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Working Paper 14

Agricultural Research Collaboration in Tajikistan

Summary of the progress of the research and capacity building partnership between Tajikistan and International Agricultural Research Centers:

- Productivity of agricultural production systems
- Natural resources conservation and management
- Conservation and evaluation of genetic resources
- Socioeconomic and policy research

AVRDC The World Vegetable Center · Bioversity International · CIMMYT · Centro Internacional de la Papa CIP · IFPRI · IWMI International Water Management Institute · MSU Michigan State University

and in collaboration with the Tajik Academy of Agricultural Sciences

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Acronyms

ADB	Asian Development Bank
AVRDC	World Vegetable Centre (Asian Vegetable Research and Development Centre)
BMZ	The Federal Ministry for Economic Cooperation and Development (Germany)
CA	Conservation Agriculture
CAC	Central Asia and the Caucasus
CACILM	Central Asian Countries Initiative for Land Management
CC	Climate Change
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Centre
CIP	International Potato Centre
CLB	Cereal Leaf Beetle
CLCA	Crop-Livestock Conservation Agriculture
CMO	Canal Management Organization
CRP	CGIAR Research Program
CPRI	Central Potato Research Institute
CRSP	Cooperative Research Support Programme
EBRD	European Bank for Reconstruction and Development
EU	European Union
FAO	Food and Agriculture Organization of United Nations
GEF	Global Environment Facility
GIZ	The German International Cooperation Agency
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICBA	International Centre for Biosaline Agriculture
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IDB	Islamic Development Bank
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
IWRM-FV	Integrated Water Resources Management in the Fergana Valley
IWWIP	International Winter Wheat Improvement Program
MSU	Michigan State University
NARS	National Agricultural Research System
NGO	Non-Governmental Organization
PFU	Program Facilitation Unit
SDC	Swiss Agency for Development and Cooperation
SIC-ICWC	Scientific Information Centre of Interstate Commission for Water Coordination in Central Asia
SLMR	Sustainable Land Management Research
STT	Small Transboundary Tributaries
SVTC	State Variety Testing Commission
SWCA	South, West and Central Asia
TAAS	Tajik Academy of Agricultural Sciences
TPS	True Potato Seed
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WPL-PL	Water Productivity Improvement at Plot Level
WUA	Water Users Association

Executive Summary

This Working Paper presents an overview of the collaborative research and capacity building done by international research centers and their partners in Tajikistan since 2006 for increasing the productivity of agricultural systems; natural resources conservation and management; conservation and evaluation of genetic resources; and socioeconomic and public policy research in Tajikistan.

The work of the Regional Program on Sustainable Agricultural Development in Central Asia and the Caucasus, hosted and led by the International Center for Agricultural Research in the Dry Areas (ICARDA), supports the goals of Central Asian and Caucasus countries to increase agricultural productivity, food and nutritional security by developing and transferring new agricultural production technologies, and ensuring the sustainable use of natural resources -- an integrated agro-ecosystems approach.

To make agricultural systems in Tajikistan more productive, the CGIAR and non-CGIAR agricultural research centers, together with their national partners have pursued germplasm enhancement; the improvement of national seed supply systems; livestock production systems and integrated feed/livestock management; and integrated pest management.

The partnership between the international centers and Tajikistan has delivered a range of research and capacity building activities in four areas:

- Productivity of agricultural production systems
- Natural resources conservation and management
- Conservation and evaluation of genetic resources
- Socioeconomic and policy research.

Key achievements:

- **Germplasm enhancement** of cereals, potato, food legumes, sorghum and pearl millet, and vegetable crops.
- **Improved crop varieties with higher yield and tolerance to stress factors.** Improved four new wheat varieties; two of potato; one of barley; three of chickpea; and one of pearl millet; and many vegetable varieties using new plant genetic material that was introduced, tested and adapted to local conditions. New frost tolerant chickpea varieties are sown in autumn, increasing yield by 15-20% compared with spring planting. To date, several hundred farmers have adopted them.
- **Seed multiplication and delivery.** Increased efforts to deliver improved varieties to farmers for all improved crops. Scientists in Tajikistan receive more than 1,000 new crop entries from international research centers for testing and improvement each year.
- **Improved livestock production.** The initiative in Tajikistan that trained artisans and livestock breeders in value-added fiber production has increased employment and income opportunities for poor rural populations, particularly women. Another study identified two salt-tolerant, high-yielding varieties of alfalfa, which brings increased fodder to livestock owners.
- **Ecologically-based integrated pest management packages** are being used for improved field and vegetable crop production in Tajikistan.
- **New technologies for sustainable water and soil management.** A range of practices have been developed, introduced and adopted for improved crop management; irrigation, drainage, and water basin management; conservation agriculture; and rangeland rehabilitation.
- **Rehabilitating rangelands.** New species and improved varieties of forage crops are being introduced for rangeland rehabilitation and management. Integrated Water Resources Management has been in place in the Fergana Valley since 2001; it ensures more sustainable use of irrigation water by Water User Associations.**Conservation and evaluation of genetic resources.** Considerable work was done to document and preserve local varieties particularly in fruit trees - apple, apricot, pear, almond, currant and grape. A national gene-bank was organized at the Research Institute of Agriculture, maintaining cereals, legume and forage crop collections.. This work also facilitated the creation of the Tajikistan's National Centre for Plant Genetic Resources.

Introduction

Tajikistan is an agrarian country. Agriculture is one of the most important and biggest earners for the country's population, providing people with food and employment opportunities, especially in the rural areas. It accounts for about 60% of employment and 30% of GDP, according to widely available sources. The country's agricultural sector is based on cotton, cereals (mainly wheat), potato, vegetable, fruit crops, and livestock production. About 70% of the land in use for agriculture depends on irrigation. Forest cover is very low (between 3-5%) with predominantly protection forests in higher elevations. Driven by the high profile of agriculture in a low-income country, Tajikistan introduced a reform process aimed at transition to a market economy that began after independence in 1992. It led to the creation of a new category of midsized peasant farms, known as the *dehkan* farms. Overall agricultural production has shown a remarkable recovery since the mid-1990s to date.

Recognizing the needs and challenges associated with the transition in agriculture, and seeing a great potential for pro-development research, beneficial partnerships started to be forged between Tajikistan's researchers and the international community shortly after the break-up of the former Soviet Union. It was in 1998 when ICARDA, later joined by several other international agricultural research centers, decided to set up an office for the Region of Central Asia and the Caucasus, in Tashkent, Uzbekistan. Today this hub has grown into a consortium of international not-for-profit research organizations under the umbrella of the Regional Program for Sustainable Agricultural Development in Central Asia and the Caucasus. The Program operates in Tajikistan and four other Central Asian countries, plus Azerbaijan, Armenia and Georgia. It supports all countries in achieving the strategic goals of increased productivity, food and nutritional security through developing and transferring modern production technologies, while ensuring protection and sustainable use of natural resources. Overall, the Program aims at reducing poverty and hunger, improving human health and nutrition, and enhancing ecosystem resilience through high-quality international research, partnership and leadership.

The collaborative efforts have been guided by the Tajik Academy of Agricultural Sciences with its network of research institutes and field stations, which represents a significant pool of scientific knowledge, expertise and advice in agriculture in the country. Increasingly, collaboration has been extended and the Program works with additional partners in universities, private sector, associations of farmers, and the civil society. The policy support provided by the Government of Tajikistan has been instrumental for advancing the agricultural pro-development research over the years of collaboration.

Capacity-building has been an important element of cooperation between the international centers and Tajikistan. Scientists work with their counterparts in Tajikistan to share new technologies, knowledge and enhance the skills of local researchers and farmers. As part of these efforts, local partners are provided with new equipment and facilities. Many local researchers, farmers and agricultural workers have been trained at international centers and participated in regional and international workshops.

1. Productivity of Agricultural Systems

1.1. Germplasm Enhancement

Since the Program's establishment in the Region, improving crops by introducing advanced germplasm and conducting collaborative research activities with National Agricultural Research Systems (NARS) partners in Tajikistan has been among its priorities. For instance, collaboration with ICARDA and the International Maize and Wheat Improvement Centre (CIMMYT) in crop improvement has led to introduction of improved germplasm of wheat, trial and selection of new varieties jointly with Tajikistan's scientists, seed multiplication of improved varieties, training of young scientists and development of research infrastructure. Similar collaborative activities are carried out between Tajikistan and the International Centers in other crops including chickpea, lentil, soybean, potato, vegetable crops, sorghum, pearl millet.

1.1.1 Grain Crops

Collaboration of Tajikistan with ICARDA and CIMMYT in wheat improvement includes introduction of improved germplasm of bread wheat, testing and selection of new varieties jointly with Tajik scientists, seed multiplication of improved varieties, training of young scientists and development of research infrastructure. Similar collaborative activities are carried out between Tajikistan and ICARDA in other crops including durum, barley, chickpea, lentil, fababean and grasspea. This crop improvement collaboration in Tajikistan is undertaken primarily with the Farming Research Institute under the Tajik Academy of Agricultural Sciences. There has also been research collaboration of ICARDA and CIMMYT with the Tajik Agrarian University.

Germplasm introduction and varietal release

Through this international collaboration, more than 1,000 improved crop germplasm materials are provided to Tajikistan every year. A number of crop varieties have been released through international collaboration in Tajikistan (Table 1). The collaboration involving the Farming Research Institute and the Tajik Agrarian University in Tajikistan and ICARDA and CIMMYT has resulted in identification of new varieties of winter wheat and spring wheat. The new improved wheat varieties 'Ormon', 'Alex', 'Sadokat' and 'Chumon' are resistant to yellow rust, and possess high yield potential and superior agronomic traits. These varieties are expected to replace several yellow rust susceptible varieties currently being grown in Tajikistan, and thus help to reduce economic losses to the farmers.

Farmers' Field Day demonstrating out-scaling of chickpea in Fayzobod District, Tajikistan (24 June 2012).

In partnership with ICARDA, one barley ('Pulodi') and two chickpea ('Hisor-32' and 'Sino') varieties were released in Tajikistan to date. 'Pulodi' is an early-maturing barley variety suitable for rainfed conditions. It has higher yield and better resistance to diseases than the locally grown varieties. 'Hisor-32' and 'Sino' are high-yielding chickpea varieties with large grains and Aschochyta blight resistance. These chickpea varieties possess a good level of cold tolerance, hence are suitable for planting in autumn as well as in spring. When planted in autumn, chickpea has shown 25 to 50% higher yield than traditional spring planting in Tajikistan.

Adoption of new improved varieties

The Farming Research Institute and ICARDA have undertaken extensive activities on adoption of new improved varieties of cereals and legumes in Tajikistan. The institutions launched a pilot project in 2010 to out-scale chickpea varieties 'Hisor-32' and 'Sino' to the rural farmers starting with 50 farmers. Within three years, these new chickpea varieties have reached more than 300 farmers across more than 18 districts in Tajikistan. The production of chickpea is not only contributing to the better nutrition of the rural farming communities but also improves soil health of the fields where it is cultivated. Similarly, out-scaling activities were also undertaken using improved varieties of barley and wheat.

