hours)

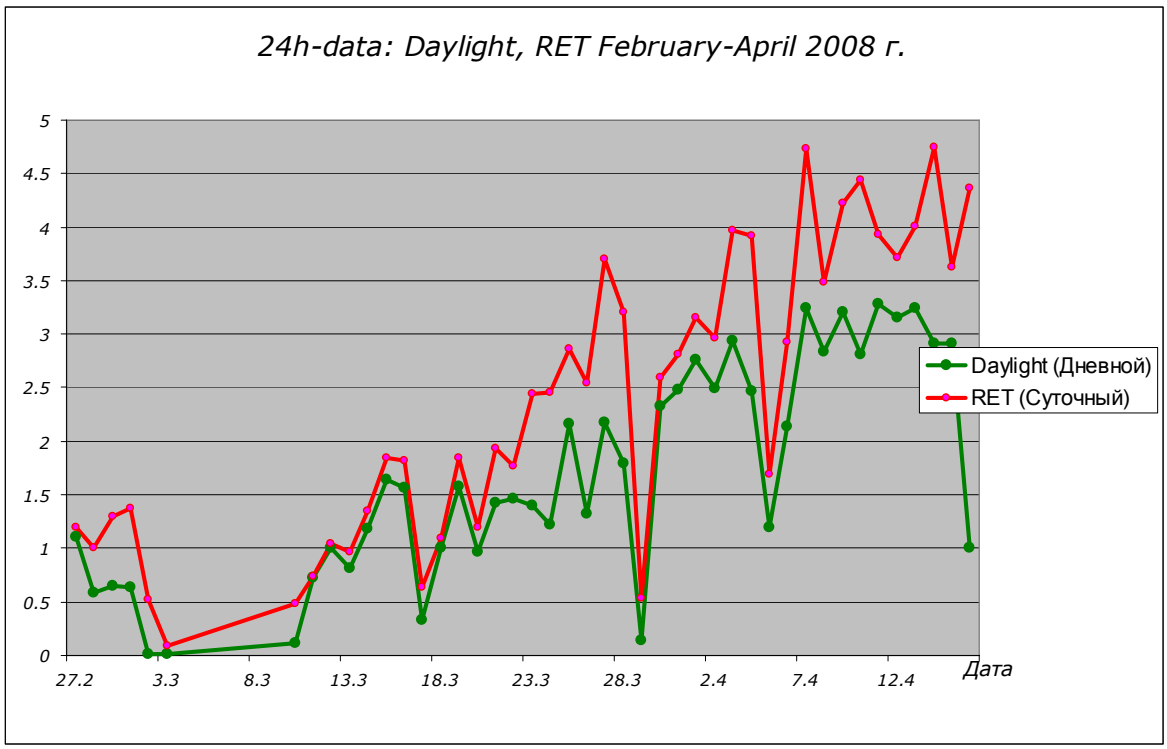

Figure 4.1. Dynamics of the evaporation during 24 hours, farm holding Daniyar, 2007-2008

Preliminary results suggest that even in the salt sensitive early growth stages, maize had no adverse effect on the plant growth. It seems that drainage waters of ECw ~ 2dS/m can be used. Final results will be available after the crop harvest .

Activity 4.5 Evaluation of the impact of laser-assisted precision land leveler on water economy, salinity and crop yields in irrigated soils.

Experiment will be started in autumn, 2008 due to the late delivery (May 21, 2008) of the equipment to Kyrgyzstan for land leveling.

Activity 4.6 Calibration and use of the optical sensor "Green Seeker".

On the farmer holding in 'Daniyar' an experiment was initiated with the wheat crop to calibrate the optical sensor GreenSeeker' to predict demand based N requirement for the winter wheat. There were 6 N levels (0, 30, 60,90, 120 and 150 kg N /ha).The treatments were replicated thrice. Area of plot in each N level was 15 m^2 (5 m x 3 m) plots.
Calibration of the equipment was conducted on the wheat crop with "Intensive" variety that was planted on October 3-4, 2007. Fertilizer was applied on April 2008. Measurements have been taken on average after every 15 days.. As it can be seen from the table (13), the NDVI index increased after applying fertilizer and was more where 90 and 120 kgN/ha was applied. For the variations where nitrogen was applied in the amount of 0-60 and 150 kg/ha increase in NDVI index was less than N 90 or 120Kg level. Preliminary results indicated that optimal rate of nitrogen fertilizer for the winter wheat for the Chu Valley is between 90-120 kg/ha, where as farmers generally apply a much higher dose. **Please see combined report on page 111-115.**

Activity 4.7 Training courses and technology dissemination

During first half of the year 2008 national scientists and specialist attended training courses in Tashkent organized by ICARDA:

1. Use of Green Seeker for determining plant biomass – 3 participants attended (M.Bekenov, P.Jooshev, B.Asanakunov).
2. Use of laser land leveler – 1 participant attended (O.Mamayev)
3. Training on Repair of Zero-till/ raised bed ferti-seed drill, Bishkek, Nov. 2007
4. Training on the laser land leveling and multicrop planter, May , 2008
5. Socio-economic surveys and livelihood mapping, Bishkek, April 2008
6. Research Prospectus Meeting Fen 7-8, 2008 (4 participants)

Activity 4.8 Technology dissemination- Farmers' days and TV Reports

- Farmers' day and field workshop were organized on June 10-11, 2008 within the framework of the SLM-R Project on the fields of farmer holding Daniyar. On June 10 field leveling with the use of laser leveler and scrapper bucket, raised bed planter while silage maize planting were demonstrated to farmers, agriculture specialists and representatives of mass media.
- On June 11 field workshop was organized for farmers within the stated farmer holding on which the regulation and settlement of the laser leveler and raised bed planter as well as their operation were demonstrated. Raised bed planted maize crop irrigation was shown as well. Information/consultation on technology of agricultural crops cultivation with the use of raised bed planter and Plastic Chutes irrigation was discussed and was given.
- Three TV channels of the Republic and two Radio channels covered the two day Farmers' field Days.

5. Tajikistan

The SLMR WorkPlans for 2007-08 for Tajikistan

Tajikistan	Q r s 3	Q r4	Q r 1	Q r 2	Q r 3	Q r 4	Q r 1	Q r 2	Indicators	Outcomes
1. Effect of Strip cropping on runoff and soil erosion in sloping lands under in agri-horti production system	X	X	X	X	X	X	X	X	• Annual Reports • Technologies for crop production in sloping lands √ • Technologies for soil moisture conservation for terrace agriculture, gully plugs, and tree-crop combinations in agri-horti production systems Methodology for assessment of the agronomic and crop management interventions on growth and land quality • New cultivars for yield improvement in rice • Methodology for assessment of the agronomic and crop management interventions on growth and land quality • Technologies for rehabilitation of the saline soils	•Neighboring farmers and other projects practice the different technologies developed in the project to improve quality of natural resources •Institutions use the methodologies for comparative evaluations of the SLM interventions.
2. Study the impact of tillage, terrace configurations and snow catching soil moisture conservation and yield of cereal crops and grape fruits, soil erosion in sloping landscapes		X	X	X	X	X	X	X		
3. Rationale use of degraded sloping lands for enhancing productivity in low and high rainfall regions.		X	X	X	X	X	X	X		
4. Evaluate the efficiency of mechanical and vegetative measures in control of gully erosion for rehabilitation of degraded sloping lands	X		X	X	X	X	X	X		
5. Calibration and use of Optical crop canopy sensors (Green Seekers) for measuring crop development, comparing crop management practices for SLM and efficient nitrogen management.		X	X	X	X	X	X	X		
6.Promoting communities based nursery raising for plantation in sloping lands.	X		X	X	X	X	X	X		
7. Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options		X	X	X	X	X	X	X		
8. Evaluate the performance of wheat, barley, rapeseed and cotton and Halophytes in saline soils in Vakhsh		X	X	X	X	X	X	X		
9. Study the impact of land leveling and agronomic interventions on salinity and soil moisture distribution patterns and crop performances using Electro-Magnetic (EM) probe and Optical Sensors.				X	X	X	X	X		

5. Tajikistan work plans and progress report

The national coordinator and the director of the Research Institute of Soil Science, who was the focal point for coordination and implement of the SLMR program was removed by a Presidential decree. The new national coordinator and the director will take time to understand and respond to the project requirements. No report has been received despite reminders and requests.

6. Turkmenistan Workplans

Turkmenistan For details SLMR Workplans										
Activity	**Qr 3**	**Qr 4**	**Qr 1**	**Qr 2**	**Qr 3**	**Qr 4**	**Qr 1**	**Qr 2**	**Indicators**	**Outcomes**
1. Assessment of yield losses due to late planting in cotton-wheat cropping system		X	X	X	X	X			• Reports on crop yield losses due to salinity and salt tolerance ratings	Neighboring farmers and other projects practice the different technologies developed in the project to improve quality of natural resources
2. Assessment of yield losses due to salinity. Determine the salt tolerance of cotton and wheat under prevailing climatic conditions.				X	X	X			• Surface cover and Resource conserving technologies developed for sustainable land management	Institutions use the methodologies for comparative evaluations of the SLM interventions
3.Farmer participatory trials for validation , fine tuning and development of new RCTs				X	X	X	X	X	• Methodology for assessment of the agronomic and crop management interventions on growth and land quality	Farmer begin custom service and SMEs initiate agribusiness
4. Develop permanent raised bed planting system in cotton –wheat sequence.				X	X	X	X		• Report	
5. Maintaining favourable salt balance in raised-bed furrow system in cotton-wheat				X	X	X	X		• Report	
6. Impact of pigeon-pea and tree species in development of surface covers to control soil erosion in sloping lands.			X	X	X	X	X	X	• Reports	
7. Calibration and use of Optical crop canopy sensors (Green Seekers) for measuring crop development, comparing crop management practices for SLM and efficient nitrogen management.				X	X	X	X	X	• Report	
8. Evaluate the impact of laser-assisted precision land leveling on water savings, salinity and crop yields in irrigated agro-ecologies.			X	X	X	X	X	X	• Report	
9.Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options				X	X	X	X	X	• Report	

Activity 6.1. Assessment of Yield Losses Due to Late Planting in Cotton-Wheat Cropping System

Timely planting for winter wheat is very important to get good crop stand and good harvest. Wheat is planted in different time windows, namely (i) end of August till the 15th of September, (ii) the optimal time widow is often considered as from Sep.15-10 Nov. and (iii) late planting window is one wherein wheat is planted from 10th till 30th of November and (iv) very late planting is generally – after 30th of November. Farmers generally get late in planting operations due to lack of machinery and water particularly when pumping is not possible. Sowing time also affects the seedling emergence. Normally , it takes 6-7 days for early crop and 22-25 days for emergence of the very late sown crop. Time to seedling emergence affects tillering, booting and ripening processes. It may be mentioned here that winter 2008 unusually has been extremely cold with long period of temperature < -15˚C. Under such situations very late sown crop suffered from frost and resulted in low crop productivity.

From the results it is clear that October 6-22 is the optimal window for planting of the winter wheat in "Bygdayly" of Akbygday region (Figure 6.1). The general notion amongst farmers that the best window for planting winter wheat is from September 15- 10 November is not supported by the results of this study. Thus there is a need to educate the farmers on the optimal planting time of winter wheat in Akbygday agro-ecoregion of Turkmenistan. Similar studies should be conducted to work out the optimal planting for winter wheat in other ecoregions of central Asia to avoid yield losses.

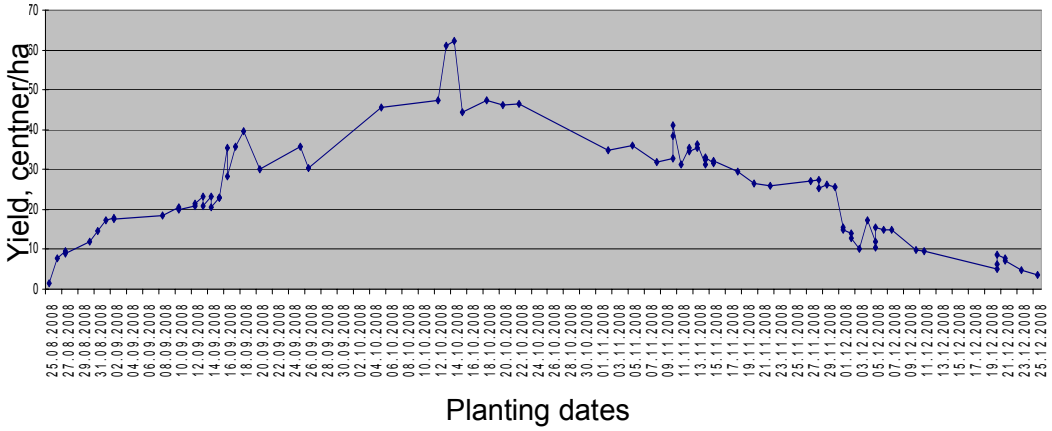

Figure 6. 1 Effect of planting dates on winter wheat productivity.

In order to assess how sowing time influences the development and productivity of winter wheat a farm field survey with different sowing times (experimental farms of seed grower association "Bygdayly" of Akbygday region) was conducted. Field surveys on different plant attributes were recorded and are presented in Table 6.1.

Table 6.1.Growth, development and productivity of winter wheat as affected by planting time.

№	Time of sowing	Plant attributes					
		Plant height, cm	Density, plants/ha	Ears per м^2	# number of grains / ear	Test weight g/1000 seeds	Yield , centner/ha
1	Early type 25.08-15.09	49,1	208	250	20	32	16,1
2	Optimal, 15.09-10.11	88,5	316	395	30	35	41,1
3	Late, 10.11-30.11	73,7	258	310	28	34	31,9
4	Very late after 30.11	37,8	186	205	18	30	10,3

Survey results of 20 farms presented in Table 6.1 clearly suggested that plant density, number of ears, grain / ear and seed test weight are significantly affected by sowing dates. In timely sown crop, plant density was 3.16 mln plants. per ha, number of ears/1м^2 -395; number of seeds/ ear 30, seed test weight 35g. Productivity of timely sown wheat was 41.1 centner/ha. At all other planting time, yield of wheat crop was less. Reduction in yield of wheat crop was substantial particularly in very early or very late planted crop due to reductions in all the relevant plant attributes contributing to crop yield. Yield reductions were mainly due to very cold winter, frost and hot and dry spring during crop maturity.