Table 1. Varieties of cereal and legume crops selected from international nurseries in Tajikistan

	Crop	Variety	Nursery name	Pedigree/Entry name	Year	
					Submitted	Released
1	Wheat	Alex	1WWEEERYT-11	PYN/BAU	2002	2007
2	Wheat	Norman	5FAWWON-37	OR1.158/FDL//BLO/3/SHI4414/Crow	2000	2007
3	Wheat	Ormon	8FAWWON-36	NWT/3/TAST/SPRW//TAW12399.75	2002	2008
4	Wheat	Tacicar	5FAWWON-35	TAST/SPRW//ZAR	2000	
5	Wheat	Iqbol	Unknown	RSK/CA8055//CHAM6	2005	
6	Wheat	Shokiri	5WEERYT-17	SHARK/F4105W2.1	2009	
7	Wheat	Faizbakhsh	5EYTIRR-9815	TAM200/KAUZ	2009	
8	Wheat	Chumon	10CWA-WFYT-16	CADET/6/YUMAI13/5/NAI60/3/14.53/ODIN//CI13441/CANON	2011	
9	Wheat	Umed				2011
10	Wheat	Sadokat	Special nursery	JUP/BJY//URES	2006	2011
11	Wheat	Oriyon	Unknown	ND/VG9144//KAL/BB/3/Yaco/4/Vee#5	2005	
12	Wheat	Markaz-3	Unknown	Bochro	2007	
13	Wheat	Yusufi	25ESWYT-22	SOROCA	2007	
14	Wheat	Isfara	25ESWYT -5	SW89.5181/KAUZ	2007	
15	Wheat	Vahdat	25ESWYT -31	VORONA SN079	2007	
16	Wheat	Sarvar	25 ESWYT -9	CHEN\A. sq. (TAUS0//BCN/3/BAV92	2007	
17	Wheat	Vakhsh	3 WON-IR	PASTOR/3/VORONA/CN079	2009	
18	Wheat	Nurbakhsh	6WWEERYT-11	Prina/Star	2009	
19	Barley		Pulodi			2010
20	Barley		Zirotkor-70		2004	
21	Barley		Alanda-01		2004	
22	Chickpea		Hisor-32			2009
23	Chickpea		Sino			2012

In 2012, the Farming Research Institute, ICARDA and CIMMYT started adoption of yellow rust resistant winter wheat varieties in Tajikistan under the CRP WHEAT Partners Grant scheme. This project was started to replace yellow rust susceptible wheat varieties currently being grown by the farmers with new resistant varieties. Under this project, an area of 61 ha was planted in 2012-2013 using yellow rust resistant varieties 'Ormon', 'Alex' and 'Chumon'. In 2013-2014 further seed multiplication will be donein an area of 1,000 ha. In 2014-2015, it is expected that an area of more than 15,000 ha will be planted with these yellow rust resistant varieties. To demonstrate the potential of these yellow rust resistant varieties, a Farmers'Field Day was organized on 4 June 2013 around the seed multiplication plots in Durbat and Turdik farming communities in Tajikistan. The event was attended by men and women farmers, seed producers, policymakers and researchers. Since there were severe epidemics of wheat yellow rust in Tajikistan in 2013, cultivation of the resistant varieties is likely to boost wheat productivity and lower the risk of losses caused by the disease.

Wheat yellow rust problem and resistant varieties in Tajikistan

Participants at the wheat Farmers' Field Day in Tajikistan (4 June 2013).

Wheat is the most important cereal directly linked to food security in Tajikistan. Yellow rust is an important disease of wheat causing substantial economic losses. This is reflected in frequent epidemics of yellow rust with the most recent ones in 2009, 2010 and 2013. Collaboration of the Farming Research Institute and the Tajik Agrarian University with ICARDA, CIMMYT and the International Winter Wheat Improvement Program (IWWIP) has resulted in many improved wheat germplasm materials which have been released as resistant cultivars. These include 'Ormon', 'Sadokat', 'Alex' and 'Chumon'. Inthe 2013 yellow rust outbreak when many commercial varieties including widely-grown 'Krasnodar-99'were severely affected by the disease, several lines in the international nurseries were found out to be resistant. A list of winter wheat advanced lines with high levels of yellow rust resistance in the 2013 yield trial is given in Table 2. These lines could be further evaluated and released as new cultivars, as well as used in the national wheat improvement program.

Table 2. Winter wheat varieties and lines showing high levels of yellow rust resistance in the yield trial conducted in 2013 when the disease outbreak occurred in Tajikistan

Variety name/pedigree	Yellow rust severity (%)
AGRI/NAC//KAUZ/4/55.1744/MEX67.1//NO57/3/ATTILA	10
JI5418/MARAS//SHARK/F4105W2.1	10
SHARK-1/3/AGRI/BJY//VEE/4/SHARK/F4105W2.1	5
SHARK-1/3/AGRI/BJY//VEE/4/SHARK/F4105W2.1	10
BLUEGIL-2/BUCUR//SIRENA	5
RSK/CA8055//CHAM6/4/NWT/3/TAST/SPRW//TAW12399.75	5
KARL//CTK/VEE/3/F1502W9.01/4/STEPHENS	10
4WON-IR-257/5/YMH/HYS//HYS/TUR3055/3/DGA/4/VPM/MOS	5
4WON-IR-257/5/YMH/HYS//HYS/TUR3055/3/DGA/4/VPM/MOS	5
ZARRİN/SHİROODİ/6/ZARRİN/5/OMİD/4/BB/KAL//ALD/3/Y50E/KAL*3//EMU	5
CH111.14511	10
MEX65/MOMT/4/COR71-11460/3/PKG/LOV13//JSW3/5/BUL5052-1	10
REMESLINA	5
POSTROCK	5

1.1.2 Potato

Since the beginning of its activities in Tajikistan in March 2005, the International Potato Centre (CIP) has collaborated with two organizations in the country: the Institute of Botany, Plant Physiology and Genetics of the Academy of Sciences. The first organization was chosen because it has tissue culture facilities and staff competent in biochemistry, biotechnology, plant physiology and genetics, whereas the collaboration with the FAO project OSRO/TAJ/401/CAN "Establishment of disease-free seed potato production in Tajikistan to increase and sustain food availability" was in the field of breeding and selection because it had national experts in potato from among breeders, agronomists and pathologists.

Importance of Potato in Tajikistan

Potato has a high potential for contributing to food security in Tajikistan. It is the only food security and cash crop with comparative advantages in the highlands and a profitable alternative for agricultural diversification in lowland systems. Potato comes second after wheat as a food crop, and brings a high nutritive value to the local diet. Potato areas have increased rapidly in the last decade, grown mostly by smallholder farmers. In Tajikistan these areas increased by about 44% from 25,471 ha in 2000 to 36,720 ha in 2011 (FAOSTAT). Such slow but constant progression is expected to continue in the coming years due to changing eating habits and government's intention to diversify the agricultural production system, which is still based on cotton monoculture. To meet growing demand, areas have expanded because yields have remained low (23.5 t/ha in 2011), although among the highest in Central Asia.

Low yields are due in part to low levels of technical knowledge of farmers, inappropriate European varieties and poor quality seed. These factors are constraints due to the unique impacts of the transition from the centrally planned economies of the former Soviet Union. Most potato farmers were previously farm laborers, most varieties were of Russian origin and all seed came from elsewhere in the Soviet Union. With the collapse of the Soviet Union, many farm laborers became smallholder farmers without any farm decision-making experience, seed started to be imported occasionally from Europe to replace the seed no longer available from Russia and with the imported seed, old local cultivars were replaced by new European varieties, which lack required resistance and adaptive traits, and render farmers dependent on expensive imported seed.

In the past several years, a small but increasing import of ware potatoes has started from Pakistan that many farmers, in the absence of quality seed, have started planting with yields that in certain cases have been higher than 30-40 t/ha. However, consumers complain about the taste of those imported potatoes which belong mostly to Dutch variety 'Kondor'. Some 93% of Tajikistan's territory is mountains, and the country is also influenced by common abiotic constraints that are exacerbated by global warming and consequent climate change affecting the agriculture of those areas situated in the northwest (Sughd) and in the southwest (Khatlon). Results, which were obtained in the course of the BMZ/GIZ-funded project "Enhanced food and income security in SWCA through potato varieties with improved tolerance to abiotic stress" from 2008 to 2011, are important because they have a 'spill-over' effect and can be utilized in many other places where the potato crop is subject to similar abiotic stress conditions.

From 2007 onwards, once the FAO project was completed, other organizations and individuals became active collaborators: the local NGO Tukhmiparvar in Jirgatol, the Institute of Horticulture Bogparvar in Jirgatol and Muminobod districts, and the international NGO Global Partners in Gharm District. Collaboration was also established with Welthungerhilfe (German for World Hunger Aid) in a project funded by the EU and carried out in Kuhistoni Mastchoh and Ayni districts of the Zeravshan Valley from January 2010 till December 2011. Since 2012 CIP has been also collaborating with an agronomist based in Gharm, Mr Khudoynazar Ghoibov, who has shown very good qualities in managing a small True Potato Seed project,getting 56 farmers of Gharm District interested. CIP has, therefore, established the basis for a public-private partnership that needs to be strengthened and supported by the government especially in the case of seed production that, for instance, cannot be managed integrally by the public sector. Unfortunately, the private sector is still nascent but it is the task of local authorities to stimulate its development though a series of measures to facilitate credit, etc.

The Indian Central Potato Research Institute (CPRI) and the German partners in two consecutive BMZ/GIZ-funded projects were very helpful, providing important support in capacity-building in breeding and selection, and potato physiology.

Potato (*Solanum tuberosum* L.), the third most important food crop worldwide after rice and wheat, is much more sensitive to heat and soil moisture content than most of the other crop species, although important diversity has been observed in the germplasm materials. Therefore, our work in Tajikistan proceeded to identify and select heat- and drought-tolerant varieties growing under adverse climatic conditions like those present in Khatlon Region and Fayzobod District during summer and earlyautumn. Resistance to viruses (PVY, PLRV, PVX and PVS) is also another trait of interest researched in the advanced clones on trial in the country. Three growing cycles were also researched in the planting materials: early-maturing (90 days from planting till harvesting) for planting in the lowlands and medium (100-110 days) and late-maturing (120 days) for planting in the highlands during the main cropping season (May-October).

Drought stress and potato

Drought is a severe environmental stress that limits agricultural production worldwide and alarms in particular potato growers in the arid and semi-arid conditions of Central Asia because of the reduced water supply as a consequence of global warming and relative climate change. It is well-known that potato is considered as a drought susceptible crop because of the shallow root system, but in Peru there is a large biodiversity represented by Andean landraces with different kinds of stress tolerance, and wild potato species that grow in desert-like conditions as those present in the coastal area of Peru. These were the basis from which CIP built up sound and robust potato varieties capable to resist adverse climatic and agro-ecological conditions anywhere in the world and particularly in the targeted project areas of Tajikistan.

Heat stress and potato

In Central Asia, according to the Intergovernmental Panel on Climate Change (IPCC), a temperature increase of 1-2°C is expected until 2030-2050. To partially mitigate the effect of temperature on the crop, Tajik farmers in southern Khatlon Region tend to plant towards mid-August to have plants harvested in November.

It would be difficult to keep seed produced in the highlands in suitable physiological conditions until planting time. It would be more logical to re-utilize seed harvested in May and artificially treated to break dormancy. The development of early-maturing and heat-tolerant potato varieties adapted to the long day conditions of Central Asia would allow farmers to invest in a profitable crop that would fit in the interval between two consecutive wheat crops, thus making an incredible contribution to better land use and profits. At present, fallow is normally practiced after the harvest and before the sowing of wheat in June and October respectively in one of the major monoculture patterns in Central Asian lowlands, the other being represented by cotton.