Table 6.2. Effect of planting dates on winter wheat crop productivity

№	Time of sowing	Total area, hectare	Gross harvest, tons	Crop productivity, centner per hectare	Yield Changes (+/-)
1	Early	230,5	371,0	16,1	-25,0
2	Optimal	274,0	1125,8	41,1	-
3	Late	336,25	1073,1	31,9	-9,2
4	Very late	210,0	215,6	10,3	-30,8

Data presented in table 6.2 indicate that compared with timely planting, early and very late planting crop reduced wheat yield by 25,0 and 30,8 centners/ha, respectively.

Cotton crop

A similar monitoring survey was conducted in cotton to develop yield-planting date relationship. Incase of cotton, planting is considered (i) early -(March 15- 10th April), (ii) optimal time- (April 10-25), (iii) late- (April25- 10May) and (iv) very late- (after 10th of May). It was observed that seedling emergence was after 10-12 days in early planted crop, 9-10 days in timely planted crop, 7-9 days in late planted cotton crop.

The crop is still in field and the relationship between cotton yield and planting dates will be computed after the crop is harvested in December, 2008.

Commentary:
The collaborators have not been able to compute any relation between Yield-Sowing date and express the relationship in some simple equation for future use. Collaborators

have to collect more data and do a better analysis. An improved treatment of the data collected during wheat and cotton crop season is expected.

Activity 6.2. Evaluation of crop losses as a result of soil saltines, evaluation of cotton and wheat resistance for salty soils at local soil and climate conditions

Salinity varies in space and time under field conditions. When salinity in the soil solutions becomes excessively high it manifests itself on plant growth through poor germination and crop stand, stunted growth and at times in plant mortality. For managing saline environments for good plant growth, farmers often practice salt leaching and or resort to salt dilution through application of irrigation water. The experiment was set up on the fields of the lease holders' farms. These farms had slopes in direction from south to north, typical of the pre-mountain zone of Kopetdag mountain ridge. Five large size fields were identified for collecting data in the first quarter of the root zone (0-30 cm) which generally contribute to most of the water uptake to crop water demand (60-65% water use). The root zone salinity of 0-30 cm layer was monitored in wheat and cotton growing seasons and yields were also determined. These fields had gradation in crop performance according to no-salinity, low, medium and high salinity. The salinity and yield data were proposed to be used to compute salt tolerance and crop yield losses as a function of salinity.

Winter wheat (super quality Jubelee type of winter wheat variety) was planted on 27-30th of October 2007. Seed rate was kept at 240 kg/ha following the farmer practice. Soil texture varied from loam to fine loam at these sites. Winter wheat was planted in standing cotton crop and irrigaion water was applied @ 600-700 m^3/ha. It is well established that a NaCl content of 0.33 % and Na_2SO_4 content of 2,4 % kills wheat. Wheat suffers heavy losses when chloride concentration is 0.05-0.1 % or SO_4 concentration is 0.3-0.4% (Shakhov,1956). Mineralization of ground water in the low , medium and highly salinized fields was 16.4; 25.7; 34.8 mS/cm or 10.4; 16.5; 23.3 g/l, respectively.

Ground water-table depth in the experimental area fluctated between 96-140cm. Salinity of the ground water varied between 10-29 g/l or (16.4-34 ms/cm) according to initial soil salinity and irrigation norms and surface roughness and landscape position. It is very crucial to have precision laser assisted land leveling to avoid development of slick spots and have uniform salinity distribution in fields.

Commnetary:
The technical program has not been followed as planned and no conclusions can be drawn without establishing a salinity-yield plot. From the results submitted to ICARDA, the desired salinity –yield relationship can not be computed. Collaborators have to make more efforts for better results.

Activity 6.3. Farmer participatory trials for validation, fine tuning and development of new resource conserving technologies (RCTs).

For the study large field plots (total area of 34.2 ha) was identified which comprised two farms.
In Central Asia, a large proportion of wheat is traditionally planted into standing cotton crop initially sown in flat fields. Cotton crop is gradually shifted from flat system to on the raised beds. Whereas during the wheat season, cotton stubbles are kept anchored and serve as mulch, there are usually no residues during the cotton growing season. Thus, the para-cropped wheat crop is generally planted as a reduced till crop, cotton crop is traditionally planted after preparation of good soil tilth.

A field experiment was planned to (i) compare RCTs (reduced till /no-till, residue management) with the farmer practices, (ii) compare cost of cultivation and net profits (saving in total water use, saving in fuel and labor and other inputs over time), and (iii) evaluate role of surface retained residues on the weed population, soil temperature and soil moisture profile.

The technical program mutually agreed earlier was changed by the national partners without notice. The new technical plan included the following treatments:

a. traditional method of wheat sowing
b. wheat sowing on cotton field, more advanced one (look Table)

Soils were fertilized with 300 kg/ha super phosphate, then chiseled, seeds treated with "Dividend" chemical @ 1L/ton seed. Wheat was planted on 25-30 of October using a seed rate of 180 kg/ha. The first irrigation was applied on 1-6 of November. Seedling emergence was observed between 9-14 November. Nitrogen was supplied through nitrate fertilizer twice applied @ 300 kg/ha. The crop was irrigated 4times.

With the traditional method of wheat growing lot of weeds such as : wild oats, *овсюг*, reeds, sturdy, *канареечник,* bindweed and others were observed. The herbicide molecules 'Topic and Khusar' were used to control weeds. No herbicide molecule was used in reduced till/ zero till plots (minimal land disturbance) weeds were not seen in cotton field. It was observed that compared with traditional fields, the zero-till cotton mulched fields had low soil temperature (5-10C) and more soil moisture (30-35%). After harvest, cost of cultivation and grain yield of winter wheat were compared with the two crop establishment methods. Results have been summarized in Table 6.3.

Results show that zero till method of crop establishment significantly reduced the production costs. Normally zero till plots would need application of herbicides for control of weeds during the crop growth season. However, no herbicide was used to control weed in zero till plots which possibly resulted in marginal reduction of wheat yield as compared with traditional practice. If the herbicide costs are added to the costs of zero till plots, it would appear that the new RCTs would reduce the costs of wheat cultivation by 23% without yield penalty.

Table 6.3 Production costs in traditional and zerotill methods of wheat growing .

№	Land treatment	Wheat production cost	
		Traditional	**Zero till**
1.	Preparation of border for irrigation	3075	-
2.	Pre-sowing irrigation	12264	-
3.	Leveling of channels /drainage	12332	-
4.	Fertilizing	26772	26772
5.	Ploughing	63620	-
6.	Current leveling	43100	-
7.	Chizelling	1130	-
8.	Chizelling with simultaneous harrowing and leveling	16430	-
9.	Cutting of drainage canals	14473	-
10.	Cutting of temporary irrigation system and irrigation canals	4166	-
11.	Seeds treatment	75000	75000
12.	Transporting of seeds and loading a sowing machine	70300	70300
13.	Sowing	46680	46680
14.	First vegetation irrigation	10629	10629
15.	Fertilizing (first feeding)	26772	26772
16.	Second vegetation irrigation	10629	10629
17.	Herbicide treatment	179712	-
18.	Fertilizing (second feeding)	26772	26772
19.	Third vegetation irrigation	9811	9811
20.	Forth vegetation irrigation	9811	9811
21.	Moving and grain thrashing	106662	106662
22	**Yield t/ha**	**3.65**	**3.47**
Total costs (manats)		**780310**	**419838**
Saving (360472-Herbicide costs)=180760 manats		**23%**	

Test of significance not known whether observed yields in two treatments were any different.
Exchange rate: 14,250 manats per 1 USD

Activity 6.4. Develop permanent raised bed planting system for cotton-wheat sequence

The activity report has not been submitted

Activity 6.5 Maintaining favorable salt balance in raised-bed furrow system.

Most crops are sensitive to excessive amounts of salts at early germination, tillering / branching and flowering/ fruiting stages. It has been reported that salt tolerance ratings of crops differ at with crop growth stages. Generally, most crops are sensitive at germination and become more salt tolerant in later crop growth stages (a phenomenon known as crop ontogeny). When crops are planted on raised bed –furrow irrigation system in saline environments, it is a common knowledge that salts generally accumulate in the central portion and on the tops of the raised beds. Therefore, before sowing of the next season crop, these salts must be leached from the seed zone to allow good germination and establishment of the following crop. It is usually recommended to leach with $4000m^3$/ha water (40-cm/ ha). Farmers generally dismantle the raised-beds prepared the previous season before leaching. Dismantling raised-beds besides increasing the tillage costs also increase tillage and soil disturbance.

It may also be mentioned here that the generally recommended leaching guidelines ($4000m^3$/ha water- 40cm ha^{-1})do not take into account initial salinity status, salt tolerance of crops, dynamics of soil salinization during the crop season under the prevailing ground water table conditions and quality of the irrigation water *per se*. The experiment is designed to effect saving in irrigation water generally used for leaching the soil in the fall and the spring/ summer season before planting. In this trial crop residues will be retained except the plot with farmer practice.

Treatments:

- Farmer practice – 40cm /ha water before winter and summer planting and sowing.
- Determine the soil salinity in the saturation paste (ECe, dS/m). Leach excess salts above salt tolerance of the crop at germination stage. (A normally thumb rule- To leach 80% salts from 1 cm layer it requires 1cm of water. Calculate and leach).
- For *Pelewa* use 10-12 cm-ha of irrigation water and seed immediately. No pre-planting leaching. Pre-sowing irrigation required to build *antecedent soil moisture* content is sufficient.(save water 28-30cm water). If salinity is very high use a little more water.
- Direct dry seeding on the flat or raised beds followed by irrigation.

A field experiment was initiated in Peasant Association farms in "Bugdayly", 70 km from Ashgabat. For the cotton-wheat sequence, winter wheat crop was planted as the first crop. The bulk density of the soil varied between 1.39-1.42 g/cm^3.

Te technical program was changed by collaborators and following technical program was followed.

In Turkmenistan, wheat crop is planted by two methods, namely (i) sowing on flat surface, and (ii) sowing on top of raised beds in raised bed -furrow system. Irrigation is applied in the furrows to keep raised beds wet. The study was conducted with variants given in Table 6.4.

Table 6.4 Treatments for the trials .

#	Treatment	Area, farmer and cultivar
T1	Wheat planted without pre-sowing irrigation	Area 54.5ha, Farmer- Myradov Meret. Cultivar"Batko"
T2	Wheat planted with pre-sowing irrigation	Area50ha, Farmer-Yazberdye, Variety- Turkmenbashy
T3	Wheat planted on beds without pre-sowing irrigation + mulching	Area 50ha, Farmer-Orazlyev; var.Turkmenbashy
T4	Cotton on beds without pre-sowing irrigation.	Area 50ha, Farmer - Myradov Meret
T5	Cotton on raised beds after pre-sowing irrigation	Area 50 ha, Farmer -Kazakov
T6	Cotton on raised beds + mulch@	Area 50ha, Farmer -Kazakov Kakadyrd

Note; Wherever mulch was provided, thickness was 2-4cm

Since the salinity of the surface 30 cm soil before wheat sowing was 1.06 % (W/W), soil was flushed twice with 5000 м^3/ha from September 5-10, (Table 6.5). Flushing reduced the salinity of the surface-30cm soil from 1.06% to 0.62%. The nature of salinity was chloride-sulfate. the details of operations for wheat and cotton crops are given in Table 6.5

Table 6.5 Time schedules of field operations in winter wheat and cotton crops (field 6)

№	Kind of land treatment	Dates of different operations					
1	Current levelling	-	01.11.07	-		15.02.08	15.02.08
2	Ploughing	-	05.11.07	-	24.12.08	21.01.07	21.01.07
3	Temporary irrigation canals	-	10.11.07	-	18.03.08	14.03.08	14.03.08
4	Furrowing ℓ =200-250 m	-	10.11.07	-	18.03.08	14.03.08	14.03.08
5	Fertilizing (phosphorus 400 kg/hectare, nitrogen 300 kg/ha)	07.11.07	11.11.07	07.11.07	20.03.08	15.03.08	15.03.08
6	Pre-sowing irrigation of winter wheat (@1200m^3/ha)	-	12.11.07	-			
7	Pre-sowing irrigation of cotton (@1600m^3/ha)				-	29.03.08	29.03.08
8	Sowing	08.11.07	20.11.07	09.11.07	23.03.08	07.04.08	07.04.08
9	Vegetation irrigation: 1. m = 900 m^3/hectare	18.11.07	22.01.08	18.11.07	06.04.08	18.04.08	18.04.08
	2. m = 800 m^3/hectare	30.03.08	28.03.08	28.03.08	20.04.08	31.04.08	31.04.08
	3. m = 800 m^3/hectare	20.04.08	10.04.08	13.04.08	29.04.08	10.05.08	10.05.08
	4. m = 800 m^3/hectare	08.05.08	15.05.08	09.05.08			
10	Winter wheat mulching with straw			09.02.08			
11	Mulching cotton with straw						22.03.08

Results presented in table 6.6 indicate that salinization was more in the raised bed than in the layers below the furrow sections. salinity of the ground water varied from 10.8 to 16.1 mS/cm, which corresponds to 6,80 and 10,20 g/L. Irrigation water applied to winter wheat and cotton crops had salinity varying between 0.97- 1.33mS/cm.