In-vitro advanced clones

One set of diverse potato genotypes with different levels of stress tolerance was provided by the Lima Potato Collection of the International Potato Center (CIP) gene-bank (Peru) in April 2008. It comprised 40 in-vitro advanced clones that were immediately multiplied in the in-vitro laboratory of the Institute of Botany, Plant Physiology and Genetics, Dushanbe, waiting for further mini-tuber production in the screenhouses established on the premises of the same Institute. Mini-tubers were then distributed to the NGO Tukhmiparvar and the Institute of Horticulture for multiplication and trial. Out of these 40 advanced clones, only two really showed adaptability to local conditions in terms of growing cycle, tuberization and abiotic/biotic stress resistance (CIP '395186.6' and '396311.1').

Potato advanced clone CIP '720189', Jirgatol, Tajikistan.

From the first set of clones distributed in 2005 some clones were retained for further observation. From them only CIP '397077.16', '392797.22', '720189' and '392780.1' showed interesting traits. The first one was finally released as variety 'Faizabad' in June 2013 after a long testing procedure that took four years. The other three are still on trial by the State Variety Testing Commission.

True seed for clonal selection

As a result of clonal selection which started with 8,000 True Seed (TS) supplied by CIP-Lima in 2005 and belonging to 20 different families characterized by traits of resistance to viruses and drought, adaptation to long day conditions, and marketability, 14 clones were selected after three field generations in October 2007 (Table 3). A sample of them was distributed to other CAC countries in the spring of 2008.

Table 3. List of retained clones from the regional clonal selection carried out in Jirgatol, Tajikistan (2005-2007).

No	CIP No.	Pedigree	Tuber colour
1	302313.105	BEROLINA x TXY.2	Cream
2	302328.109	DESIREE x 92.187	Cream
3	302312.104	BEROLINA x C93.154	Cream with pinkish spots on stolon end
4	302312.106	BEROLINA x C93.154	White
5	302331.103	DESIREE x C93.154	White
6	302372.102	KONDOR x C93.154	White
7	302478.101	TITIA x C93.154	Red
8	302090.111	397036.7 x LR93.050	White
9	303414.104	C92.140 x 92.187	Red
10	303414.108	C92.140 x 92.187	Red
11	302089.107	397036.7 x C93.154	White
12	302089.108	397036.7 x C93.154	White
13	302089.109	397036.7 x C93.154	White
14	303408.106	C91.640 x C93.154	White

In 2012, out of the above 14 clones, the following ones were retained for further multiplication and inclusion in multi-location trials:

Table 4.List of retained clones from the previous regional clonal selection (2012).

No	Tajik Code	CIP No.	Pedigree	Tuber colour
1	27/5	302313.105	BEROLINA x TXY.2	Cream
2	30/9	302328.109	DESIREE x 92.187	Cream
3	36/3	302331.103	DESIREE x C93.154	White
4	37/2	302372.102	KONDOR x C93.154	White
5	40/1	302478.101	TITIA x C93.154	Red
6	47/4	303414.104	C92.140 x 92.187	Red
7	47/8	303414.108	C92.140 x 92.187	Red
8	50/7	302089.107	397036.7 x C93.154	White
9	50/9	302089.109	397036.7 x C93.154	White
10	52/6	303408.106	C91.640 x C93.154	White

They are characterized by traits of resistance to viruses, drought tolerance, a cycle from 95 to 120 days, high yield, marketability and high dry matter content.

True Potato Seed (TPS)

After three years of selection, two TPS families were retained for further multiplication: CIP '998010' (LT-8 x TS-15) and '988141' (MF-II x TPS-67). They are characterized by the following performance (see Tables5-6):

Tables 5-6. CIP-TPS families tested according to the direct sowing technique in the highlands of Tajikistan (June-October: 2008-2009-2010). Means of four replications.

CIP No.	TPS families	Plant vigour (*)	Plant height (cm)	Flowering stage (**)	Uniformity of flowering
998010	LT-8 x TS-15	1	79.3	2	No segregation (white flowers)
988141	MF-II x TPS-67	1	74.9	2	Some segregation (white, purple and light blue flowers)

(*) at flowering time: 1 = very vigorous; 2 = average; 3 = weak growth
(**) Flowering stage: 0=no bud, no flower; 1=budding stage; 2= flowering initiation; 3=full flowering; 4=fall of flowers; 5=fruit formation

CIP No.	TPS families	Plant height (cm)	No. of stems/plant	Tuber shape	Skin colour
998010	LT-8 x TS-15	94.3	3.9	Round	Cream
988141	MF-II x TPS-67	96.5	3.4	Round to oval	Cream

CIP	No. of seedling tubers/m^2			Mean	Total weight (kg/m^2)			Mean	Mean tuber weight (g)			Mean
	2008	2009	2010		2008	2009	2010		2008	2009	2010	
998010	348.8	310.8	220.5	293.4	6.1	5.7	3.0	4.9	17.7	18.5	13.1	16.4
988141	381.5	352.8	334.8	356.4	6.4	6.8	4.1	5.8	17.2	19.1	12.4	16.2

A potato breeder of the NGO Tukhmiparvar, who was impressed by the performance of TPS family '998010', decided in 2007 to start massal selection by isolating the individuals showing earliness. Since the whole family had shown great resistance to diseases, high yield of oblong and well-shaped tubers with yellow skin, and strong behavior, these traits were not considered in the selection. In 2009, seed samples were supplied to the State Variety Testing Commission that released it in June 2013. Details of the release of 'Dusti' and 'Faizabad' (CIP '397077.16') are in the following Tables (Tables7-8).

Tables 7-8.Details of the release of varieties 'Dusti' and 'Faizabad', provided by the StateVariety Testing Commission (2013).

Variety	Year				Mean	Deviation from standard	
	2009	2010	2011	2012		t/ha	%
Cardinal (standard)	31.8	25.7	33.9	33.2	31.15	0.0	0.0
Zarina	36.5	30.8	35.7	37.3	35.08	3.9	12.6
Dusti (CIP 998010)	39.5	36.0	39.2	38.5	38.30	7.1	22.9
Faizabad (CIP 397077.16)	39.8	35.0	40.8	38.5	38.53	7.4	23.7
Tajikistan	41.4	39.8	40.9	40.1	40.55	9.4	30.2
Rasht	40.0	40.2	39.3	39.3	39.70	8.6	27.4
CV %	13.2	13.7	12.5	15.0	13.60		
LSD 0.05	1.85	1.98	1.47	1.70	1.75		

Variety	Dry matter (%)	Starch (%)	Vitamin C (mg/%)	Organoleptic traits
Cardinal (standard)	18.8±0.2	16.3±0.3	18.7±0.1	7.5±0.2
Zarina	21.0±0.2	18.5±0.1	18.2±0.2	8.5±0.2
Dusti	22.3±0.2	17.3±0.2	31.3±0.3	8.2±0.1
Faizabad	22.1±0.2	17.5±0.3	33.1±0.1	8.9±0.2
Tajikistan	22.7±0.1	16.5±0.3	32.6±0.2	8.7±0.2
Rasht	21.4±0.2	16.5±0.3	32.7±0.2	8.6±0.1
LSD 0.05	0.81	0.72	2.52	0.11

Potato hybridization in Tajikistan

In the highlands of Tajikistan, a potato breeder associated with the project and who was trained at Central Potato Research Institute (CPRI), Shimla, India, started a crossing program in 2009 using CIP clones as female parents and varieties'Picasso', 'Zarina', 'Kondor' and 'Kufri Surya' as male parents. He observed the different generations of clones issued from crossings, and, in collaboration with CIP, wrote an article that was published in the Potato Journal. First, he studied potato pollen fertility (Figure1) in Jirgatol District at an altitude of 2,700 meters above sea level where an experimental plot of the NGO Tukhmiparvar is situated.

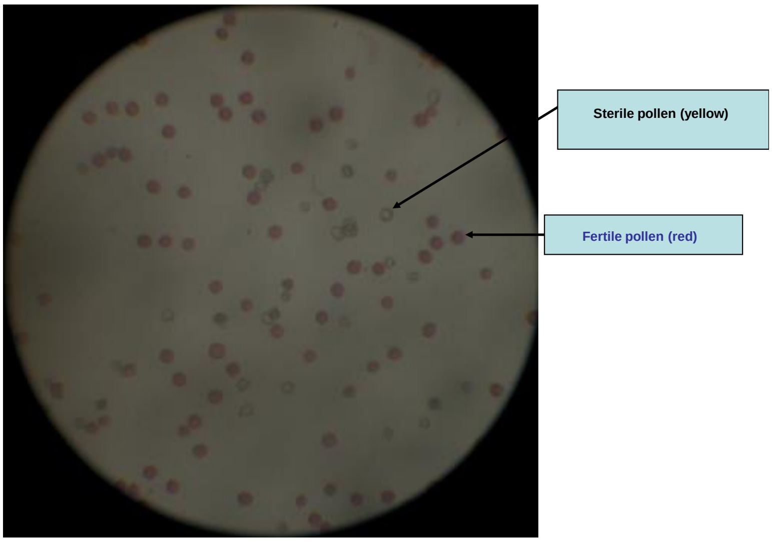


Figure 1.Sterile (yellow) and fertile (red) potato pollen grains detected through the microscope.

Among the potato varieties cultivated in Jirgatol, Dutch variety'Cardinal' had the least average percentage of fertile pollen grains (26.5%), thus justifying its role of female more than male parent, while candidate variety 'Dusti', obtained by mass selection conducted in the TPS family '998010', had the greatest %age of viability (95.2%). In general, clone '392780.1' had the highest average percentage of fertility (97.0%). Pollen viability was analyzed at three different dates: 20 July (the beginning of blooming period), 1 August (mass blooming period) and 10 August, 2009 (the end of blooming period). Each time the pollen was taken from the flowers of five plants per sample. Viable and sterile pollen grains were counted by the means of microscope MBU-4A at the enlargement of 20x7.

After hybridization, a label was attached to the stem indicating the hybrid combination and the date of crossing written in pencil (see Figure 2).

Figure 2.Potato berries ('Dusti' x 'Picasso')

The number of pollinated flowers and the dates of hybridization were recorded in the potato crossbreeding logbook. In 2010, True Seeds were sown under screenhouse conditions. During the harvesting of 'F1C2', pictures were taken of some of the most promising selections (see Figures 3-4).

Figures 3 and 4.Harvesting of "F1C2"

Clone 3 - F1C2 ('Dusti' x 'Kondor')

Clone 16 - F1C2

('397077.16' x 'Picasso')

In terms of plant productivity, many clones had an average weight ranging from 800 to 1,000 g per plant. In particular, clones 'K-13' and 'K-40' produced a lot of berries (see Figure 5).

Figure 5.Clones 'K-13' and 'K-40'

Berry formation on F1C2:
Clone 13 ('Dusti' x 'Kondor') on the leftand Clone 40 ('394034.7' x 'Kufri Surya') on the right.

Laboratory screenings

Screening for salinity tolerance was conducted under in-vitro conditions at the Institute of Botany, Plant Physiology and Genetics, Dushanbe, in order to identify, first, suitable screening methods to quickly test important amount of germplasm materials and, second, to detect quickly salinity tolerant clones.

Using Murashige&Skoog nutrient media containing three different concentrations of NaCl (0.5%, 1.0%, and 1.5%), the viability of in-vitro potato plantlets at 1.5% NaCl concentration was estimated to be 100% after 42 days for CIP-bred clones '301029.18', '370120', '391580.30', '393708.31', '397006.18', and '709004' and 80% for the following clones: '301024.14', '370121', '380389.1', '380583.8', '393381.4', '393536.13', '394881.8' and '720118'. In-vitro plants of Dutch variety 'Picasso' and CIP-bred clone '397077.16' were used as controls with viability of 0% and 100% respectively. The in-vitro plantlets are considered viable when they have ability to regenerate once placed in a medium without NaCl. Furthermore, CIP-bred clones '380583.8', '381379.9', '389429.31', '391580.30', '394034.7', and '394881.8' showed good in-vitro micro tuberization at 1% NaCl with a weight ranging from 24.2 mg (CIP '381379.9') to 81.2 mg (CIP '394881.8') and an average number of micro tubers/per plant ranging from 1 (CIP '380583.8') to 2.3 (CIP '389429.31'). At the end of the work, a protocol for laboratory screening of potato germplasm materials under different salinity levels was formulated. This will allow CIP's partners in Tajikistan to compare data obtained from laboratory and field experiments.

1.1.3 Sorghum and Pearl Millet

At national nurseries 12 accessions of sorghum and 19 improved lines of pearl millet derived from the International Centre for Biosaline Agriculture (ICBA)/ International Crops Research Institute for Semi-Arid Tropics (ICRISAT) germplasm were evaluated through multi-location and on-farm trials on Ziroatkor farm andthe Institute of Plant Husbandry of the Tajik Academy of Agricultural Sciences. The most adapted high-yielding accessions and improved genotypes (in terms of green biomass and grain production) of pearl millet ('Raj 171', 'IP 19586', 'HHVBC Tall', 'ICMV 7704', 'IP 22269', 'Raj 171', 'Sudan Pop III') and sorghum ('ICSV 93046', 'ICSV 1411', 'ICSV 112'(SP4495) , 'S-35' and 'ICSV 25280 ICSSH 28', 'ICSSH 58', 'Speed Feed', 'Sugar Graze') were tested. Based on these accessions and genotypes, further breeding work and evaluation of productivity and profitability for forage and grain production was evaluated.

'Dwarf ICSV 172' and 'ICSV 745' sorghum lines were found to be the most promising ones for grain production at the abandoned farmer lands in northern Tajikistan. These sorghum and pearl millet lines showed good performance in hot summer, survival rate of adult plants, plant height and vegetative cover (plant density) compared with local variety 'Gissar'. Most of them had about 30% more dry fodder and 25% more seed yield than the local varieties. The high morphologic diversity in grain size, colour and number of grain/panicle was observed as distinctive features for the majority of the screened varieties of pearl millet. The top-performing eight varieties/lines of sorghum germplasm (with average dry matter production of 13.3-27.3 t/ha and seed yield of 0.26-0.50 t/ha tested under field conditions at different levels of soil and irrigation water salinity) were selected for further dissemination in Tajikistan.

Progress in breeding pearl millet

A new promising dual-purpose and early-maturing local variety of pearl millet 'Durahshon' was released by researchers of the Institute of Plant Husbandry, the Tajik Academy of Agricultural Sciences. This new variety was selected as a result of series of cross-pollinations of improved line 'HHVBC Tall' (ICRISAT) with local varieties. Trial was organized in Randomized Complete Block Design with three replications at the Ziroatkor location, which is characterized by dry sharply continental climate. Seed bedding was conducted in spring (April). Fertilizers were applied during plant vegetation, especially in June-July at a rate of N_{150}:P_{60}:K_{60}. During plant vegetation, irrigation was done three times, including during the i) 10-11 leaves stage (500-600 m^3/ha), ii) flowering stage (800 m^3/ha) and iii) milky stage -when necessary. This variety is distinguished by its expressive tillering and re-growing ability with an average plant height of 190cm, and showed promising results as a main crop for grain production (distance between rows - 60-70cm) and as a summer crop after wheat harvesting (with a distance between rows - 30-35cm) for forage production.

Evaluation of sorghum and pearl millet performance with farmers' participation

Multi-location trials of advanced lines of sorghum and pearl millet showed that several lines produced high yields of forage biomass. These yield levels could increase under better management. Forage yield levels of the best lines were at least 15% higher than the best local checks. It was also identified that seed bedding with 30cm inter-space between rows leads to a significant increase of plant density/vegetative cover and, consequently, enhances fresh forage production at the end of harvesting of sorghum and pearl millet.

Sorghum and pearl millet can be recommended as a second crop (planted in mid-June and early July) after wheat harvest as well as integrated into rice crop rotation. The appropriate maturity requirement when used asa main crop and a second crop will depend on the time of onset of the frost, when planted as a main crop in different agro-ecological zones in Tajikistan.Sorghum varieties maturing in 110-140 days can be taken only as a main crop as the frost starts early in this area. Pearl millet maturing in 85 to 90 days fits well as a second crop. As a second crop, pearl millet with the maturity period of 65-70 days, as demonstrated by newly released variety 'Durakhshon', will have a good chance of fitting with the prevailing cropping system in all the eco-regions.

A social network of farmers involved in seed multiplication of pearl millet at village level during a Farmers Day on Bobojon Gafurov farm in northern Tajikistan.

On-farm seed multiplication

Specialized on-farm seed multiplication trials for sorghum and pearl millet with the involvement of interested farmers were conducted in northern SughdRegion (five farms), and southern Qumsangir District (four farms) of Tajikistan. At each of thetrial sites,an area of about 0.3 ha was specially allocated (600-700m) with an inter-row spacing of 75cm and a plant-to-plant spacing of 30cm. The selected farmers were provided with selfing bags or a similar type of bags (like bags made of porous cotton textile), and special fish nets to protect seeds from birds. They were able to sell the seed to other farmers at a profit to recover the cost of seed production.

However, the availability of seeds of improved lines of non-conventional salt-tolerant crops is still a major constraint. Potential extension and large-scale seed multiplication of high-yielding varieties should be planned to meet the growing demand of farmers. In various agro-ecological zones of Tajikistan,areas for breeding seeds have to be established and monitored in order to maintain the purity and quality of seed, as well as to multiply certified seeds and distribute them among interested farmers. Progressive farmers under supervision of ICBA scientific/technical staff could become a strong force in crop diversification and seed production programs in order to enhance the productivity of salt- affected lands and increase the income of poor rural populations. Farmer-participatory research in villages iscrucial in transferring the technology of cultivation of salt-tolerant crops for rapid adoption.

It is expected that seed producing farmers will make some profitfrom producing the seed, and hence can ensure adequate and timely supply of quality seed. These farmerscan produce seed for farmers from one village or for a cluster of nearby villages. The international centers and national institutions in the target areas of seed production continue to provide technical guidance on quality seed production.

1.1.4 Vegetable Crops

Tajikistan is the member of the Regional Network for Vegetable Systems Research and Development (CACVEG), initiated in August 2006 for Central Asia and the Caucasus. From 2007 to 2013, a total of 140 accessions of nine vegetable species were introduced from the Asian Vegetable Research and Development Centre (AVRDC)-The World Vegetable Center to Tajikistan, including 37 of tomato, 26 of sweet pepper, 44 of hot pepper, five of eggplant, 12 of cucumber, six of soybean, six of mungbean, two of bean and two of cabbage. Research was focused on evaluation of germplasm in terms of biological, morphological and marketability traits.

The Research Institute of Horticulture and Vegetables, Tajikistan, participated in the Regional Variety Trial initiated by AVRDC in different soil and climatic conditions of eight countries of Central Asia and the Caucasus. As a result of these trials in Tajikistan, a number of promising lines (early-maturing, high-yielding, resistant to diseases, good quality, etc.) were identified and seeds of promising lines were multiplied.Since2008 seven new varieties have been developed on the basis of improved lines from AVRDCand submitted to the State Variety Testing Commission of Tajikistan (see Table 8).

New hot pepper varieties 'Serkhosil' ('PP0437-7506'), 'Zulfi surkh' ('PP9852-173') and 'Khanchar' ('PP0407-7538') are characterized by the long duration of fruit-bearing (until autumn frost), higher yield (40% more compared with local varieties), original fruit shape and colour.For the first time, early-maturing new variety 'Istemoliy' ('10134-Ryokkoh') of non-traditional species such as vegetable soybean has been developed for multi-purpose use. This variety has a very rich nutritional value (42% of protein, 20% of oil and vitamins) in green beans which can be consumed for cooking on the 60th day after appearance of seedlings. Green mass can be used as feed for livestock and poultry. Vegetable soybean productionalso helps to improve soil fertility.

Moreover, new mungbean varieties 'Dubara' ('VC 6378' (145-8-1), 'Muattar' ('VC 6153 B 6') and 'Marvorid' ('VC 1178') with upright bushes, which makes themeasy for mechanized seed sowing and harvesting, were developed. All of them demonstrated yieldsof 10-25% more than the best local variety and are characterized by such traits as early maturity (95 days), productivity, larger seed size, disease resistance and drought tolerance.

Early-maturing varieties of legume vegetables such as mungbean and vegetable soybean are important for soil improvement and double cropping after harvesting cereal crops under irrigated conditions.Newly developed varieties have high potential to increase the production of vegetables, diversify local diet, increase the export potential of fresh and processed products and farmers' income.

Table 9.New varieties submitted to SVTC in Tajikistan (not yet released)

Crop name	Entry no.	Variety name	Year of submitting to SVTC
Mungbean	VC 6378 (145-8-1).	Dubara	2008
Mungbean	VC 6153 B 6.	Muattar	2008
Mungbean	VC 1178	Marvorid	2008
Vegetable soybean	10134 (Ryokkoh).	Istemoliy	2008
Hot pepper	PP 0437 - 7506	Serkhosil	2009
Hot pepper	PP 9852 - 173	Zulfi surkh	2009
Hot pepper	PP 0407 - 7538	Khanchar	2009

1.2 Strengthening National Seed Supply System

1.2.1 Potato Seed Production

Potato seed productionwas started using two technologies, the traditional or clonal multiplication and TPS technology which is considered as an alternative technique that uses the true seed produced in the berries as propagule.

Agronomists, advisors and farmers of Jirgatol, Fayzobod and Gharm districts have been trained in positive and negative selectionthat are two simple seed production techniques that can be implemented in the absence of an official seed certification system.

In order to provide resource-poor farmers living in the highlands of Tajikistan with high quality and cheap potato seed, the CIPoffice in Tashkent in collaboration with Bogparvar, NGOs and private farmers disseminated TPS technology in various areas of Tajikistan.From 2009 to 2013, the activities took place in two geographical regions of Tajikistan, the Zeravshan and Rasht valleys, in the northwest and northeast of Tajikistan respectively. These activities were preceded by intensive training courses where advisors and farmers were trained separately. The objective was to develop a strategy to initiate farmers and advisors into a technology that was completely new to the large majority of them.

At the training courses, farmers, who mainly specialized in vegetable growing, learnt how to prepare and manage a nursery and handle rooted seedlings for transplanting to the field. All the materials were translated into Russian and distributed to farmers by CIP's partners. A few nurseries were established in strategic points where the new technology could be further spread easily. The following partners were instrumental in the success of the activities: Deutsche Welthungerhilfe (German for World Hunger Aid) through the project "Comprehensive seed potato system in the Zeravshan Valley" (project TJK 1065) -the Zeravshan Valley (altitude ranging from 1,886 to 2,448 m above sea level);Global Partners -Gharm District, the Rasht Valley (from 1,300 to 2,100 m above sea level); the Institute of HorticultureBogparvar-JirgatolDistrict, the Rasht Valley (2,000 m above sea level).