Table 6.6 Initial saltiness of 30 cm soil layer of experimental field 6

Crops	Variants	On ridges (Г) On bottom (Д)	Conductivity $EC_{1:5}$, mS/см	Mineralization of water extraction gr/liter	Solid residue, %	Ions, %							Degree of salinity	
						HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	FAO	Dokuchaev
Winter wheat	I	Г	1.140	0.680	0.30	0.030	0.066	0.101	0.020	0.005	0.069	0.006	ns	ls
		Д	0.375	0.254	0.150	0.030	0.015	0.056	0.016	0.009	0.018	0.003	ns	ls
	II	Г	1.390	0.830	0.480	0.031	0.096	0.196	0.062	0.010	0.074	0.007	ns	ls
		Д	0.662	0.397	0.200	0.037	0.040	0.057	0.022	0.006	0.028	0.005	ns	as
	III	Г	5.350	3.230	2.430	0.030	0.414	1.221	0.266	0.075	0.391	0.024	vs	Solanchak
		Д	0.499	0.296	0.190	0.030	0.029	0.070	0.022	0.007	0.023	0.004	ns	as
Cotton	IV	Г	0.588	0.353	0.220	0.043	0.029	0.081	0.032	0.006	0.023	0.005	ns	as
		Д	0.290	0.174	0.130	0.037	0.015	0.037	0.016	0.022	0.016	0.004	ns	ls
	V	Г	2.840	1.710	1.050	0.031	0.177	0.502	0.140	0.032	0.138	0.012	vs	Solanchak
	VI	Д	0.658	0.395	0.190	0.037	0.040	0.051	0.026	0.004	0.025	0.004	ns	as

Notice:ns – not salty,ls – low salty, as – average,vs – very salty

Table 6.7 Mineralization of irrigation water and of ground water at experimental site

Variant	Data of sampling	Mineralization, g/L	Conductivity, mS/cm
Ground water			
I	16.03.08	8.10	13.00
II	16.03.08	9.50	15.83
III	16.03.08	10.20	16.10
IV	06.04.08	6.80	10.80
V,VI	06.04.08	8.20	13.02
Irrigation water salinity for winter wheat			
I,II,III	18.11.08	0.80	1.33
	30.03.08	0.58	0.97
	20.04.08	0.62	1.03
	08.05.08	0.68	1.13
Irrigation water salinity for cotton			
IV,V,VI	29.03.08	0.58	0.97
	18.04.08	0.60	1.00
	31.04.08	0.65	1.08
	10.05.08	0.63	1.05

Depth of ground water in February and March in experimental field of winter wheat fluctuated between 80 and 150 cm depth.

Comparison of treatment 1 and 3 revealed that retention of crop residues as mulch reduced the soil temperature by 1-4 ^{0}C. Similar reduction in soil temperature was observed at 30cm soil depth (fig. 6.2). How does crop residues (mulching) affect the dynamics of weeds was not studied as planned.

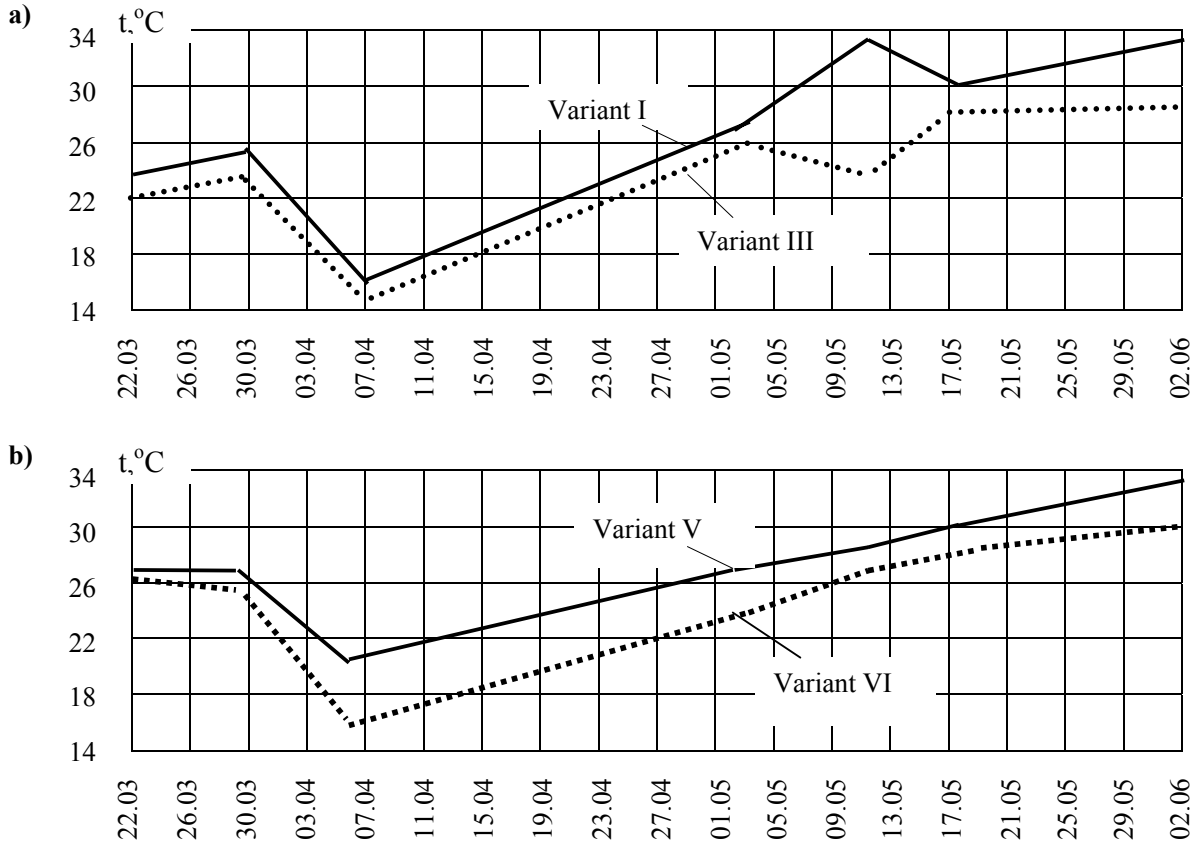

Figure 6.2 Temperature regime on surface of soil and on ridges (raised beds) in winter wheat ; and b) cotton field

Table 6.8 Density of standing and prognosis of winter wheat yield

Variants	Density of standing, plants /m^2				# of seeds/ ear	Seed test weight g/1000 seeds	Yield, centner/hectare			
	replication			average			replication			average
	1	2	3				1	2	3	
I	259	285	267	270	47	34,1420	41,6	45,7	42,8	43,4
II	240	251	197	229	55	32,7811	43,3	45,2	35,5	41,3
III	202	227	189	206	32	26,3932	17,1	19,2	16,0	17,4

As one can see from data of table 6.8 plant density was maximum with treatment 1 (270 plants per m^2) The plant density was 229 plants/ m^2. in treatment 2. It seemed that yield in treatment 1 and 2 were at par with each other. Due to excessive salinity in the raised beds the treatment 3 performed poorly. Results are also indicative of the fact that Treatment 1 provides an opportunity to save **1600m3/ha of irrigation water**.

Commentary:

The experiment was designed to focus on developing an appropriate salt leaching practice so that the need to dismantle raised beds can be avoided. In raised bed-furrow planting system, skip or alternate furrow irrigation is used to save on water. Irrigation is applied to dry furrows

in the second irrigation cycles. Alternate irrigation facilitates redistribution of salts in the rootzone. For effective leaching of soluble salts from the raised beds, it may turn out to be not a good strategy to follow alternate the furrow (even or odd) for watering, each irrigation cycle. It may prove a useful to continue even number furrows (2, 4,6, 8…..) in each irrigation cycle and when salt builds up excessively irrigate the odd furrows. This is likely to save on irrigation water for leaching . The present study need to be repeated in a more focused manner to achieve the desired objectives.

Activity 6.6. Effect of Pigeon-pea and tree species in development of surface covers in control of soil erosion in sloping lands and creation of the field protective strips on the irrigated lands

In order to arrest the advance of desert and to improve air quality, the local government creating a green belt area around Ashgabat. This green belt is is part of the agro-ecological region where other SLMR research works in "Bugdaily" are being carried out. Submontane zone of the green belt goes through the hilly areas where soil erosion processes are quite intensive. In order to prevent soil erosion dfferent types of woody plant species and the grapes are planted. In order to improve survival of the young saplings, drip irrigation system has been introduced on the sloping lands. The green belt area strategy to prevent soil erosion is good butdoes not utilize the full potential of drip system created at huge costs for afforestation of the hilly tracts around Ashgabat. Due to slow growing nature of the woody tree species rate of development of surface cover is slow such to sufficiently reduce soil erosion or to entrap the further movement of the airborne particulate sand and silt materials.

In order to further improve effective water use and decrease soil erosion process it is important to facilitate quick development of the surface cover. In order to make use of the drip irrigation system, improve fertility of the skeletal hilly soils for growth of the hard woody species, pigeon-pea was sown around the dripper moisture zone, in close vicinity of the tree saplings. Two strips (1 ha area), provided with criss-cross drip lines, were selected along the slope. The first strip with western exposure has a 30^0slope. The second strip has 45^0 inclination with easterly exposure. The experimental area (Pre-mountain area of Kopetdag) is 5 km to the south from Ashgabat. The area is assigned to State Bank of Foreign Economic Affairs for building a forest-park zone. Drippers are so placed as to irrigate each tree sapling planted in rows 6m apart. The spacing between tree saplings has been kept at 5m. Apparently tree saplings are widely spaced and would take time before they fully cover the space.

Seeds of pigeon pea received from ICARDA in early May were planted manually at 5-6 cm depth from May 5-15, 2008. Seeds were dibbled at 0.5m distance from each tree sapling. Total quantity of pigeon pea seeded was 285. One of the pigeon pea cultivar was ICPL 880391 (175 seeds) and the other cultivar planted was ICPL- 85010 – (110 seeds). The first sprouts were observed after 10 days on the 20^{th} of May. On 23^{rd} - 25^{th} of May at all sown places the first sprouts with two leaves were observed. Due to regular drip irrigation, growth of pigeon pea plants is very good and by 16^{th} of June the height of plants was around 30-35 cm. Using the optical sensors, NDVI measurements will be taken to analyze changes in surface cover. The experiment is in progress and detailed results will be available in December, 2008.

Activity 6.6.1. Creation of wind breaks to prevent wind erosion and improve productivity of the irrigated lands.

The irrigated lands in "Bugdaily" are located in the newly cultivated zone where wind breaks are being developed to protect irrigated lands. Filed protecting forest strips significantly decreases the effect of hot dry winds by increasing air humidity within the forest strips, decrease temperatures to lessen the overheating of the soil surface.

A plan for creating the wind break was developed and is given in SLMR work plans . There were tow objectives for this trials, namely (a) to study the effect of planting density on crop growth, and (b) to evaluate the performance of different tree species under hot dry summers and very cold winter season.
For objective (a) four hundred saplings of mulberry and poplar were planted in December 2007. Planting was done rows and seedlings were placed in a staggered manner. Total length of green belt is 400m. Survival of seedlings was high and nearly 92% of saplings had rooted very well. Provision of irrigation led to high survival rate of the saplings. .

For objective (b) planting was carried out in March 2008 after land treatment in dugout holes. At farmers' and management's wish 500 ash-trees (Fraksirus) and 100 trees of Eldar pine (Pinus eldarika) were planted. A total of 600 young saplings were planted. Total length of green strip was 600 m. It is observed that 95% of the tree saplings have rooted well.

Activity 6.7. Calibration and use of Optical crop canopy sensors (Green Seekers) for measuring crop development, comparing crop management practices for SLM and efficient nitrogen management.

The combined results have been presented on page 115-119

Activity 6.8. Evaluate the impact of laser-assisted precision land leveling on water savings, salinity and crop yields in irrigated agro-ecologies.

The laser unit was imported and provided to national partners in early 2008. The hydraulic scrapper bucket was developed indigenously and was supplied to national program. The instruments could not be got released from the local customs until April 2008. Laser land leveling training program was organized in July again in Dashauz. Actual field leveling work will be initiated in September to evaluate its impact on water use etc.

Activity 6.9.Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options

No activity has been reported by the national coordinator

7. Uzbekistan *SLMR Workplans*

Uzbekistan For details SLMR Workplans										
Activity	**Qr 3**	**Qr 4**	**Qr 1**	**Qr 2**	**Qr 3**	**Qr 4**	**Qr 1**	**Qr 2**	**Indicators**	**Outcomes**
1. Assessment of soil leaching requirements in irrigated plains to enhance water productivity and reduce drainage volumes (Lysimeter and Field Experiment)		X	X	X	X	X	X		• Reports	Neighboring farmers and other projects practice the different technologies developed in the project to improve quality of natural resources
2. Maintaining favourable soil salinity balance in permanent raised-bed planted cotton-wheat irrigated systems		X	X	X	X	X	X		• Technologies on salinity management	Farmer begin custom service laser land leveling services and SMEs initiate agribusiness
3) Assessment of both native and non-native tree and grass species for their biomass productivity, salt tolerance and bio-drainage ability to rehabilitate the degraded rangelands in arid agro-ecologies		X	X	X	X	X	X		• Afforestation technologies for diversification of saline environments	Farmers use the improved truthful seed of the diversified crops.
4. Evaluation of diversified, salinity-resistant crops for enhancing biomass production for livestock in degraded rangelands			X	X	X	X	X		• Seed availability for diversification crops	Institutions use the methodologies for comparative evaluations of the SLM interventions
5. Calibration and use of Optical crop canopy sensors (Green Seekers) for measuring crop development, comparing crop management practices for SLM and efficient nitrogen management.				X	X	X	X		• Report	
6. Study the impact of precision laser-assisted land leveling on water saving, salt leaching, and crop performance in irrigated agro-ecologies using EM probe and Optical sensors			X	X	X	X	X		• Report	
7. Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options		X	X	X	X	X	X		• Report	

Activity 7.1 Assessment of soil leaching requirements in irrigated plains to enhance water productivity and reduce drainage volumes in Cotton-Wheat System (Lysimeter and Field Experiment)

It is generally recommended to leach the soils before planting wheat and cotton crops. Farmers use 4000m^3/ha of fresh canal water for leaching the salts that accumulate during the preceding crop season. Water-saving irrigation technologies, such as precision land leveling, furrow irrigation, and residue retention (mulching) can reduce salinization rates and water use by up to 30%. This research program will investigate the integration leaching and water-saving irrigation techniques to reduce field-level water input without decreasing the productivity of the cotton-wheat systems. It is hypothesised that inefficiencies of water application in surface irrigation methods and the rains received during the winter and spring seasons leach out the salts sufficiently from the seed zone and obviate the need for the customary heavy leaching, raise water table and consequently large drainage volumes. Therefore, the need is to improve the antecedent soil moisture content by a pre-sowing irrigation water effect a salt free seed zone and to enable germination of seed. Several recent studies conducted recently by international projects suggest that annual loss in crop productivity due to secondary salinization is close to USD$ 919 million. It is for these reasons, lysimetric and field studies were conducted to save fresh water for leaching and to explore possibilities on the reuse of the drainage water. Research study was conducted on the "Sherzod Samandar Birligi" farm situated in Sardobinskyi district of Syr-Darya province and the "Paxtakor" farm in Djizzakh region – both are located at the boundary of the alluvial zones of Hungry steppe within the medium stream of Syr-Darya river. Research activity included lysimetric studies and validation of the results through a field experiment. Lysimetric and field experiments were conducted in close vicinity on a farmer's fields.