In Gharm District, in 2012, 35 smallholdersobtained a yield of 2.06 tons of seedling tubers F_1C_0 in 578 m^2, corresponding to a mean yield of 3.32 kg/m^2 of seedling tubers, or 183 pcs/m^2, with an average seedling tuber weight equivalent to 19.3 g. The performance of the TPS producers was variable ranging from a yield of 0.83 to 5.88 kg/m^2, with an average seedling tuber weight varying from 12.0 to 32.0 g.

In JirgatolDistrict, in collaboration with the Institute of HorticultureBogparvar, a number of nurseries with an area of 102 m^2 (102 x 1 m) and 72 m^2 (72 x 1 m) were sown in 2009 and 2010 respectively. The results obtained in 2009-2010 are given in Tables 8 and 9. In 2010, the average yield per unit area was 30.4% higher than in 2009 (7.3 vs 5.6 kg/m^2). However, the number of tubers was smaller in 2010 compared with 2009 (281.7 vs 406.8), meaning that mean tuber weight was higher in 2010 compared with the previous year (25.9 vs 13.7 g). In both years, the majority of the seedling tubers were less than 10 mm (49.5 vs 57.2% in 2009 and 2010 respectively).

In order to make this seed production system self-sustainable, the production of hybrid TPS (LT-8 x TS-15) was initiated by the NGO Tukhmiparvar in JirgatolDistrict. A total of 3,350 flowers were hybridized in the open field in 2012 which resulted in the setting of 1,700 berries (50.7% of success) weighing 7 kg in total and containing 140,000 seed pieces that were then sold to the Aga Khan Project in the northern Badakshan region of Afghanistan. This is a highly qualified job that requires a lot of attention, skills and intense labour during the flowering period. However, it has been very difficult so far to convince the hybrid TPS producer that the production of hybrid TPS must be privileged as opposed to the production of tubers by applying a technique that favors the development of plants and flowers at the expense of tubers.

Table 10. Tajikistan: Direct seeding method. Average results per unit area (m^2) obtained in six nurseries in Jirgatol District (8-12 June-10 October 2009). Partner: Institute of Horticulture, Dushanbe.

Tuber size distribution								Tuber weight (kg/m^2)				Mean tuber weight (g)
	>25 mm	%	10-25 mm	%	<10 mm	%	Total	>25 mm	10-25 mm	<10 mm	Total	
1	39	10.5	148	39.8	185	49.7	372	2.0	2.6	0.81	5.41	14.5
2	37	9.0	139	34.0	233	33.0	409	1.89	2.81	0.93	5.63	13.8
3	42	8.8	180	37.7	255	53.5	477	2.6	3.6	1.0	7.2	15.1
4	54	13.8	133	34.1	203	52.1	390	1.7	2.3	0.83	4.83	12.5
5	56	15.5	181	50.1	124	34.4	361	2.1	2.3	0.24	4.64	13.0
6	63	14.6	152	35.2	217	50.2	432	2.9	2.1	0.79	5.79	13.4
Mean	**48.5**	**12.0**	**156**	**38.5**	**202.8**	**49.5**	**406.8**	**2.2**	**2.6**	**0.77**	**5.6**	**13.7**

Table 11. Tajikistan: Direct seeding method. Average results per unit area (m^2) obtained in four nurseries inJirgatol District (1-9 June - 25 October 2010). Partner: Institute of Horticulture, Dushanbe.

	Tuber size distribution							Tuber weight (kg/m^2)				Mean tuber weight (g)
	>25 mm	%	10-25 mm	%	<10 mm	%	Total	>25 mm	10-25 mm	<10 mm	Total	
1	10.0	2.8	124.0	35.0	220.0	62.2	354.0	1.4	5.3	2.6	9.3	26.3
2	13.0	4.8	95.0	35.4	160.0	59.8	268.0	1.6	4.0	2.5	8.1	30.2
3	5.0	1.9	123.0	46.6	136.0	51.5	264.0	0.8	3.7	1.3	5.8	22.0
4	14.0	5.8	94.0	39.0	133.0	55.2	241.0	1.5	3.2	1.5	6.2	25.7
Mean	**10.5**	**3.8**	**109.0**	**39.0**	**162.2**	**57.2**	**281.7**	**1.3**	**4.0**	**2.0**	**7.3**	**25.9**

1.3 Livestock Production Systems and Integrated Feed/Livestock Management

In Central Asia, livestock plays an important role in the agricultural economies. In Central Asia livestock does not only contribute to the livelihoods of the most vulnerable rural sector, particularly in isolated regions and highlands, such as in Tajikistan and Kyrgyzstan, but also played a critical role in the period of transition when other sources of income were substantially reduced. However, livestock production has been severely affected by the economic transition, which resulted in the disruption of the former Soviet markets for traditional products such as wool and pelts, fragmentation of large production units into small and unproductive flocks/herds, the collapse of production support services and animal health control, a lack of technology transfer services and disruption of livestock research.

Specific objectives included:

- To increase the overall productivity and performance of the goats through testing a number of low-cost farming methods to improve flock productivity and farmers' income;
- To assess the quality of Tajik mohair through collection and analysis of mohair samples from multiple farms, and production and test-marketing samples of yarns and knitted products from different types of mohair;
- To improve some of the main shortcoming of Tajik mohair such as the high %age of kemp and medullated fibers and the high average fiber diameter through an organized community based breeding program;
- To improve the quality of value-added products from mohair goats in order to access international markets.

Main project activities included:

- Improvement of the goat flock productivity through implementing affordable management practices;
- Development a new draft standard for classification of mohair based on international commercial requirements;
- Creation of a decentralized and joint plan for breeding for farmers' access to improved animals;
- Local processing of mohair by women to add value to Angora mohair and market opportunities for processing.

1.3.1 Better livelihoods, more opportunities for rural women

A four-year initiative by the International Fund for Agricultural Development has increased employment opportunities and income options for poor rural populations, particularly vulnerable women, in Tajikistan, Kyrgyzstan and Iran. Launched in 2009, the initiative targeted specifically rural women artisans and small livestock breeders, and aimed to improve their livelihoods and income through improved production, processing and export of value-added fiber in these three countries.

Angora goat production in Sughd Region and the processing of mohair fiber is of high socioeconomic significance for Tajikistan. Approximately 250,000-300,000 people are involved in production of mohair primarily in the northern and some southern districts. Tens of thousands of residents (women) are involved in processing (yarn and finished products: mittens, socks, shawls, scarves, pullovers, etc.) and hundreds are involved in the sale of raw materials and semi-finished products.

The main project objective in Khujand was to improve the productivity of Tajik mohair goats and at the same time facilitate access of mohair producers and processors to global markets to receive higher prices for fine, quality mohair yarns and other products.

Testing and implementing low-cost management practices to improve goat productivity

A number of acceptable and affordable management interventions were pilot-tested and implemented with the aim of improving flock productivity and overall management of mohair goats.

Assessing mohair quality and developing a new draft standard for classification of mohair based on international commercial requirements

The following activities were conducted:

- collection of samples for laboratory analysis in Almaty;
- developing a draft new standard for classification of Tajik mohair taking into account international norms;
- training farmers and scientists in international qualities standards.

Developing a breeding program for mohair goats based on international fiber standards

The breeding program was developed jointly by the Livestock Research Institute in Khujand, the communities and ICARDA. At the planning stage the team began to identify farmers who were well positioned to apply new breeding strategies and produce fine mohair suitable for luxury yarn production. Criteria used in the selection of candidate farmers included experience, pasture conditions and fodder availability, and flock size (preference was given to the relatively larger flocks).

Value adding activities

- The production of handspun mohair yarn for export in Khujand can provide very good earning opportunities for women spinners and knitters. By switching to high-priced yarns, women spinners will be able to earn approximately USD 240 per month as opposed to USD 24 per month which they currently earn by producing yarn for Russia.
- The yarn export market will also benefit Angora goat farmers by increasing the price of undervalued kid and super kid mohair. It is expected that the strong demand for fine kid mohair will increase the price of fine, kemp-free kid fiber from the current USD 3-4 per kg to USD 9 per kg and continue to increase further as farmers realize the value of those fleeces to spinners. Moreover, quality, kemp-free adult mohair can also be used to make woven blankets and hand-knotted carpets for the US and European markets. Eventually, a high market price for kemp-free, quality mohair will be established region-wide.

In Khujand (northern Tajikistan)the breeding programled to a common agreement and good understanding of selection traits for Angora goats and record keeping was established during the project duration. The inclusion of fiber fineness into the breeding objectives was agreed and its importance for the market value of the fiber is now recognized. The latter was also an outcome of creating demand for fine fiber by women processors in the neighborhood. The farmers applied the agreed selection strategies within their flocks but they were less interested in sharing or exchanging bucks and in joint performance testing.

Mohair market in northern Tajikistan

The mohair market in Sughd Region is unstable and depends heavily on the wholesale customers from Russia, and it is difficult to predict the expected number of foreign buyers. For households with a small number of goats it is difficult to access markets in Russia directly due to the high marketing costs involved. Mohair producers with a subsistence income level who cannot wait for more favourable prices as they need the cash for daily expenses. As a result, middlemen with more financial resources and storage facilities benefit from low mohair purchasing prices in the spring season and high selling prices in fall.

Mohair producers in most cases do not sort the fleeces by quality or other criteria. Such value addition activities as sorting, packaging, and washing of mohair are mainly undertaken by wholesale procurers who are interested in selling big volumes of mohair to customers on markets located in Sughd Region or to CIS countries. Mohair prices depend on the season, distance between the local markets and central markets and marketing costs. Lack of information, shortage of financial resources, and inability to efficiently market mohair put the small producers at a disadvantage and lowers their net income.

Value-added local processing of mohair by women and assessing potential for its international marketing

The objective of this activity was to research the opportunity of increasing incomes of local women spinners and Angora goat producers through value-added local processing and export of mohair yarn and clothing. Most Tajik rural women in the mohair-producing region earn income by spinning coarse, cheap yarn for the Russian market and selling it for a low price of about USD 10 per kg. The project objective was to explore the development of an alternative market for value-added mohair products that would bring higher revenues for producers. The project identified the US market for luxury knitting yarns as an alternative, high-value market for Tajik mohair yarns. On this market, luxury mohair yarns sell for retail prices that range from USD 150 to over USD 500 per kg.

1.3.2 Community action in feed livestock productivity

In response to the key challenges, ICBA together with ICARDA and ICRISAT launched a collaborative project on "Diversification of crops of sorghum and pearl millet to improve food supply and well-being of livestock farmers in Central Asia", implemented from 2011 to 2014 and funded by the Islamic Development Bank. The main national partner in Tajikistan is the Institute of Plant Husbandry and Sughd experimental soil station of the Tajik Academy of Agricultural Sciences. The main aim of this project is to improve rural livelihoods and food security by using marginal lands in Tajikistan by applying principles and practices of biosaline agriculture to achieve sustainable land and water resources management. Its purpose was also to develop and promote community-based actions to support productive and sustainable livestock systems, access to market opportunities, and sustainable management of the natural resource base in the region.