A. 1. Lysimeter Experiment

To begin with by end of August 20, 2007, 2 irrigations (Saline drainage water of ECw 5-6dS/m) were applied to allow salts to redistribute in the profile in lysimeters. Maintain a saline water table of ECw 3-4dS/m at a depth of 100-110cm during the winter wheat and cotton crop seasons. Before the planting of winter and spring season crops determine the salt and water profile. Use primed seed for planting at 5-6cm depth.

1. Farmer practice – Leach the salts in autumn and spring seasons @ 4000m^3 /ha
2. Light leaching followed by planting @ 2000m^3 /ha
3. Usual Pre-sowing irrigation @ 1000m^3 /ha and planting
4. Shallow direct dry planting and usual Pre-sowing irrigation @ 1000m^3 /ha

Lysimeters were constructed using a thick circular iron sheet in 2001 having a net surface area of 1.44 m^2 (Figure 7.1). The containers are sealed in the bottom to permit development of water table at any specific depth. The lysimeters have stabilized after many cycles of irrigation and cropping system in the last 7 seven years and thus represent local soil conditions found locally. Lysimetric soil represents the predominant loam soils found on the farm. The soil texture down in the profile becomes sandy loam (70-120 cm). Soil of the experimental site is characterized by underdeveloped macrostructure.

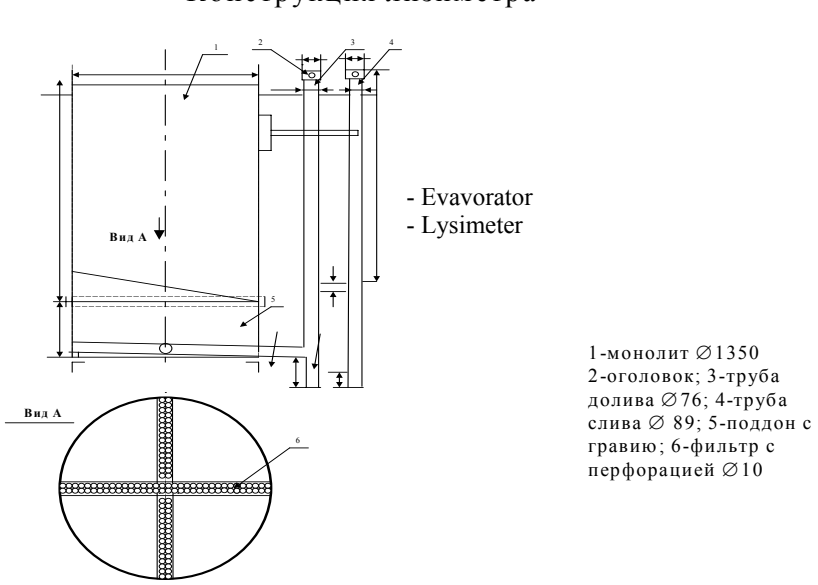

Figure 7.1 Design sketch of the filled-in- soil lysimeters with provision to maintain water table

It may be mentioned that water-stable macro aggregates were found mainly in the surface soil layer and the lime (transitive) horizons. Low water-stable units are associated with low humus and coarse texture of the soils and sub-soils (data not presented here). Bulk density of the soil in different layers varied between 1.35-1.46 g/cm$^{3.}$ Porosity (48 %) was more in the surface soil layers due to mechanical disturbance. Initial data on the maximal hygroscopic and soil moisture content (wilting point) was collected for experimental site for future use (but not presented here). The greatest value of these water-physical constants was observed in surface soil layers and lowest values were observed at depth of 45-70 cm. The permeability of the soil after 24 hrs was observed to be 0.21m/day

The soil was salinized by irrigating with drainage water (ECdw 5-6 dS/m). The results presented in Table 7.1 indicate that winter wheat irrigation water requirements under constant surface to ground water table conditions (100-110cm) in Sardobinsky district of Syr-Darya province varies from 730 to 860 m^3/ha. The traditional pre-season leaching applied @ 2000- 4000 m^3/ha increases the drainage load varying from 1460- 3600 m^3/ha. When leaching is accomplished by a slightly heavier pre-plant irrigation or by post-sowing irrigation (after dry planting; 1000m^3/ha) the contribution to drainage water during the crop season is around 550 m^3/ha which is 42% of the total water used (~ 1300 m^3/ha) during the winter wheat season. Thus, the results of the lysimetric studies indicate that ~ 3000 m^3/ha can be easily saved under the boundary conditions of the trials provided the salt balance is also positive (root zone salinity regimes remain favorable during the crop season). Use of larger irrigation volumes during the crop season only increased the salinity of the ground water table (ECdw) due to salt addition through irrigation water and concentration effects (ET loses of water, concentrates soluble salts in the soil).

Results presented in Table 7.2 indicate that a little heavier pre-sowing (pre-plant) irrigation can effect leaching of soluble salts to the extent of 20-25 % from the plow layer (seeding zone), thereby facilitating crop establishment with minimal irrigation water use. It has been further observed that compared with pre-plant irrigation; dry seeding immediately followed

by post-sowing irrigation was more efficient (nearly 15% more efficient) in salt leaching such as to keep the seed zone free of salts. This is mainly because of the evaporation loses from the irrigated soil before planting and re-salinization.

Table 7.1 Irrigation and drainage volumes under different treatments during winter wheat growing season in Lysimeter trials

Water application	Farmer practice, T1	Light leaching before sowing; T2	Preparatory irrigation,leaching,T3	Dry seeding & Post irrigation , T4
Vol of leaching water m^3/ha, ECw 4.2 dS/m	4000 (4-6.10.07)	2000 (4-6.10.07)	—	1000 (4-6.10.07)
1st Irrigation m^3/ha (24.10.07.)	160	40	1000	55
2 Irrigation m^3/ha (16.03.08.)	280	280	280	280
Total applied water , m^3/ha	**4440**	**2320**	**1280**	**1335**
Drainage , m^3/ha	***3600***	***1460***	***550***	***550***
ECgw before leaching 4.10.07, dS/m	6.44	5.83	5.48	5.24
ECgw after leaching 18.10.07, dS/m	15.8	11.28	4.15	7.68

Table 7.2 Soil salinity changes on different dates and leaching protocols in the lysimeters planted with winter wheat.

Salinity on different dates	**Treatment 1**	**Treatment 2**	**Treatment 3**	**Treatment 4**
Soil salinity before leaching mS/m[a], 04.10.07.	67.3	143.8	60.0	96.6
Soil salinity after leaching, mS/m. 18.10.2007	47.1	56.3	46.8	61.7
Soil salinity after leaching, mS/m . 12.01.2008	65.4	58.3	57.1	62
Soil salinity after leaching, mS/m. 08.03.2008	73.1	54.3	53.4	68.8
Soil salinity after leaching, mS/m. 04.05.2008	63	51.5	52.2	62
Soil salinity after leaching, mS/m. 12.06.2008	68.3	57.7	85.0	56.4

[a]**1mS/m= 0.1dS/m**

Data on the grain yield of winter wheat crop is given in Table 7.3. The results show that grain yield in treatment 3 and 4 were similar to the traditional wheat agronomic practices followed by the farmers, where they use excessive leaching before winter planting. A heavier pre-sowing irrigation practice to meet soil moisture deficit and to cause effect some salt leaching from the seed zone seems to be sufficient in achieving our twin goals of water saving and reducing the problem associated with disposal of excessive drainage volumes. The irrigation water productivity of winter wheat almost doubled with the new salinity management strategy.

Table 7.3. Yields (t/ha) and water productivity of winter wheat (kg/m^3) in the Lysimeter trial.

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Crop yield, kg/ha	5900	6000	6400	5900
Total applied water, m^3/ha	**4440**	**2320**	**1280**	**1335**
Total applied water +Rainfall, m^3/ha	6743	4623	3583	3638
Water productivity, kg/m^3	0.875	1.300	1.786	1.622

From the data presented in Tables 7.1-7.3 it appears that 2000-3000 m^3 of irrigation water can easily be saved by just refining existing salt leaching recommendations. It implies that 2500 million m^3 of irrigation water can be saved in actual fields equivalent to 2.5 cubic kilometers of water (assuming 1 million ha of wheat area). It also suggest that appropriate recommendation on the leaching practices when properly implemented can annually save about 5% of the total water consumed in Uzbekistan. In this computation, conveyance losses of water canal system (delivery of water) to the actual fields where additional savings can also be affected.

A 2. Field Trials

The experiment was conducted in a field which is in vicinity of the Lysimeters installed in the " Sherzod Samandar birligi " farm of Syr-Darya region. Following treatments were evaluated for their performance yield of winter wheat in cotton/ Maize-wheat system. Treatment for winter wheat planting will comprise the following:

(a) Saline ploughed field with all residues removed- leach @ 4000m^3 /ha and plant as usual. Plant Primed seed at 5-6 cm depth.
(b) Saline ploughed field with all residues removed- Saline irrigation (7cm) to improve the antecedent soil moisture and then immediately leach with @ 1500m^3 /ha. Plant as usual. Use primed seed at 5-6 cm depth.
(c) Saline undisturbed field with all residues retained on the surface - Saline irrigation (7cm) to improve the antecedent soil moisture and then immediately leach with fresh water @ 1500m^3 /ha. Plant as usual. Use primed seed at 5-6 cm depth.
(d) Saline un-disturbed field with residues retained on the surface - Prime seed placed in shallow 2.5-3.0 cm depth, and soil immediately leached with @ 1500m^3 /ha. Fertilizer nutrients will be used as per local practice (all N after sowing)
(e) Saline un-disturbed field with residues retained on the surface - Prime seed placed in shallow 2.5-3.0 cm depth, and soil immediately leached with @ 2200 m^3 /ha (actual planned was 1500m^3 /ha). Note that 50% N and all other nutrients will be applied before pre-sowing irrigation to compare with Treatment (d).

The farmer participatory trial was conducted in a 80x72 m size field with 5 treatments replicated twice. The winter wheat crop was planted (Cultivar –Dostlik) at the seed rate of 250 Kg/ha on 22nd October 2008. The crop was row planted (4 rows) on 90cm wide beds using a traditional seeder. Except the treatment (E) fertilizer nutrients were applied in March, 2008 at the end of the winter season. Herbicide was also applied late the March and hence was not very effective in control of the grassy weeds.

The yield data is presented in Table 7.4. Results clearly suggest that the traditional leaching practice consumes lot of fresh canal water supplies. Heavy leaching in absence of

functional drainage system only builds up the ground water table and reduces leaching efficiency. It was observed that before leaching, water table was close to 240cm below surface. After leaching the, ground water table came close to surface and was within surface 110cm. This only facilitates the secondary salinization during the summers (Figure 7.2).

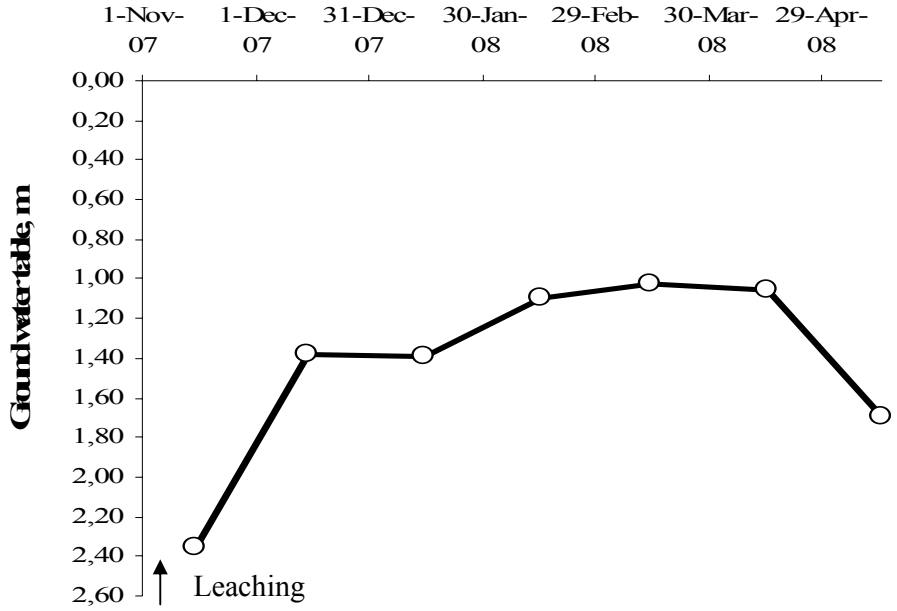

Figure 7.2 Surface Ground water table fluctuations during winter wheat crop season

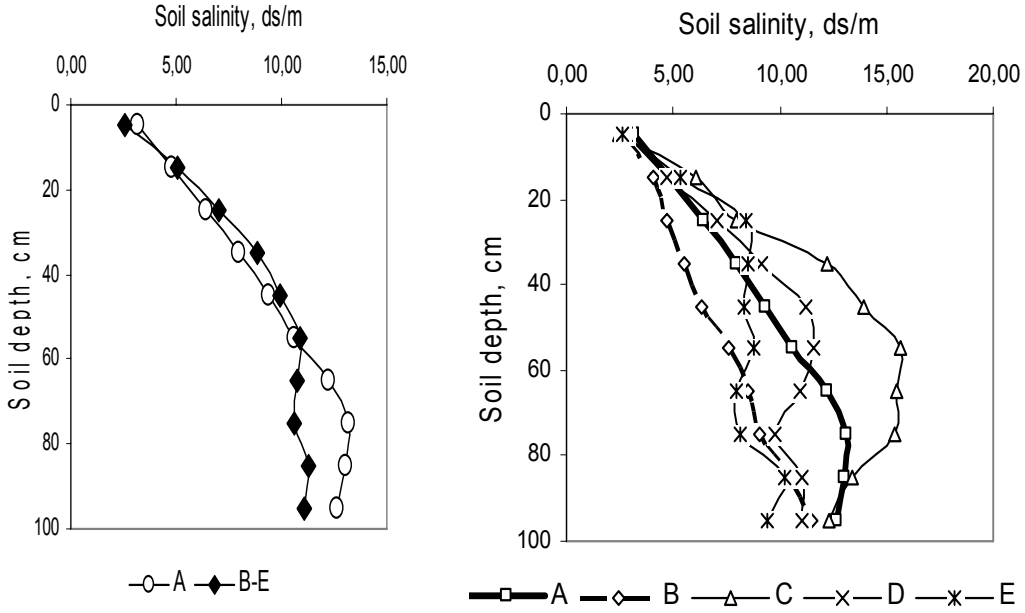

Figure 7.3. Salinity distribution in soil profile (control-A and variant treatment B-E)

The salinity distribution in the soil profile after leaching and crop season (March 2008) is shown in Figure 7.3. The results indicate that rising water table leads to steady salinization through capillary movement of the top layers. The salinization is expected to be more

where water table is close to the surface. Saline irrigation to fill the soil pores (improve antecedent soil moisture contents) followed by fresh water not only saved canal supplies but also resulted in the similar desalinization in the root zone and little higher wheat yields. It is interesting to note that pre-saline irrigation (Treatment C) had higher salinity in lower layers but this has no consequence on the crop yield. Therefore, it would be an excellent strategy to have low initial salinity at germination and early growth and then allow for slow salinization as higher salinity towards end of the wheat season does not have any adverse effect on crop yields.