The livestock productivity component of the project "Community Action in Integrated and Market-oriented Feed Livestock Production in Central and South Asia" looked at ways of improving mohair production in Sughd Region in northern Tajikistan. The project's overall purpose was to develop and promote community-based actions to support productive and sustainable livestock systems, access to market opportunities, and sustainable management of the natural resource base in the region.

1.3.3 Productivity enhancement of fodder-based cropping systems through using saline drainage water

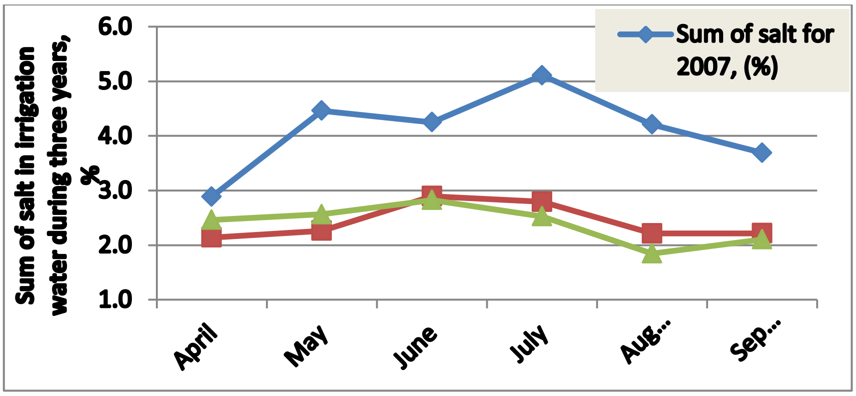
The three years of field research (2005-2007) carried out at Yangiobod experimental site in Tajikistan demonstrated that applying canal water is important especially for first-time irrigation, when the young plants are most sensitive to salt-affected conditions.Mixing of low saline water (1,500 mg/L) and saline water (4,500 mg/L), pumped from vertical well in the respective ratio of 1:1 was applied for second-time irrigation on Yangiobod farm.

The most appropriate scheme for conjunctive water use might be expressed as follows i) at the planting and seedlings germination stage irrigation with low saline water with salinity levels around 1,500 mg/L); ii) at the growth and before flowering stages the cyclic use of low saline water (for first-time irrigation) and drainage water (4,000 mg/L; as for further irrigation). Significant seasonal decrease in water table up to 1.30m from April to September before crop harvesting was followed by decreasein chemical composition and salt content (TDS). In several low depression areas of the experimental field, however, water table and soil salinization increased, which indicates poor land planning/levelling measures done before seed sowing. Salinity of irrigation water was at 3,900 mg/L in early spring and up to 5,100 mg/L in July-August and 2,215 mg/L in September by prevalence of Ca^{2+} and SO_4 as the dominant cation and SO_4 among anions. From April to September the decreasing of Cl ion concentration evidently occurred.

Table 12.Chemical composition of drainage water used for crop irrigation (Average data for 2008)

Soluble cations and anions, mgeq/l	Unit	April	May	June	July	August	September
Soluble Ca2+	mgeqL-1	4.1	5.3	6.4	6.8	7.3	8.3
Soluble Mg2+	mgeqL-1	8.1	8.4	8.8	9.2	3.7	4.5
Soluble Na+	mgeqL-1	17.4	16.8	24.3	22.2	18.9	17.4
Soluble K+	mgeqL-1						
Soluble HCO32-	mgeqL-1	16.5	16.75	17.25	17	12	11.5
Soluble Cl-	mgeqL-1	0.6	0.9	1.3	1.5	0.2	0.35
Soluble SO42-	mgeqL-1	12.5	12.85	20.95	19.7	17.7	18.35
Cl-/SO42-		0.04	0.07	0.06	0.07	0.01	0.02
Mg2+/Ca2+		1.97	1.58	1.37	1.35	0.50	0.54
Total salt	%	2.207	2.263	2.896	2.792	2.214	2.215
SAR	-	7.05	6.42	8.81	7.85	8.06	6.88
SARadj	-	7.94	7.24	9.91	8.83	9.07	7.75

The composition of irrigation water from April to September in terms of cations content showed insignificant temporal variations. During crop vegetation season, cations were distributed as Ca^{2+}> Mg^{2+}> Na^{+}; Ca^{2+}-6.36 mgeq/L; Mg^{2+}- 7.12 mgeq/L; Na^{+}- 19.5 mgeq/L).Among anions significant increase from April to September showed SO_4^{2-}, which reached the high valueof up to 20.96 mgeq/Lin June. Presence of $CO_3^-$was not detected in the composition of irrigation water over the crop vegetation season. The levels of SAR and SAR_{adj} ranged from7.51 to 8.45, suggesting that irrigation water is non-sodic in its characteristics. It is obvious that irrigation conducted by applying this quality water will not cause sodicity problems in the soil and consequently will not negatively reflect on the crop growth.



Fluctuations in mineralization of irrigation water during vegetation period (Average data for three years 2007-2009).

The data obtained showed that yield of fodder crops did not significantly decrease because of the treatment where low-saline drainage water was applied for irrigation during the whole crop vegetation season.Despite high level of soil salinity, the introduced alfalfa, sorghum and pearl millet germplasm showed relatively promising results in comparison with local alfalfa, sorghum and barley varieties. In the first year of cultivation of fodder crops, heavy soil leaching (2,000-2,400 m3/ha) should be applied at the site in order to dissolve harmful salts from the root zone and it will create favourable conditions for crops growth and development. Only after this farming practice the cyclic use of drainage and irrigation water could be implemented.

Significant decrease in soil salinity (soil reclamation) during the three-year period calculated as a sum of toxic salts in the upper soil profile under alfalfa and less under sorghum and pearl millet was observed.

Table 13.Desalinization effect (DE) under alfalfa fields on Yangiobod farm, northern Tajikistan

Horizon (cm)	Sum of toxic salts, %		DE, %
	Before planting	After three years	
0-30	1,530	0,630	59
30-50	1,300	0,872	33

The presence of alfalfa on medium saline soils for three years stimulated the decreasing of salt accumulation in the upper soil profile at 35%, and up to 24% toxic salts in the lower profiles, up to 59%.

Table 14.Desalinization effect under sorghum fields on Yangiobod farm (average data for 2008-2010)

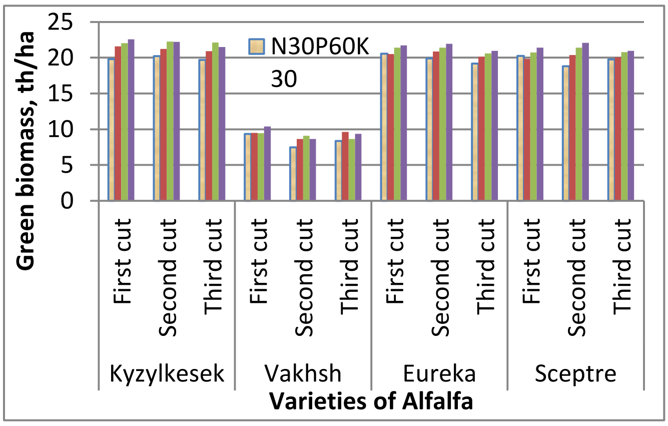
Soil horizon, cm	2008			2009			2010		
	Total dissolved salts (%)		DE, (%)	Sum of salts (%)		Desalinization, %	Sum of salts (%)		DE (%)
	Before planting	At harvesting		Before planting	At harvesting		Before planting	At harvesting	
0-30	2,474	2,055	16,9	1,798	2,724	-	2,064	1,488	27,9
30-50	2,155	1,834	12,8	1,61	2,303	-	1,884	1,272	32,5

Source: Nazira Tashmatova, 2012

Accumulation of total soluble salts in the root zone of salt tolerant ICBA germplasm during a period of three years decreased to 1.7, while amount of toxic salts decreased by 1.9 times. Significant decrease of total soluble salts in the upper soil profiles during vegetation period (from April to late September) was observed under pearl millet. Statistically it was shown that fertilizer use efficiency is better at N30:P150:K30 under sulfate-chloride soil salinity conditions with a variation of SAR value as 2.27-3.98 at the soil depth 0.0-0.50 cm.

1.3.4 Forage legumes

After three years of evaluation two salt-tolerant varieties of alfalfa (*Medicago sativa*), 'Eureka' and 'Sceptre' from ICBA were found to outperform local variety 'Vakhsh' (used widely in Tajikistan). The introduced salt-tolerant alfalfa germplasm showed rapid germination, high seed production and excellent regenerative capacity. Additionally, these two varieties were superior to the local onein terms of length of generative sprouts, number of flowering buds, size and number of pods and seeds per one pod, which, in combination, demonstrate higher seed productivity of the introduced germplasm. Fresh biomass production in the third year varied from 23 t/ha for 'Eureka' variety and 20 t/ha for 'Sceptre' respectively.From these studies it is clear that yield of alfalfa hay in the control variety (without fertilizers) was 2.54 t/ha.



Impact of different norms of fertilizers use on alfalfa multi-cut forage crop (Average data for 2008-2010).

According to the norms of fertilizers, a dose of N30:P150:K30 had significant effect on yield. Its introduction increased from 24 to 54%, or from 14.4 to 29.6 kg/ha compared with a dose of 60 kg/ha. Introduced salt-tolerant alfalfa 'Eureka', 'Sceptre' from ICBA and 'Kyzylkesek' from Uzbekistan are considered as one of the most promising lines both for forage and seed (grain) production in saline environments of northern Tajikistan, when irrigated with moderately saline drainage water. These varieties can be also characterized as early-blossoming and fast-ripening. The green yield biomass of introduced germplasm of alfalfa (total for three cuts during the season) irrigated by mineralized drainage water was three times higher than for local variety 'Vakhsh'. Alfalfa varieties 'Kyzylkesek' and 'Sceptre'yielded 20-25 t/ha at the average application rate of fertilizer-$N_{30}P_{120}K_{30}$.Agronomic techniques evaluated for cultivation of salt-tolerant varieties of alfalfa from ICBA, showed advantages both in green biomass and seed production compared with the local variety.

Table 15.Effectof fertilizers use on biomass accumulation for different alfalfa varieties at the same salinity level (at 3.6-5.0 dS/m) on Yangiobod farm, 2009.

Treatments	Green biomass				Dry biomass			
	Kyzylkesek	Vakhsh	Eureka	Sceptre	Kyzylkesek	Vakhsh	Eureka	Sceptre
N30P60K30	59,74	25,2	59,67	58,85	13,45	5,82	13,14	12,55
N30P90K30	63,73	27,78	61,55	60,31	13,89	6,35	14,28	13,95
N30P120K30	66,45	27,17	63,47	62,93	14,4	7,09	14,66	14,19
N30P150K30	66,33	28,35	64,62	64,43	15,14	6,91	16,15	14,73

There is high demand among farmers to get good quality seeds of salt-tolerant alfalfa. For this purpose, seed multiplication trials of alfalfa were established on Yangiobod farm, Sughd Region in northern Tajikistan. Some agricultural specifications were worked out on-farm and could be recommended to reduce groundwater level and grow cash crops and/or forage crops. Since cotton and vegetables are the cash crops in the region, the yield has been reduced significantly due to the existing salinity problems. It is unlikely that in the near future these areas will be reclaimed and can be cultivated with these crops to give economic yields.