The yield data indicate that with traditional agronomic practices wheat grain yield was only 4.25 t /ha. The maximum yield was obtained (Treatment B) when saline water was used to improve the antecedent soil moisture content of the soil (7cm saline water) followed by leaching with fresh water (15cm). This cyclic use of saline and fresh water is known to improve the leaching efficiency of the rain/ irrigation waters (Minhas and Gupta 1998).In Treatment B grain yield (5.1t/ha), and water productivity (1.036 kg/ m3) was observed to be maximum. It is worth mentioning here that in spite of the late operations in management of weeds and fertilizer applications, the productivity of the variant treatments B, C, D and E was always higher than the traditional practice (Treatment A). The results of the field trial presented in Table 7.4 and the lysimetric trial (Table 7.3) clearly brings out the fact that wheat production and water productivity can be improved substantially through changing the leaching practices. Results show that at least 2000m^3/ha fresh water can be saved during the winter wheat season without any yield penalty.

Table 7.4 Grain and straw yields and water productivity of winter wheat at Sherzod Samandar Birligi farms , Syrdarya Province.

Items (Attributes)	Treatments				
	(A) control + 4000m^3 /ha leaching	(B)saline irrigation + 1500m^3/ha - mulch	(C) saline irrigation + 1500m^3/ha+ mulch	(D) Dry Sowing +post sowing irrigation, 1500m^3/ha	(E)same as D + 2200m^3/ha water +50% N basal
Grain yields, t /ha	4. 28	5.085	4.565	4.400	4.525
Straw yield t/ha	5.14	6.105	5.56	5.28	5.42
Total applied water+Rainfall, m^3/ha	6930	4908	4758	5406	6106
Water productivity, kg/ m^3	0.618	1.036	0.959	0.814	0.741

Activity 7.2 Maintaining a favourable soil salinity balance in permanent raised-bed planted cotton-wheat irrigated systems

Experiment was conducted to determine the effect of soil leaching, evaluate irrigational water saving, develop permanent system of raised bed planting.

Research methods and materials

Experiments have been laid out on the farmer holding Esanbay Ota of Pakhtakor district in Jizzakh region of Uzbekistan on a representative coarse loam soil, with clay content ranging

between 23.9 and 29.7% . Most of the water stable aggregates have been found within in plow soil layer of the experimental site. Due to the low humus content and light mechanical content of soil and ground general content of the water-stable aggregates is low. Soil's bulk density varied from 1.34-1.37 g/cm^3 in the surface -30 cm soil in the beginning of the crop season and 1.40-1.43 g/cm^3 at end of vegetation. two irrigations were applied on 15.04.08.(600 m^3/ha), and 26.06.08(600 m^3/ha). Thus a total of 1200 m^3/ha irrigation water was applied during the growth season of wheat. Soil was leached at the rate of 2500m3/ ha water on November 11, 2007 before planting.

Soil of the site is slightly saline and ground water table fluctuated at the depth of 2.5-3.0 m. Soil salinity assessment was conducted in accordance with the traditional method by selecting soil samples and conducting analysis of the water extract in a laboratory. The results of this analysis indicates that down the soil profile concentration of the chlorine ion increases up to the moderate level of salinity together with the increase of solid content.

In a field experiment, winter wheat cultivar ("UJ-12" variety of wheat) was planted in raised bed planting without residues. The specifications are given below. The area of the each treatment was kept at 0.14 ha (14.4 x 100m). As mineral fertilizers, ammonium nitrate was applied with the rate of 530 kg/ha and ammophos at the rate of 100 kg/ha. Due to water shortage for each variation 3700 m^3/ha were applied that include leaching. This was beside the usual rainfall (~119mm or 1190 m^3/ha) during the season.

Treatment #	Method of planting
1	Traditional planting by broadcasting (on plain field)
2	Planting on raised beds with Indian planter without plant residue. Inter row distance is 90 cm. Wheat is planted in 4 rows with 15 cm in between.
3.	Treatment T2 with residues of the previous cotton crop

For the activity 2a data collected with the use of conductivity meter EM-38 RT indicates that during vegetation period of winter wheat, soil salinity changed from moderate to high salinity levels; less salinity in the surface -75 cm which increases with depth up to 50 cm. Data collected with the use of electric conductivity meter "Progress 1T" indicated that in raised bed system soil salinity increases from the furrow bottom towards middle part of the raised bed (Figure 7.4).Thus suggests that special bed configuration may be required for efficient leaching of the salts from the raised beds.

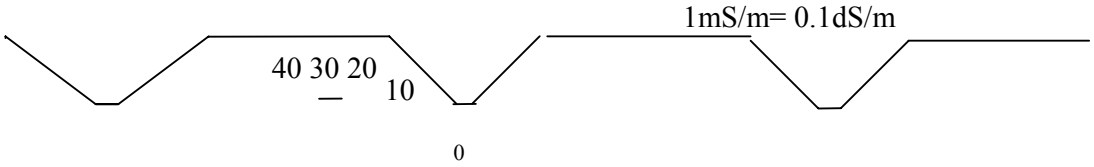

Figure 7.4 salt distribution in raised bed- furrow system

Results presented in Table 7.5 indicate that compared with the traditional flat planting, planting on the raised beds improved the winter wheat yields by 0.45 and 0.85 tons/ ha in absence and presence of the crop residues (yield improvements up to 14.2%). The seed test weight (weight / 1000 grains) was also higher on the raised beds.

Table 7.5. Growth and Yield of winter wheat on loam soil in village Palhtakor.

Treatment	Height of the plant, sm				Seed test weight, g/ 1000seed	Yield Tons/ha	Water Productivity Tons/1000m^3
	1.03.08	1.04.08	1.05.08	1.06.08			
1 Control	46.7	67.3	88.4	115	45.0	6.00	1.23
2 Raised bed,RB	48.8	69.1	92.8	117	46.5	6.45	1.32
3. RB+Residues	49.7	71.3	93.1	120	46.8	6.85	1.40

The water productivity per 1000 m^3 was highest (1.40 tons) under the condition of raised-bed wheat planting with plant residues. It was observed that Raised bed planting also improved the water productivity in winter even when residues were no retained/ removed. Low productivity per 1000 m^3 , registered for traditional method of planting (1.23 tons)suggest that retention of residues is highly desirable for control of weed , moderate the ambient temperatures, reduce evaporation (unproductive losses of water) and provide energy to the soil biota to proliferate for improved nutrient turn over rates and their continuous supplies to the plants.

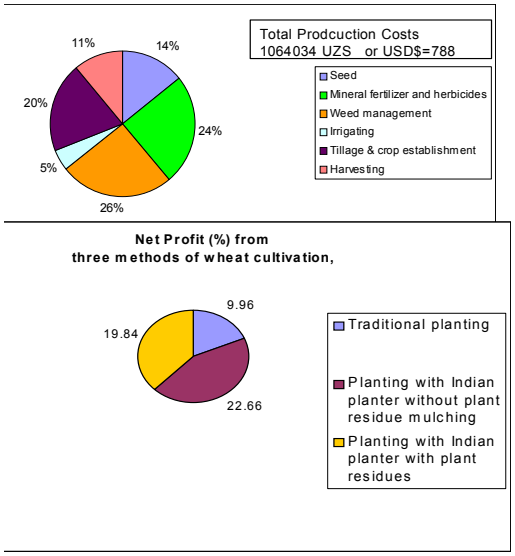

Figure 7.5 Net profit from three methods applied for winter wheat sowing

Data presented in Figure 7.5 indicate 70% of the total production costs of winter wheat are mainly due to (i) tillage, (ii) fertilizers and (iii) herbicide/ pesticides. Seed contributes to another 14% costs. Conservation agriculture saves nearly half the seed and reduces the production costs (~42K Uzbek sums). It saved almost 100kg of wheat seed/ ha with the use of Indian planter. Improved tillage and crop establishment method (raised bed planting enhanced the income of the farmer by 10-12% percent in wheat season. through 'yield enhancing and cost reducing' factors.

In another field trial, cotton crop was grown on 90 cm and 60 cm wide raised beds with intercropping of mungbean- a legume crop. The treatments are given in the table below and planting geometry is shown in Figure 7.6.

Scheme of the Activity 2b with raised bed cotton-mungbeen planting is given in the table below (Table 7.6):

Table 7.6. Methods of planting under different treatments

#	Treatment scheme	Method of planting
1.	A	Raised-bed cotton-mungbean planting with the 90 cm width between rows.
2.	B	Raised-bed cotton planting with the 90 cm between rows (control).
3.	C	Raised bed cotton- mungbean planting with 60 cm between rows
4.	D	Raised-bed cotton planting with 60 cm between rows

Area of each treatment was 0.18 ha (18m x100m), total area was 0.72 ha. Seed rate for cotton planting (Bukhara variety) was 102.25 kg/ha and the mungbeen seed rate was kept low at 4 kg/ha due to non-availability of the improved seed material.

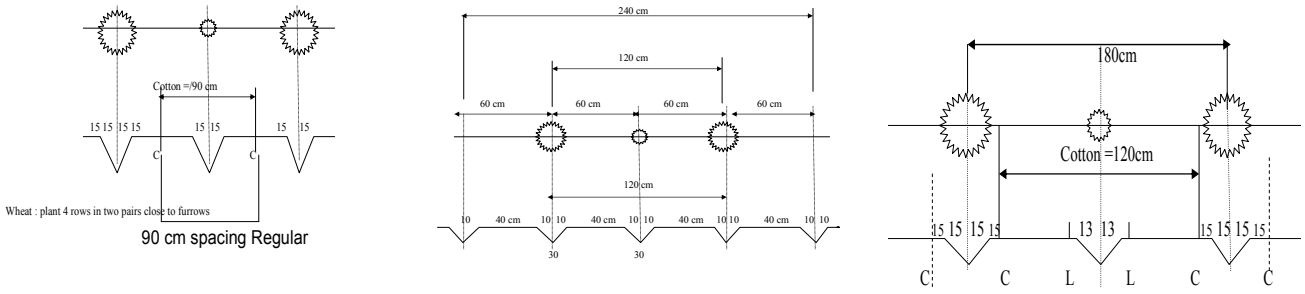

Figure 7.6. Planting geometry of mungbean and Cotton on 60 and 90 cm wide raised furrow irrigated systems.

The trial planted in April 20/04/08 is still in progress and therefore only some plant attributes are discussed here. Yield data will become available only in Autumn/ beginning of the winter season. The plant attributes are given in Table 7.7 below. It may be mentioned here that population cotton plants in 90cm wide spacing is less by nearly 30% than the population achieved with 60cm wide row spacing. It is a natural corollary that when plant population is increased the N application should have also been enhanced. But this not done in this trial and the 60cm wide beds have received the same amount of N and other fertilizer nutrients as applied to 90cm wide raised bed system. Therefore, the plant height , number of branches and buds were found less in 60cm row spacing as compared with 90cm plant spacing.

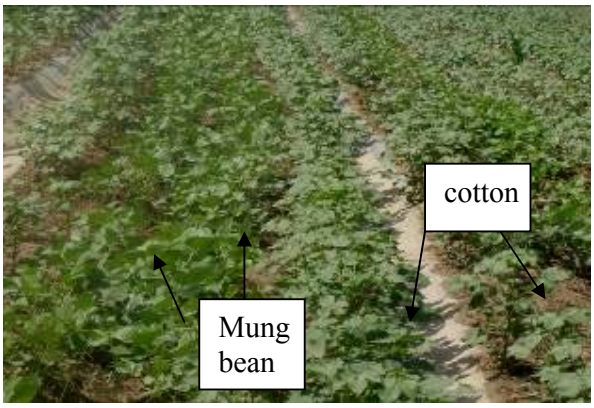

Photo. General field view of intercropped mung bean with cotton on 90cm beds

A slight change in the planting geometry of the cotton has opened a new window for introduction of the mungbean / legume crop. The growth of the legume crop has been very good in the 90cm spacing (see photo).

Table 7.7. Biometric parameters of cotton on 1.07.08

Treatment (crop establishment geometry)	Plant Height, cm		# Branches		# Buds per Cotton plant
	Cotton	Mung bean	Cotton	Mung bean	
Cotton, 90 cm	38		7		8
Cotton + mungbean, 90cm	35	23.4	6	4	6
Cotton, 60 cm	29		5		6
Cotton + mungbean, 60cm	27	19.7	4	3	5

It must be mentioned that it was the First Experience in Central Asia to plant a complimentary crop in cotton system. Therefore the planting was not near perfection for the legume crop (less seed rate and missing hills could be seen). Also the farmer used a tractor with wide wheels. The new system would go very well if narrow tractor wheels (18-22cm wide) are used to avoid compaction of the raised beds on either side during planting and subsequently facilitating trampling of the inter-crop during inter-cultivation operations required for weed management. Therefore, agronomic works in 60 or 90 cm raised-beds would need wider tires for tractor MTZ-80 (30- 40cm wide) and must be replaced with narrow tyers (18-22 cm). The final results will become available after harvest.

Commentary on leaching of soluble salts in permanent raised bed system of cotton growing

Irrigation water has dissolved salts. One meter depth of snow melt water (0.2dS/m) applied annually can contribute nearly 1.28 tons of salts/ ha. If these salts are not leached and drained out they continue to accumulate in the root-zone, builds up soil salinity such to adversely affect plant growth and yield. Salt distribution curves normal to raised bed planting –furrow irrigated systems as shown below are normal under such situations.

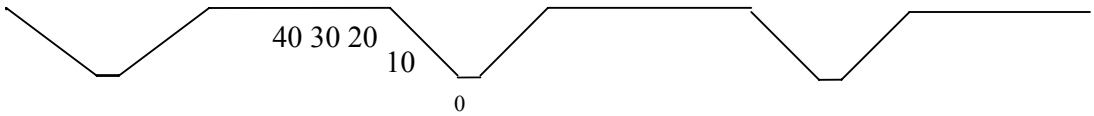

Photo Transplanted cotton Photo Skip furrow irrigation system

In order to save on irrigation water, farmers generally practice skip furrow irrigation system as shown in the picture. In this scheme of water is applied to furrow # 1,3,5, 7 ….. etc in 1st irrigation cycle and then to furrow 2,4,6, 8 etc in 2nd cycle. This scheme promotes a uniform distribution of soil moisture and salts. But when salt accumulates in excess amounts, the issue is how to leach them without dismantling the raised bed systems. It is hypothesized that it is better to continuously irrigate the same furrows numbers, rather than alternating the water application to even furrows under saline environments. Such a scheme will facilitate salt accumulation in the dry subsoil layers immediate below the un-irrigated furrows (e.i. even number furrows) to facilitate salt leaching even with less irrigation volumes. Care should however be taken to ensure that odd number furrows are first filled with water to prevent salts moving back from salinized dry soil zones.

It has also been observed that most corps including cotton is sensitive to salts in early growth stages (germination, emergence and braching) and become more tolerant as crop growth proceeds. Therefore, patchy germination and reduced crop growth is commonly observed in cotton fields in slick spots. Reseeding of cotton many times proves futile under saline environment. Also some farmers who are not able to plant cotton timely have to either keep their fields fallow or divert the area to some other crops. in order to meet both situations it is suggested that cotton seedlings should be raised in small diameter polyethylene tubes to transplant cotton late in the season/ and to ensure establishment of a good crop stand. This technology allows to catch up late planting. as well as allows the crop to escape early salt injuries and facilitate good establishment of crop stands. The above picture shows a transplanted crop of cotton in a relatively saline field in Vakhsh, Tajikistan.

Activity 7.3. Assessment of the performance of native/local and non-native/exotic tree and grass species for their biomass productivity, salt tolerance and bio-drainage ability to rehabilitate the degraded rangelands in arid agro-ecologies/environment/conditions.

Kyzylkum desert in general occupies roughly 300,000 sq km territories of Kazakhstan and Uzbekistan (between the Syr Darya and the Amu Darya rivers, southeast of the Aral Sea). Desert plants grow on its sand ridges, serving as pasture for sheep, horses, and camels. The weather is characterized by small amount of precipitations. Irrigation water is the most important limiting factor for agriculture in region. Limited availability of irrigation water requires the using of different sources of irrigation water, such as groundwater suitable for irrigation. Use of pastures without considering fodder capacity leads to degradation. As an example, from total pasture area of 22.4 mln. ha about 16.4 mln. ha (or 73%) subject to degradation. By estimate, in deserted zone of Uzbekistan during the vegetative period total volume groundwater could be provided total area of 25-30 thousand ha. (Morozov, 1968).Under this condition there are the following ways for increase efficiency of natural grassland and maintenance and therefore to maximize farmers profit in this region: rational use, development of improved range management methods and organizations fodder production under irrigation (with use artesian water). The objective of the present study is to evaluate the response of tree', shrub' and grass' species growing to improved soils properties, restoration biodiversity and productivity of degraded rangeland within light-textured and saline soils with respect to biometrical parameters of trees and yield of crops. This work focuses on the risk assessment of using artesian water for irrigation tress, shrubs and grasses by study the influence on plant's growing and soil salinity.

In Central Asia there are 900 halophyte' species. *Climacoptera, Kochia, Suaeda and* licorice *[Glycyrrhiza glabra]* are more promising. They can be formed of 10-12 ton dry fodder masses, of 1.0–1.5 ton seeds (fruit), and provided protein up to 1.5 ton in condition of saline water use under sandy soils. Ability of halophytes to formation relatively tall, branched aboveground organs (canopy) promotes to decrease evaporation from soil and therefore reduction of salt concentration in top layer (green mulch effect). On sandy soils the halophytes are salt tolerance (even under saline irrigation water ranged from 5.5 up to 40 g/L), whereas most crops are not salt tolerance (under salinity of 3 g/L). Halophytes with aboveground biomass of 18 – 20 t/ha promote to 10-12.5 ton per year salt removal. The green mulch effect makes 2.5 t/ha salts. As a result, under halophyte' plantings, salts removal from soil reaches 10- 12.5 tons per year (Shamsutdinov, Z.Sh., Shamsutdinov, N.Z., 2002). This will be examined more extensively in this study.

In Kyzylkum desert, low biomass production, soil erosion, salinity in low-lying areas, scarcity of irrigation water, high evaporation rates, ground waters of low quality, degraded pastures and range lands, water and fodder shortages in winter season and long term fallows are some of the major problems. For sustainable use of the desertic lands it is absolutely obvious that tree crops (fruit or forest specie), and grasses have a very major influence on soil erosion and thus on the food web and trophic interactions, critical for flow of energy and nutrients through the systems. Stability of the desertic lands such as found in Kyzylkum seems closely linked to relative abundance of the tree plantations (thus the food web structure). Conventionally, these lands are devoid of trees and have very low green surface cover Erosion was less in tree plantations than in the open spaces cultivated for cereal/ other crops.

Soil characteristics

Root zone salinity under different tree species was determined using electromagnetic probe (EM38) and Conductivity Meter Instruments 'Progress1'. Saplings were planted in April, 2008 on a saline soil. After planting, soil salinity increased predominantly in the lower soil layer (75-150 cm.), where as surface soil layers were generally only poorly saline. Thus the initial salinity surveys conducted in April- May, 08 only indicated that soil salinity increased with soil depth. soil texture is primarily coarse sandy loam with clay content upto 10% and silt (10-12%). The chemical composition of the soluble salts given in Table 1 indicates the presence of chlorides and sulfates of mainly sodium. High sodium adsorption ration in soil solutions {SAR> 15, (m.mole/l) ^{½}} indicate that these soils are highly prone to dispersion upon leaching with fresh quality water. For efficient leaching these soils must be amended with gypsum or else leached with saline waters initially to avoid clay dispersion and any reduction in infiltration rate of the soils during the leaching process.

Table 7.8. Soluble ions' content in soil and water (Kyzylkum, Uzbekistan)

	Soil depth (cm)	Solid residual	Soluble anions				Soluble cations				SAR
			CO_3^{-}	HCO_3	Cl^{-}	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	
Unit		(%)	mmol/L								
Soil	0-2	13.60	0.08	1.44	10.90	370.99	3.59	23.08	354.80	1.94	97.16
	2-28	9.23	0.00	0.56	26.96	248.46	4.99	28.90	241.31	0.78	58.62
	28-62	0.88	0.00	0.44	9.44	29.27	3.79	15.86	19.31	0.19	6.16
	62-100	1.24	0.00	1.08	21.91	16.90	4.19	6.12	27.67	3.82	12.19
Unit			mmol/L								
Groundwater		1.24	0.96	0.5	11	8.4	2.1	3.06	14	1.9	8.62
Irrigation water		0.60	0.64	0.3	2.4	6.1	1	4.2	3.1	1.3	1.31

Survival and growth performance of tree species, fodder and cereal/ oilseed crops in Kyzylkum coarse sandy loam sodic soils.

Sapling survival was monitored 4 months after transplanting in April 2008. It was observed that survival of Apricot [*Armeniaca vulgaris* ; 50%]; Ailanto [A*ilanthus aitissima*; 61%]and Ash [*Fransinus silvestrus*; 40%] was satisfactory under the harsh climatic and strongly sodic soil conditions of the soils. However, in terms of growth increments, Apricot *[Armeniaca vulgaris*-103cm*];* Ailanto*[Ailanthus aitissima- 23 cm];* Poplar *[Populus puramidalis- 40cm]and* Peach *[Persica vulgaris- 15cm]*seemed very promising. These species need to planted again in a larger area in more planned manner to validate the results during the cold winter season when temperatures remain below -15C for several weeks. Use of carbamide before each irrigation will also be useful. Cherry *[Cerasus vulgaris] and Peach[Persica vulgaris]* had very low survival rates (<20%(but put up good growth. These fore these species should also be further evaluated. The low survival counts could also be due to fewer numbers of saplings transplanted.

Table 7.9. Biometric measurements and survival rate of trees (Kyzylkum, Uzbekistan)

Tree species/Latin name	# of saplings planted	# of survived saplings	Survival rate (%)	Mean height ± SEM		Mean height increase (cm)
				Before planting	2 July	
Apricot *[Armeniaca vulgaris]*	90	45	50	84.81±6.1	103.02±5.2	103.02±5.2
Peach *[Persica vulgaris]*	136	16	11.8	84±	99.63±7.3	15.63±1.3
Quince *[Cudonia oblonga]*	105		0	-	-	-
Cherry *[Cerasus vulgaris]*	102	18	17.6	57±2.6	61.84±3.6	4.84±0.7
Ailanto *[Ailanthus aitissima]*	46	28	60.9	60.35±4.2	84.11±4.3	23.78±1.7
Ash *[Fransinus silvestrus]*	74	29	39.2	71.11±5.2	79.45±4.9	8.3±0.8
Poplar *[Populus puramidalis]*	700	104	14.8	7±0.7	40.64±3.6	33.64±2.1
Grape*[Vitis vinifera]*	106	8	7.5	9±0.6	18.3±1.8	9.3±0.9
Poplar *[Populus puramidalis]*	100	0	0	-	-	-

Performance of the halophytes and fodder species

Atriplex Nitens Kochia scoparia Pearl millet and Licorice species were grown in sodic coarse sandy loam soil (Table 7.10). It was observed that Pearl millet cultivars Aip 19586 Aip 13150 and Aip 22269 received from ICRISAT Hyderabad performed very well to produce more than 50t/ha of green biomass. If these cultivars are grown near the watering points in vicinity of the herds (size 2000 units) on 10 hectare area, it could easily double the survival ration from 2 kg to 4 kg/day per animal during the fragile winter season. Increased fodder availability will improve survival of the livestock. Kochia scaparia yield (green biomass) was (22.3 t/ha). Preliminary data evidence that licorice *[Glizerriza glabra]* known to be very tolerant to salinity /sodicity also proved quite promising under Kyzylkum conditions. Kyzylkum sandy soils promoted development of vigorous root system and rapid self-replication of licorice. Biomass of licorice is good forage fodder, and roots - high-value raw material for pharmaceutical and food industry. Licorice yielded 23.0 t/ha. Harvesting of roots will be estimated during fall.Licorice could be as source for feeder and thereby increase the net income of the farmers in Kyzylkum region. Biomeliorative ability of licorice could improve fertility of saline soils.

Table 7.10. Productivity (mean ± SEM) of fodder crops (species and varieties), harvested on 25 June, 2008 (Kyzylkum, Uzbekistan)

	Species and vatiety	Plant density (thousand/m^2)	Height (cm)	Green mass yield (t/ha)
1.	Atriplex Nitens	546.4±3.7	124.6±4.1	12±1.3
2.	Kochia scoparia	763.3±2.4	86.9±4.3	22.3±4.2
3.	Pearl millet			
	• Raj 171	166.6±2.8	167.3±4.1	24±1.9
	• BR 75	116±3.7	91.7±8.6	30±2.6
	• HHVBC	116.6±4.8	169.7±9.2	40±3.1
	• JCMC	106.3±3.2	126.3±7.1	40.6±1.9
	• Aip 19586	83±2.1	176.3±5.2	58±4.3
	• Aip 13150	70±3.2	136.3±4.8	78±5.8
	• Aip 22269	63±4.8	117.6±5.3	50.6±4.1
4.	Glizerrisa glabra (licorice)	163±5.9	131.6±5.1	23±3.7

Estimation of edibility of halophyte species

On 30 June halophytes were sown (row sowing with row space of 60 cm) as cover crop under pearl millet and sorghum (local varieties) on total area of 312 m^2. Two trials were conducted for estimating the edibility of halophyte species. In trial one (1): Food ration included hay of separate species of halophytes. Rations included combined fodder of maize (fine-cut leaves and stems) and chopped hay of halophyte mixed @ 30, 50 and 100% of the total ration, respectively. Hays of halophytes consisted of 60% (Kochia scoparia), 30% Atriplex Nitens, and 10% Climacoptera lanata.. The feeding trial conducted with 8 gelded rams indicated that the Percentage of edibility (%) varied from 65- 85 %, with Atriplex Nitens as the preferred halopytic fodder.

Results indicated that rations (Experiment 1), including halophyte with value of 30-50 % had highest quality as compared with ration mixed with halophyte. Such rations, provided as wet mesh are willingly consumed by animals. Edibility of ration in case of hay of halophytes (30 %) was 84.3%, and in case of hay mixed with (50% proportion) halophytes was 79.8 %. Ration that included hay of halophytes of 100 % was 75.4 %. (Table 7.11).

Table 7.11. Edibility of halophytes by gelded rams (n=8) (Kyzylkum, Uzbekistan)

Plant	Weight of food (kg)			Percentage of edibility (%)
	Total	Included		
		Consumed	Left over	
Kochia scoparia	12.0	9.3	2.7	77
Atriplex Nitens	12.0	10.2	1.8	85
Climacoptera lanata	12.0	7.8	4.3	65

Activity 7.4. Evaluation of diversified, salt tolerant crops for enhancing biomass production for livestock in degraded rangelands.

The purpose of research activity was to introduce new crops and develop production technologies for fodder, cereal-legume crops such as barley (var. Mavlono), Ray, *triticale*, Indian mustard, winter wheat (var.Kroshka), safflower, Indian rapeseed, pearl millet (Raj, HB-75, HHVBC, JCMC and AIP cultivars), as well as AICPH accessions in sorghum. The green biomass production is given in table 1.