1.4 Integrated Pest Management

1.4.1 Development and delivery of ecologically-based IPM packages for field and vegetable crop systems in Tajikistan

Pest management programs during the Soviet Union era were designed around the intensive use of chemical pesticides and monoculture cropping systems. To break this isolation and introduce ecologically-based IPM approaches, Michigan State University (MSU) in collaboration with the Tajik Academy of Agricultural Sciences (TAAS), Institute of Zoology and Parasitology of the Academy of Sciences of Tajikistan, the Tajik National University and ICARDA and a number of non-governmental organizations (NGOs) has implemented an Integrated Pest Management (IPM) program in Tajikistan.

View of Research Plot.

The Tajikistan IPM project is funded by the USAID. The project started as a regional integrated pest management project for Central Asia. Phase I of the Tajikistan project began in early 2006 and was completed on 30 September 2009. The project focused on two major components: collaborative research program to enhance biological control of pests through landscape ecology and habitat management; and strengthening of outreach and educational programs using ecologically-based IPM approaches.

MSU scientist visit to research plot

In collaboration with the national agricultural research system, a database on native flowering plants was developed. Available plant seeds were collected for field testing. Twenty-four native and locally adapted plant species were evaluated for their attractiveness to natural enemies of pests. Out of 12 native plants species that were the most attractive to natural enemies, eight plants showed potential for use in agricultural landscapes for enhancing biological control and were tested in farmers' fields consisting of maize, cotton, wheat and vegetable crops.

Flowering plants strips in vegetable and cotton fields

Flowering plant strips in a wheat field.

1.4.2 IPM CRSP Project Phase II (2010 - 2014)

Building on the strong foundation and the regional network established during Phase I, MSU with USAID support launched Phase II, a five-year (2010-2014) collaborative program to develop and deliver ecologically-based IPM packages for key food security crops for Tajikistan. The project took an integrated and applied approach to develop and deliver ecologically-based IPM packages for wheat and potato cropping systems in Tajikistan.

The objectives of Phase II of the Tajikistan IPM CRSP project are:

- Develop ecologically-based IPM packages for wheat and potato through collaborative research and access to new technologies;
- Disseminate IPM packages to farmers and end-users through technology transfer and outreach programs in collaboration with local NGOs and government institutions;
- Build institutional capacity through education, training and human resource development;
- Enhance communication, networking and linkages among local institutions and with US institutions, international agricultural research centers, and IPM CRSP regional and global theme programs;
- Create a "Central Asia IPM Knowledge Network" encompassing a cadre of trained IPM specialists, trainers, IPM packages, information base, and institutional linkages.

Ecologically-based IPM packages are being developed through integrating existing pest management practices with new technologies developed through collaborative research with appropriate links with IPM CSRP global theme and regional programs. In Tajikistan for wheat, three IPM applied research and demonstration sites have been established for collaborative research, training and outreach to farmers. These pilot sites have been used as farmer field schools (FFS) to disseminate findings to local farmers. As part of the training and capacity-building strategy, over the four-year period the project has trained around 15 local graduate students, and provided opportunities to more than 50 IPM professionals from Tajikistan to attend various training programs, workshops, seminars and short courses. Participants were selected with due consideration for gender balance.

To harness the resources and expertise of global theme projects of IPM CRSP, the project has developed collaborative links to four cross-cutting areas including pest diagnostics, virus disease management, impact assessment and gender issues. Through regional and global partnerships, the project has helped to create the "Central Asia IPM Knowledge Network" which encompasses a cadre of 21 trained IPM specialists, nine master trainers, and two IPM packages for wheat and potato crops with an extensive information base in local languages and strong institutional linkages to sustain this network. The project has placed strong emphasis on scholarship, publication and dissemination of research results through digital and print media including enhancing its existing website at http://www.ipm.msu.edu/central-asia.htm.

1.4.3 Screening wheat varieties for resistance to Cereal Leaf Beetle (CLB)

A cereal leaf beetle on wheat in Hisor District, Tajikistan.

In collaboration with ICARDA's Biodiversity and Integrated Gene Management Program (BIGMP) of Entomology and Plant Protection Department of Research, the Institute of Farming Ziroatkor of TAAS conducted a research study from 2008-2011 on "Screening of wheat lines resistance to Cereal Leaf Beetle (CLB)" (Photo 6). A total of 130 wheat entries were screened for CLB (*Oulema melanopa* L.*)* resistance, and some lines showed resistance to CLB, a serious pest of wheat in the Central Asian region. The evaluation of resistant wheat lines to CLB in Tajikistan indicated the following lines show high levels of resistance to CLB: lines 'Erythro-spermum13', 'Erythrospermum 1185\1', 'Erythrospermum 760\1', 'Odesskayakrasnokolosaya', 'Frunsenskaya 60', 'Lutescencs 1207\1'.

1.4.4 IPM applied research and demonstration site for wheat

Starting in 2010, a total of three applied research and demonstration sites were setup for wheat in Tajikistan. One of these three sites was located on a farm named after its founder Ilhom Boymatov in Spitamen District of SughdRegion of Tajikistan. At this demonstration site, the focus was on management of the Sunn pest (*Eurygaster integriceps)* and diseases including the wheat rusts: yellow rust (*Puccinia striiformis*) and brown rust (*Puccinia recondite*). The key weeds in wheat in this region include oat grass (*Avenafatua*), *s*hepherd's purse (*Capsella bursa-pastoris),* pigweed or lambsquarters (*Chenopodium album)* and bermuda grass (*Cynodondactylon*).

The following IPM package components were compared to local farmers' practices in the same area:

- Plots of 10 x 10 m planted with 'Ormon', a variety resistant to yellow and brown rusts (4 replicates);
- Two strips of flowering plants including coriander *(Coriandrum sativum* L.*)*, dill *(Anethum graveolens* L.),sweet basil *(Ocimumbasilicum* L.*),* ziziphora *(Ziziphora interrupta*Juz.), marigold *(Calendula officinalis* L.) and winter cress (*Barbarea vulgaris)* alongside the wheat plots to enhance Sunn pest egg parasitoids;
- Best cultural practices (planting date, seed rate, fertilizer application and weed control);
- Hand collection of Sunn pest adults during the second to third weeks beginning at the time of migration to wheat fields.

Local farmers participated in the establishment of the trial and in the final yield evaluation. At harvest, we measured: number of seeds in one ear of wheat, weight of seeds, thousand-kernel weight, and overall yield of wheat from plots. During the growing season, it was observed that the wheat rust diseases infestation rate in farmer practice plots with 'Starshina' variety was 40% in contrast with 5% in the IPM demonstration plot with 'Ormon' variety. In general during the monitoring and assessment of insect pests with farmers in 1 m^2 plots, the numbers of Sunn pest adult and larvae in farmer practice plots were 24 to 28 in contrast with 4 to 5 in IPM demo plots.

Table 16. The results of farmer practice plots and IPM package on wheat yield components.

	Thousand-kernel weight (gram)	Yield of wheat from plots (kilogram)
Farmer practice	31.2 $\pm$ 0.74 a	29.6$\pm$ 0.56 a
IPM package	51.1 $\pm$ 0.40 b	49.9 $\pm$ 0.48 b

Values within the same column followed by different letters are significantly different at the $P \leq 0.001$ level, T-test.

In contrast to the farmer practice plots, each of the yield components were higher in the IPM wheat package plots resulting in a 41% increase in final yield (from 29.6 to 49.9 kg/plot) in the IPM package plots. The farmers that participated in the evaluation were very impressed with the rust resistance they observed and requested access to 'Ormon' variety in the future. The results were presented to the farmers through the Institute of Farming and were shared at various meetings and programs with local farmers.

2. Natural Resources Conservation and Management

This section refers to the conservation and management of natural resources such as soil, land, water, fauna, and flora. The approach is closely interrelated with a scientific principle that forms the basis for sustainable global resource management. It brings together land use planning, water management, biodiversity conservation and the future sustainability of industries like agriculture, mining, tourism, fisheries and forestry.

The Program focuses on research related to soil and water management. Activities address on-farm soil and water management constraints, with a view to increasing agricultural production through increased soil fertility, enhanced nutrient use efficiency, and improved water productivity. Results demonstrate that this research usually results in increasing rural incomes and ensuring household food security. This approach could also contribute to the conservation of natural resources, and the sustainability of agricultural production in the Region.

2.1 Crop Management Practices

The Sustainable Land Management Research (SLMR) Project, funded by Asian Development Bank (ADB) and the Global Environmental Facility (GEF), and led by ICARDA within the framework of the Central Asian Countries Initiative for Land Management (CACILM), was successfully completed in August 2009. Between July 2007 and August 2009, this project was implemented in every Central Asian country, including Tajikistan.

The experiment was carried out at Fayzobod rainfed site (2008-2009) to study strip cropping using alternate strips of wheat with alfalfa, lentil at two sloping areas with 6-8^{o} and 16-18^{o} slope gradients. Effective soil moisture content in May was higher by 39% under alfalfa and by 19% under lentil under slope 6-8^{o}C in comparison with higher slope 16-18^{o}C. The strip cropping practice with introducing legumes at upper part significantly reduced surface runoff by up to 20-25% and soil erosion by 40-50%. Strip cropping also improved soil physical properties and nitrate content in soil and stabilized crop yields.

Additional studies on the effect of terraces and mulch on soil erosion and humus content in FayzobodDistrict demonstrated that terracing and mulching of the terrace surface by straw and vineyard cuttings are most effective methods for soil moisture accumulation (soil moisture increased by 40-45%) and increase of humus content by 0.8-1.5% and stop the soil erosion processes. Results of investigation of sowing wheat and safflower with N60 and without N fertilizer at the terraces where walnut was cultivated in half supplied rainfed conditions at the terraced slopes in Khuroson District in Khatlon Region showed that soil moisture accumulation was higher by 40% in comparison with control under N60 treatments.

In 2008-2009 optical crop canopy sensor (Greenseeker) was successfully tested and calibrated for different nitrogen application rates for winter wheat sown in both irrigated (N50, N100, N150… N250) and rainfed zones (N30, N60..N150) of Obi-Kiik site of Khatlon Region and Fayzobod District of Tajikistan. The method based on the measurement of red spectrum reflection (for chlorophyll content) and close infrared spectrum area (defined by vegetation) of electromagnetic radiation were used for the assessment of nitrogen demand during vegetation period. Nitrogen calculators were developed on the basis of these investigations. Furthermore, specialized English language and technical courses on operating an Indian planter and Greenseeker were conducted for several experts and scientists. Farmer participation also helped to raise farmer awareness and extend hands-on technology development and transfer processes.

2.2 Irrigation, Drainage, and Water Basin Analysis

The Integrated Water Resources Management in the Fergana Valley (IWRM-FV) Project, financed by the Swiss Agency for Development and Cooperation (SDC), has been implemented by the International Water Management Institute(IWMI) in partnership with the Scientific Information Center of the Interstate Commission for Water Coordination of Central Asia (SIC-ICWC) since 2001. The main goal of the project is to increase environmental sustainability, secure productive livelihoods, and promote greater social harmony through the improved effectiveness of water resources management. The Project aims to improve the effectiveness of water resources management through the introduction of IWRM principles. The project's key partner in Tajikistan is the Ministry of Melioration and Water Resources of the Republic of Tajikistan. Initially, IWMI mainly worked in Sughd Region and with the Sughd Regional Department of Melioration and Water Resources.