Total experimental area under winter crops and halophyte was 0.9 ha with the following details:

1. Barley "Mavlono" variety, Furrow irrigation, 4 rows, 312 m^2
2. Barley "Mavlono" variety, Flood irrigation, 4 rows, 312 m^2
3. Winter rye, Furrow irrigation, 4 rows, 312 m^2
4. Winter rye, Flood irrigation, 4 rows, 312 m^2
5. Triticale, Furrow irrigation, 5 rows, 390 m^2
6. Indian mustard, 1 row
7. Wheat "Kroshka" variety, primed seed, 8 rows, 624 m^2
8. Wheat "Kroshka" variety, unprimed seed, 8 rows, 624 m^2
9. Saflower, 1 row, 78 m^2
10. Amarant, 5 rows, 390 m^2
11. Climacoptera, 6 rows, 468 m^2

12. Amarant, 4 rows, 312 m^2
13. Licorice, 75 m×2.40 m, 3 rows, 180 m^2
14. Saflower, 6 rows, 468 m^2
15. Rapseed, 4 rows, 312 m^2
16. Atriplex "Nitens", 4 rows, 2.4×56=134 m^2
17. Climacoptera, 4 rows, 2.4×56=134 m^2
18. Kochia, 2 rows×1.2=67 m^2
19. American collection legumes, 3 rows, 40×1.8=72 m^2

Summer crops

20. Pearl millet "Raj 171" variety, 4 rows, 120×2.4=288 m^2
21. Pearl millet "BR-75" variety, 4 rows, 120×2.4=288 m^2
22. Pearl millet "HHVBC" variety, 4 rows, 120×2.4=288 m^2
23. Pearl millet "HHVBC" variety, 4 rows, 120×2.4=288 m^2
24. Pearl millet "Raj 171" variety, 4 rows, 120×2.4=288 m^2
25. Pearl millet "JCMC" variety, 1 row, 120×0.6=72 m^2
26. Pearl millet "AIP 19586" variety, 1 row,120×0.6=72 m^2
27. Pearl millet "AIP 13150" variety, 1 row, 120×0.6=72 m^2
28. Pearl millet "AIP 22269" variety, 1 row, 120×0.6=72 m^2
29. Legumes "AICPH-88039" variety, 4 rows, 312 m^2

Collection of Native Germplasm of Shrubs/ trees and grasses tolerant to abiotic stresses.

A seed collection was organized in the Kyzyl kum desert. Native germplasm was collected for the species for use at site for experimental purposes and also for seed multiplication. The amount of seed collected and used during the summer season is indicated in table below. Rest of the seed material will be grown during the autumn season for seed multiplication and distribution amongst the local farmers to rehabilitate their lands against soil erosion.

Table 7.13. Seed of tree and grass germplasm collected and used (Kyzylkum, Uzbekistan)

Latin name of crops	Number of collected samples	Seed's weight (kg)		
		Total seed collected, kg	Kg seed Planted	Seed Available
Kochia prostrata	5	6	-	6
Climacoptera lanata	4	10	7	3
Suaeda	1	2	-	2
Haloxylon aphyllon	7	40	-	40
Halothamnus subaphullus	4	120	-	120
Salsola Richterii	2	20	-	20
Salsola orientalis	2	20	-	20
Atriplex canescens	1	4	-	4
Atriplex nitens	1	10	7	3
Ceratoides eversmanniana	1	20	-	20
Agropyron desertorum	1	2	-	2
Kochia scoparia	1	6	-	6
Total	30	260	14	246

Table 7.14. Yield of different fodder crops and grasses in check basin and furrow irrigated systems in Kyzylkesek site

Crops	Soil salinity, mS/m , 0-75cm	Green fodder Yields; tons/ha	
		Check basin	Raised Beds- Furrows
Barley	25	2.3 t/ha	2.1 t/ha
Ray	24	1.9 t/ha	1.7 t/ha
Triticale и	23	-	2.6
Indian Mustard	26	-	-
Winter wheat	37	1.6	1.6
Safflower	33	ND	4.3
Amaranth	33	ND	ND
Pearl millet-Aip 13150-	34	-	78±5.8
Glyciriza (Licorice)	36	-	23.0
Atriplex Nitens	35	-	12±1.3
Kochia Venchenia	32	-	22.3±4.2

In view of the sandy saline- sodic nature of the soils, basin irrigation generally required more time to irrigate the plots than the furrow-raised system. We observed that under severe soil moisture stresses, it was more important to meet crop water demands using saline or non saline waters than not irrigating for fear of salinity build up using the saline artisan well water. Possibly due to this reason, no significant difference could be observed under check-basin and furrow- raised bed systems. It was always a sort of deficit irrigation during the crop duration. Unfortunately data on total water use in the two systems could also not be measured due to remote handling of the experiment.

Kochia scaparig yield (green biomass) was found to be more efficient (22.3 t/ha).Preliminary data evidence that licorice *[Glizerriza glabra]* gave quite promising results as more perspective crop for Kyzylkum conditions. Kyzylkum sandy soils promote to developing vigorous root system and rapid self-replication of licorice. Biomass of licorice is good forage fodder, and roots - high-value raw material for pharmaceutical and food industry. Licorice yielded 23.0 t/ha. Harvesting of roots will be estimated during fall.

It was observed that performance of the *Triticale* was better than barley and wheat crops. Besides grains triticale and barley can provide straws for the livestock production which is the main stay of the desert dwellers. Safflower, a salt tolerant crop was also found very promising in the desert ecology. However, pearl millet cultivar AIP- 13150 was best for biomass production for the livestock.

It may be mentioned here that desert dwellers generally keep their livestock during the winter season primarily on the survival rations varying between 2-5 kg/day for 2-3 months. If the herd size is say 1000 animals they generally would store hay close to 270 tons (3kg/day) to feed during 90days.If Pearl millet-Aip 13150 is grown on just 10 ha near the irrigation points, it will be sufficient to double the ration to improve the winter survival, health and productivity of the livestock.

Activity 7.5. Calibration of the Green Seekers- Optical Sensors

Please the combined results from all the sites on page 111-115.

Activity 7.6. Use of Precision Laser assisted land leveling systems

Training has been imparted to farmers, tractor operators and the technicians of the Mechanization Institute and to research students of the SANIIRI in March and June 2008. A 2ha field was laser leveled in July and then planted with maize using the multicrop raised bed / zerotill seed –ferti-planter. The detailed out puts will be available only in autumn when field become available for leveling.

Activity 7.7. Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options (Responsible H. Maksadov, S.Yusupov)

Activities planned:

- 4 workshops cum traveling seminars will be organized by the national teams at each site during the years to disseminate SLMR options and to sensitize policy makers and all stakeholders. SLMR options will shared using mechanisms such as Farmer's Fairs, Field Days, Farmers' Schools etc
- Mechanisms will be evolved for wider community involvement, public awareness and advocacy campaign. Efforts will be made for mainstreaming of the SLM results into national program/ activities.
- At least 3 Dialogues organized on the national TV/Radio networks by the nation team on the SLMR options.

8. Common Technical Program – Developing new methodologies

8A. Calibration and use of Optical crop canopy sensors (GreenSeekers) for measuring crop development, comparing crop management practices for SLM and efficient nitrogen management.

Recently, methods based on measurements of reflectance in the *red spectrum* (defined by chlorophyll content) and near infrared spectrum (defined by living vegetation) of the electro-magnetic spectrum have been used for estimating N requirement early in the crop season. These estimates are based on N uptake and potential yield. It is now well established that Normalized difference vegetative index (NDVI) based on in-season sensor reading can predict biomass, plant N concentration and plant N uptake.

The strategy based on optical sensors thus hold promise in developing N management options and also other uses. Optical sensors used to measure NDVI can also serve as a tool to evaluate differences in crop development over time and space as a result of the treatment differences and for comparing different crop management practices or cultivars in on-station or on-farm trials on farmer fields. Based on NDVI measurement in the cropped field plots it is also possible to map temporal and spatial variability in field and relate to salinity variations. *In the context of SLMR project, the latter facet involving measuring crop development over time and space, and perhaps more important than the use of the sensors for N management.* This is because NDVI relates very well to biomass production. The optical sensor technology allows us to have an integrated and unified index of the health of the root rhyzosphere which relates to biomass and crop vigor and to NDVI. Processes in the root rhyzosphere soil volume determine the anchorage, supply of nutrient and water for the growth of the plants. NDVI measurements at various crop development stages thus offer us a unique opportunity to monitor soil health, extent of land degradation and spatial variability.

Decisions regarding improvements in fertilizer N use efficiency are governed amongst other factors on variability in soils, climates, and cropping patterns. One of the most important factors governing any improvement in N use efficiency relates to i) fertilizer-N substitution value of soil N and ii) amounts and variations in the indigenous N supply during crop season to determine the optimal timing and amount of fertilizer N applications. Since indigenous N supply is highly variable in time and space in soils, it is difficult to accurately estimate indigenous soil N supply for enhancing fertilizer N use efficiency in rice and wheat. Successful strategies need to provide principles that can be developed into a range of management options based on location specific fertilizer N requirements of crops according to (i) seasonal / year-to-year variations in climate (particularly solar radiation) and (ii) the spatial and temporal variations of indigenous soil N supplies.

In order to improve fertilizer N use efficiency, it is crucial to reduce losses of N from the soil-plant system by synchronizing N applications with crop demands. Since rice-wheat systems have contrasting edaphic requirements, soil test based N fertilizer recommendations generally have not been successful. Therefore, dynamic N management calls for plant need–based application of N for achieving high yield and N use efficiency. Dynamic N management requires rapid assessment of leaf N content, which is closely related to photosynthetic rate and biomass production and is sensitive indicator of changes

in crop N demand within the growing season. The chlorophyll or SPAD meter, and its inexpensive and simple alternative, the leaf colour chart (LCC) can quickly and reliably monitor relative greenness of leaf as an indicator of leaf N status. These tools have provided an excellent opportunity in terms of developing real-time N management strategies for rice but these tools do not take into account photosynthetic rates or the biomass production and expected yields for working out fertilizer N requirements. Whereas chlorophyll or SPAD meter and LCC have been used successfully particularly in rice, their utility is often constrained in wheat and other upland crops. Due to continuous wet soil moisture regimes in rice crop, fertilizer N can be applied at any time which is not true for many upland crops. In upland crops, fertilizer applications, to be effective, must be synchronized with irrigation cycles.

In above context, this experiment will be carried out using optical sensors - GreenSeeker^{TM} (hand held optical sensor Model 505, NTech Industries, Ukiah, CA, USA).

Experiment with application of different amount of nitrogen for Green Seeker calibration will be carried out on Andalin massive of irrigation situated within Almata region (oblast)

Treatments (amount of nitrogen in kg/ha of active component) - 0, 30, 60, 90, 120, 150, 180, 210, 240, 270.

Number of treatment – 4-6.

Size of plots – 3 m x 3m.

Experiments were planned in all 5 countries. Each collaborator was given the choice to have N levels as per local soil situations and monitor NDVI (for each N level a minimum of plot size of 9m^2) in plots supplied with graded level of N.

Methodology adopted by partners

1. Lay out of the experiment. Apply fertilizer xamat N in graded doses on different dates. As an example, a case from Cotton Growing Institute has been given here.

Table 8.1 Nitrogen fertilizer application dates and rates during crop season

	N					
Total	**0**	**50**	**100**	**150**	**200**	**250**
12.02.08	0	50	50	50	50	50
24.03.08	0	0	50	100	100	150
21.04.08	0	0	0	0	50	50

2. Take NDVI observations at different dates after emergence (DAE). Note the emergence date correctly or else use date of planting/ sowing date.

3. Count the vegetation period from the emergence date or planting date, taking into account only the vegetation period with the Growing Degree Days (GDD) > 0 .This implies that during the winter season days with GDD values <0 will not be counted.

4. Exclude the non-vegetation period (snow period) when GDD<0 or count the period as vegetation period when GDD>0 as per equation below:

$$GDD = (Tmin + Tmax)/2 - 4.4°C>0 \quad (8.1)$$

Where, Tmin, T max are minimum and maximum air temperature expressed in ^{o}C. Typical effects of Nitrogen levels to NDVI readings of winter wheat have been shown in Figure 8.1

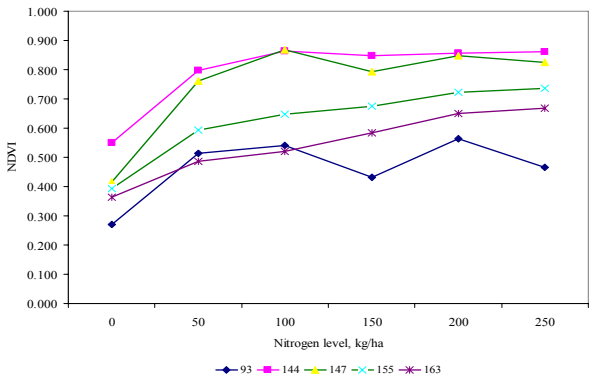

Figure 8.1 Effect of N levels on the NDVI of winter wheat on different dates (after sowing)

4. Calculation of Response Index (RI) using equation:

The response Index of N can be defined by the following equation
$RI = (NDVI_{NRS}/NDVI_{i=0;\ n\ and\ d=0,\ n})$

Where $NDVI_{NRS}$ refers to NDVI of N- Rich strip or plot where N is maximum and there is no N deficiency (hidden or otherwise. $NDVI_{i=0;\ n\ and\ d=o,\ n}$ refers to NDVI of each N treatment and each replication.

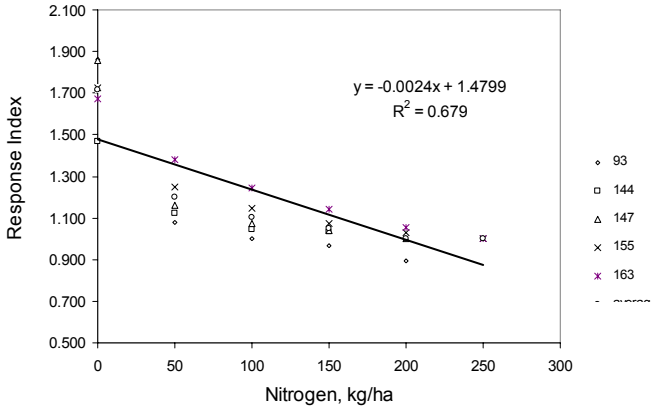

Figure 8.2 Typical Response Index of N in wheat.

5. Calculation of INSEY (*In-Season Estimated Yield*)

$INSEY = \{NDVI_{i=0;n;\ D=0,n}\}$ / DAS, where DAS= Days after sowing or emergence as the case may be) and when GDD>0

1. Collect crop yield data from all the N level plots and treatment replications.
2. Plot all the INSEY at different dates against averaged crop yield data for different N levels on a graph describing yield as function of INSEY.

3. Establish equation describing Yield as function of the INSEY.
4. Establish equation describing Yield as function of the INSEY.

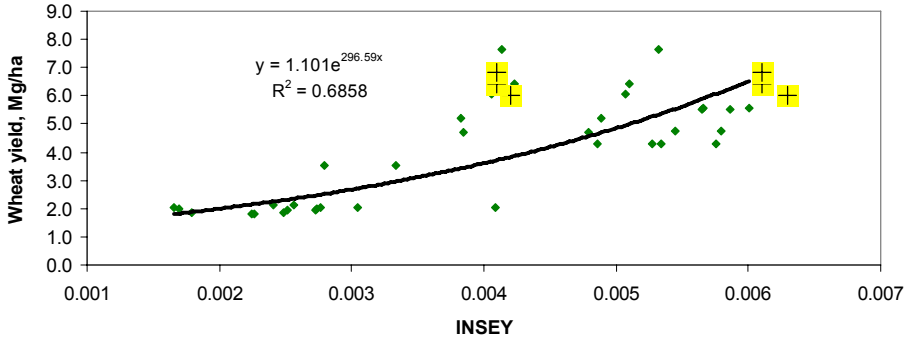

Figure 8.3 Winter wheat yield as function of INSEY at 144&147 day after sowing (DAS) (Uzbekistan, Akkawak, Tashkent province5&8 May 2008), 118&129DAS (Turkmenistan, 18&29 April 2008), 139&154DAS (Kyrgyzstan, 25 April; 10May 2008) .Check points marked in yellow collour-142&167DAS(Uzbekistan, Pahtakor, Jizakh province; 19 April, 14 May 2008).

Table 8.2 Prediction of winter wheat yield at Pakhtakor district, Uzbekistan, using Yield - INSEY relationship at 142 days after sowing; Y = 1.101×Exp^(296.59×INSEY)

Days after sowing	Control	RB without residues	RB with residues
142 Days after sowing	7.07	6.65	6.75
167 Days after sowing	3.83	3.65	3.76
Actual crop yield	6.00	6.44	6.85
% Error (142 DAS)	-17.83%	-3.26%	1.46%
% Error (167 DAS)	36.17%	43.25%	45.13%

The results show that winter wheat yields can be predicted at 142 days after seeding in Uzbekistan. In order to strengthen the Yield -INSEY relationship further more data with respect to different years, locations and cultivars will be required. The experiment will be repeated in the coming winter season.

Prediction of Maximum crop yield based on NDVI data

1. Sense the N Rich Strip (NRS) or plot where N is maximum and there is no N deficiency

2. Sense a strip parallel to the NRS (Farmer Practice or FP)

3. Determine how many days from planting to sensing (days, GDD>0)

4. Compute INSEY (NDVI/days from planting to sensing where GDD>0)

5. Predict yield YP0 = Predicted or potential yield based on growing conditions up to the time of sensing, that can be achieved with no additional (topdress) N fertilization (units:

Mg/ha). For this purpose equation should be developed YP0= Function (INSEY) or use ready equations developed in Oklahoma University for winter wheat
YP0 = 0.5902*EXP (INSEY*258.2)

6. YPN = Predicted or potential yield that can be achieved with additional (topdress) N fertilization based on the in-season response index
(RINDVI) (units: t/ha) = (YP0)*(RINDVI)

Generating a Fertilizer N Rate Recommendation

1. RINDVI= NDVI from plots receiving adequate but not excessive pre-plant N, divided by NDVI from plots where no preplant N was applied

2. Computing Grain N Uptake at YP0 and YPN:

The predicted amount of N that will be removed in the grain at harvest (using our equation generated from 1E) is computed as follows:

Grain N uptake, YP0 = Grain Yield (YP0) * expected % N in the Grain or Forage
GNUP_YP0 = YP0*0.0239
GNUP_YPN = YPN*0.0239

Where 0.0239 represents (0.0239 kg N uptake / kg grain or 2.39% N in the grain for winter wheat grown in Oklahoma.

For example, if YP0=3000 kg/ha, and desired yield is YPN=6000 kg/ha than

GNUP_YP0 = YP0*0.0239=71.7 kg/ha
GNUP_YPN = YPN*0.0239 =143.4 kg/ha.
N= GNUP_YPN- GNUP_YP0=143.4-71.7=71.7 kg/ha

3.Making Fertilizer Recommendations based on GS data

The fertilizer N rate to be applied is computed by subtracting the predicted amount of N to be removed in the grain at YP0 from the predicted amount of N to be removed in the grain at YPN, divided by Nitrogen use efficiency. This value can range anywhere from 50% to 70%.

By dividing N to NUE or 71.7/0.6=113.6 kg/ha we get amount of fertilizer rate should be added into the soil in order to achieve potential crop yield of 6000 kg/ha.

Table 8.3 Differences in actual added and needed N for attaining the winter wheat yields in Uzbekistan, Kyrgyzstan and Turkmenistan.

Country	Yield in N,0, t/ha	Actual grain yield, t/ha	Actually added N Kg/ha	Actually Needed N, Kg/ha	Excess N applied Kg/ha
Uzbekistan	2.04	6.00	180	157	23
Turkmenistan	3.55	7.65	200	163	37
Kyrgyzstan	1.80	2.11	150	12	138

The trial will be repeated next winter season for a more stable INSEY- Yield Relationship

8B. Developing a methodology for screening of improved Chickpea germplasm- for vigor and weed competitiveness.

Evaluating the performance of chickpea cultivars for cold, drought and salinity onditions-Efforts towards Crop Diversification through Evaluation of the Chickpea cultivars (ICARDA-component of developing a methodology) .

Chickpea is a tap rooted legume, fixes atmospheric N, do not require fine seed bed preparation for planting, (soil tilth), and has low water requirement. Chickpea residues although fed to livestock in South Asia, are rarely used in Central Asia. Thus the crop residues can be used to provide surface cover to reduce weed menace, soil erosion, and cut back water losses through evapotranspiration. Results of earlier ICARDA screening trials had shown that productivity of the chickpea, planted in winter season is almost double of the spring season crop. Therefore, in order to promote chickpea as diversification crop, thirty-six (36) cultivars of chickpea were evaluated in raised bed-furrow irrigated system for their yield performance, early- and mid- season vigor (competitiveness to weed) and ability to tolerate drought, cold and salinity stresses. The study was conducted in Tashkent Agrarian University experimental site with the objective to evaluate yield potential of spring planted chickpea cultivars, multiply seed for further research, and evaluate plant vigour during crop season so that selected cultivars are competitive to weeds and are stable for spring and winter season plantings.

The species were sown in randomized complete block design on 5 March 2008 in a non-saline soil (EC=10-13 ms/m). Seedling emergence was noted in late March / early April 2008 for different cultivars. Green seeker Optical sensor was used to determine NDVI values at 7 day interval from germination to crop maturity stage. Because of breeder seed restrictions, thirty-six (36) cultivars were planted in two replications. The plot size was 2.1 m^2 ($0.7 \times 3.0 = 2.1$ m^2). Total number of subplots was $36 \times 2 = 72$. Typical plant (NDVI) growth curves /dynamics of the cultivars are shown on Figure 8.4 for all the chickpea accessions.

NDVI indices show that there were wide variations in early growth vigor of the cultivars. The varieties that are more vigorous in early growth stages compete with weeds more efficiently. Using the NDVI measurements, cultivars were categorized into (i) maturity group – early and late, (ii) crop vigor at early and mid-season growth rates and (iii) the yield potential. Results of the trials are given in Table 8.4.

Based on the field results five high yield cultivars with yield potential > 3tons/ ha - (2) from the early maturity and (3) from late maturity group were identified. It was observed that cultivars such as FLIP 03-63C with good early and mid season vigour, high yield potential and early maturing can be very useful in the crop diversification program in Central Asia.

The conclusion that cultivar like FLIP 03-63C (high yield potential) is very appropriate. From the regional perspective, it is observed that cold is very common in early growth stages. Thus, lines which are moderately vigorous in early season, will escape cold and fast vigor in mid late season will help them escape terminal drought conditions. Therefore, the germplasm should also be subjected to winter cycle for devising the right strategy for screening of the newly developed germplasm to promote diversification of cotton-wheat

systems in Central Asia. The trial need would be repeated in winter 2008 for cold and water stress tolerance.

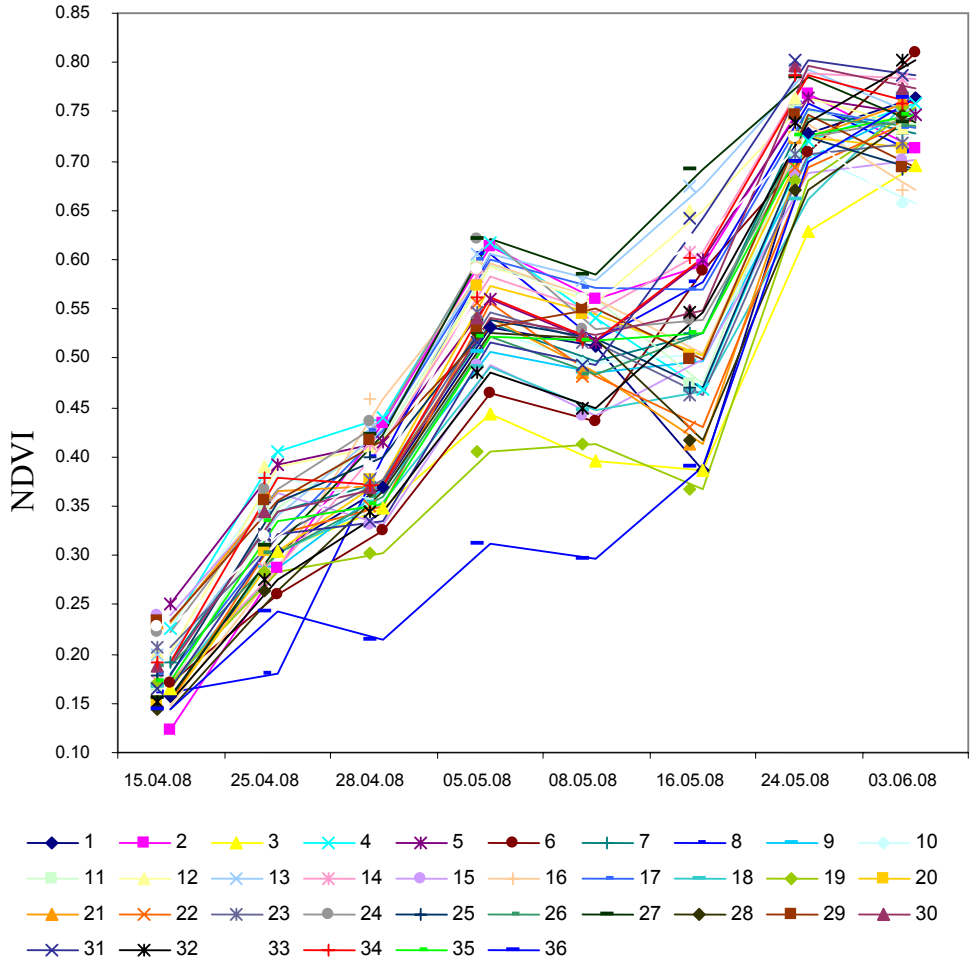

Figure 8.4 NDVI values of chickpea at TAU site on different dates

Table 8.4 Crop characterization of 36 chickpea cultivars at Tashkent Agrarian University site

SNo.	Entry name	In-season Vigor		Maturity Group	Crop yield, t/ha
		Early	Mid-late		
1	FLIP 97-118C	M	M	E	1.97
2	FLIP 97-120C	S	M	E	2.07
3	FLIP 99-34C	M	S	E	1.84
4	FLIP 00-20C	M	M	E	2.53
5	FLIP 01-32C	F	M	E	2.36
6	FLIP 01-50C	M	F	L	3.35
7	FLIP 01-52C	M	M	E	2.57
8	FLIP 01-63C	M	F	E	2.92
9	FLIP 02-02C	M	M	E	2.43
10	FLIP 03-17C	M	S	E	1.35
11	FLIP 03-31C	M	F	L	2.69
12	FLIP0 03-35C	M	F	L	2.89
13	FLIP 03-63C	M	F	E	3.30
14	FLIP 03-71C	M	F	E	2.37
15	FLIP 03-74C	M	S	L	2.81
16	FLIP 03-83C	M	S	L	1.66
17	FLIP 03-87C	M	M	E	1.61
18	FLIP 03-132C	S	M	E	1.54
19	FLIP 03-134C	S	F	L	2.55
20	FLIP 03-135C	S	S	E	2.03
21	FLIP 03-150C	S	F	L	2.51
22	FLIP 03-151C	S	M	E	2.52
23	FLIP 03-152C	M	M	E	2.55
24	FLIP 04-2C	F	M	E	2.01
25	FLIP 04-4C	M	F	E	2.59
26	FLIP 04-18C	M	F	L	3.00
27	FLIP 04-31C	S	F	E	3.46
28	FLIP 04-32C	S	M	E	2.33
29	FLIP 04-34C	M	M	E	2.25
30	FLIP 04-35C	M	F	L	3.19
31	FLIP 04-38C	S	F	L	1.46
32	FLIP 82-150C	S	F	L	2.37
33	FLIP 88-85C	S	S	E	2.32
34	FLIP 93-93C	M	F	E	1.97
35	ILC 482	M	M	E	0.78
36	Uzbekistansky 36	S	S	E	2.26

Note = F-Fast, M-Moderate, S-Slow Maturity Group = (E-Early, L- Late)