Since 2007, the project has focused on extending IWRM principles to transboundary small rivers with linkages to pilot canals. Two small transboundary tributaries (STT) were selected on the Shakhimardansai River, which starts in Kadamjai District and flows into Uzbekistan (Fargona district of Fergana Region), and the Khojabakirgansai River, which flows from Leylek district of Kyrgyzstan to SughdRegion in Tajikistan. The idea in Khojabakirgansai was to introduce institutional governance mechanisms for improved transboundary water cooperation involving all key stakeholders - basically to facilitate the same IWRM structures on the Kyrgyz side of the Khojabakirgansai STT, reach consensus before going bilateral. In 2011-2012, the project facilitated several rounds of river-wide bilateral consultations and workshops to discuss institutional arrangements with the members of sub-basin water committees from both sides – Kyrgyzstan and as well as Tajikistan counterparts discussed joint cooperation until formal inter-state framework agreement is in place.

The main outcomes of the IWRM-FV project included:

- The Khojabakirgan main canal with 14,000 ha in the command area has shifted from territorial to hydro-graphic principles of management through the establishment of unified Canal Management Organizations (CMO) to replace two existing district water management organizations - Jabbor Rasulov and Bobojon Gafurov (*rayvodkhozes*);

- The boundaries of 14 Water Users Associations (WUAs) along the main canal were re-arranged to follow hydrologic rather than administrative boundaries and there are eight Associations of Dehkan Farms to be dismantled but the project trained its water users on IWRM principles as well. Water governance and user participation in these WUA's were also improved and strengthened through water user groups established on tertiary level and below outlets. This was achieved through a bottom-up social mobilization and institutional development approach established by IWMI;

- Public participation in decision-making processes has been strengthened and extended at Tajik side sub-basin level through a union of water users in the Khojabakirgansai system;

- An innovative form of water governance has been designed in the form of Sub-basin Water Committee - a joint public and state body to govern water on the Tajikistan side of the Khojabakirgansai River.

2.3 Conservation Agriculture

A new International Fund for Agricultural Development (IFAD) project "Integrated Crop-Livestock Conservation Agriculture for Sustainable Intensification of Cereal-based Systems in North Africa and Central Asia" was launched in 2013. The project will contribute directly to the implementation of the CRP "Integrated Agricultural Production Systems for the Poor and Vulnerable in Dry Areas" through the development and application of integrated Crop-Livestock Conservation Agriculture (CLCA) systems for sustainable intensification of dryland production in Central and West Asia and North Africa. The project will be implemented in three countries: Algeria, Tunisia, and Tajikistan, together with the National Agricultural Research and Extension Systems and farmers. It will test various options for the integrated CLCA that should provide the basis of larger scale adoption by farmers in the region.

Tajikistan is one of the most mountainous regions in Central Asia. A strong rugged relief, frequent heavy showers and weak soil resistance enhance the destructive influence of water coming from the mountain slopes, and combined with strong winds, are the primary reasons for the strong soil erosion found in many parts of Tajikistan. This susceptibility to erosion highlights the need for technologies to combat soil erosion and degradation, and appropriate agricultural systems to improve soil and crop quality.

One of the major agricultural regions in Tajikistan is the Fergana Valley, on the border between the Kyrgyz Republic, Tajikistan and Uzbekistan. The climate of the region is continental, but this varies considerably, based on altitude. In the major agricultural areas, mainly in the river floodplains, the climate consists of hot, dry summers and mild, warm winters. Precipitation occurs during the winter season, mainly between September and April. The average summer temperature varies between 19°C and 32°C. The average annual precipitation in this region is 338 mm, varying from less than 70 mm in the plains and deserts to 2,400 mm in the mountains of central Tajikistan. Irrigation in Tajikistan has been important in Tajikistan for the development of agriculture and the national economy. In 1994, 93.4% of the total cultivated area was irrigated. Surface irrigation is the only irrigation technique used in Tajikistan, with furrow irrigation practiced on over 96% of this. The major irrigated crops are cotton, fodder, fruits and grapes, cereals and vegetables.

Conservation Agriculture is largely unknown among the farming population of the irrigated areas of the lower half of Central Asia. But the technologies and practices associated with CA can provide a solution to the problems of soil erosion and degradation.

The project will span a period of 36 months, and will be based on the past research experiences of main partners in Algeria, Tajikistan and Tunisia, as well as on the existing and new links established with national partners. ICARDA will undertake monitoring, evaluation, and reporting, while designated national coordinators will be responsible for implementation of the project in each country. The project outcome will be evaluated on the adoption of the CA technology and the speed of that adoption and the economic and environmental benefits that this generates.

The project consists of three main research activities. These are: ex-ante evaluation of CA-based technologies; enhanced crop-livestock integration in CA through optimized stubble grazing strategies and increased fodder availability from forages or fodder shrubs; and site-specific conservation agriculture technology packages, fine-tuned and disseminated for enhanced farm productivity, resource use efficiency and profitability.

As a result of the project implementation, productivity is expected to increase by 10%. At least 1,000 households will be targeted in the selected countries and some 10,000 people, including women in the target communities, are expected to benefit from the project. The project will also enhance the exchange of experiences and knowledge-sharing between farmers, within the scientific circles and with policymakers. Partners from the national agricultural research and extension systems and policymakers are expected to participate in and benefit from project outcomes. The national research partners will get access to new and innovative information, while policymakers will learn more about the benefits of the new Integrated Crop-Livestock Conservation Agriculture (CLCA) technologies at both district and national levels.

It is expected that recommendations will be developed and communicated to stakeholders on the basis of collected data. A stubble grazing strategy will be optimized, and suitable fodder species for alley cropping will be identified and integrated with CA. Moreover, new varieties for CA will also be identified at experimental stations of involved research institutes in the participant counties. Farmers will adopt site-specific CLCA technology packages that will have been developed as part of the project. This is particularly important for poor people in both rainfed and irrigated rural areas of Tajikistan as they lack adequate resources for farming.

2.4 Rangeland Rehabilitation and Management

2.4.1 Range and forage productivity

The rangeland productivity component of the project "Community Action in Integrated and Market-oriented Feed Livestock Production in Central and South Asia" assessed the potential for introducing new species and improved varieties of forage crops. The project purpose was to develop and promote community-based actions to support productive and sustainable livestock systems, access to market opportunities, and sustainable management of the natural resource base in the region.

Optimizing agronomic practices is very important to ensure high forage production. Seeding rates and planting dates for hybrid maize were tested in Tajikistan, and the effect of ammophos application to alfalfa in the first growing year in central Tajikistan. The on-farm experiments led to distinct recommendations for each site. In general the cost-benefit analyses revealed that moderate seed rates and applications of fertilizer proved to be most advantageous. More long-term on-farm research and demonstrations are required to develop best practices for household farms considering productivity and profitability.

Another research area in the project was to develop practical measures for rehabilitating rangelands. An exploratory vegetation study compared two sites each in central Tajikistan and Kyrgyzstan that differed in aspect (north versus south facing). Aspect had a profound effect on species composition, the number of plants, on the proportion of litter and bare ground and on dry matter biomass production. This means aspect should be considered when selecting sites for rehabilitation measures. In northern Tajikistan oversowing with indigenous species was tested in order to rehabilitate degraded rangeland areas. Due to the dry spring and summer the experiment failed in 2008 and was repeated in 2009. Hence only preliminary results are available that showed that the germination and early establishment of the species in the pastures worked well and that in combination with controlled grazing management - adequate resting periods - this low-cost measure could help to speed up the recovery of degraded rangelands. At present this would be only applicable to private rangelands.

Mungbean

In Tajikistan, mungbean (*Vigna radiata* (L.) Wilczek) was tested as a summer crop after the harvest of winter wheat under irrigated conditions. In the climatic conditions of Central Tajikistan early-maturing varieties have to be chosen because in some years early frost can decrease grain yields. Overall, mungbean seems to be a promising crop for the country to diversify the cropping system as it can improve soil fertility and decrease farmer's economic risk from climatic variability or changing commodity crop prices.

Pearl Millet

In northern Tajikistan pearl millet (*Pennisetum glaucum* (L.) R.Br.) varieties that had been recommended by ICRISAT for the agro-ecological zone were tested as an alternative to maize as a summer crop after winter wheat. The pearl millet varieties showed excellent growth and tillering capacities but were rather late-maturing, they are suitable for green forage production when used as a summer crop after winter wheat. To harvest the grains, pearl millets would have to be cultivated as a main crop in spring. It is known from other studies that pearl millet shows excellent re-growth after the first cut, therefore multiple cutting should be tested in the future.

One measure to decrease the gap in winter feeds could be to increase the productivity of hayfields which are designated areas in the communal or private rangelands to be harvested in late summer for winter feeding. The project tested the effect of oversowing with sainfoin and nitrogen fertilization on hayfield productivity in community hayfields in central Tajikistan. The results showed that the productivity of hayfields in both countries could be indeed increased by both oversowing and fertilization.

However, the yield response varied considerably between 2008, a very dry year and 2009, a year with favourable rainfall. Thus, moderate input levels are recommended to decrease the economic risk as net benefits depend on the market price of hay that may decrease considerably in good rainfall years when it is abundantly available on the markets. Practices to increase hayfield productivity are considered to be more widely applicable and more promising than rangeland rehabilitation measures as the access to hayfields is more controlled than to other communal grazing areas.

The project findings in Tajikistan indicate a number of technically and economically interesting practices that should now be taken up by more specialized development oriented projects at a larger scale. This will require external investments supported by NGOs as the country lack the organizational infrastructure in the public and private sector.

2.4.2 Introduction and promotion of biosaline agriculture technologies for improvement of degraded abandoned farms in Tajikistan

Limited water resources, soil salinity and poor soil fertility, deforestation and overgrazing are the major constraints to crop-livestock production in Tajikistan. Extensive use of traditional furrow irrigation leads to soil erosion, salinization and waterlogging, thus greatly reducing not only the sustainability of agriculture, but also the long-term security of rural communities. As a result, a huge amount of productive irrigated lands is turning to degraded marginal lands, which are then abandoned by farmers. These phenomena also results in loss of biodiversity and replacement of many useful wild species with less palatable forage crops, leading to the significant reduction of forages.

The summer-vegetation, agro-silvopastoral model for improvement of productivity of marginal salt-affected lands and all horticulture crops in Tajikistan requires supplemental irrigation to ensure better yield. Measurement of water applied to the crop and irrigation scheduling is still based on conventional approaches. This is further aggravated by the fact that there is absolutely no data available on basic requirements of water management in crops within moisture extraction pattern, water requirements of different crops, and impact of water deficits.

Awareness of the farmers about soil and water conservation and management is also very poor. Additionally, huge territories of virgin open rangelands in the Asht massif (part of the Fergana Valley) have been completely converted into irrigated farmlands. Out of the total net irrigated area, over 35-40% has drainage systems, varying from surface, sub-surface and vertical drainage (tube-wells). Therefore, the irrigated lands are characterized by high groundwater tables and salinity.

Wild native halophytes

The area with high shallow water table increased significantly between 1996 and 2009 from 25 to 46% of the total irrigated land of the Asht massif. During the same period, the area of moderately and strongly saline land (where crop yields decreased by 20 to 50%) increased from 23.4 to 38.5% of the total irrigated land. The drainage channels that were built during the Soviet Union time were last maintained some 15-20 years. As a result, most of these channels are choked with reeds and there is an imbalance between the inflow and outflow of water in these channels. Drainage water with the mineralization of 4,000-5,000 ppm, 6-7 dS/m is the unique available source of water for irrigation of crops. Increase in groundwater depth due to high water use and non-functional drainage system.

The main problem in the Asht massif, Yangiobod farm in particular, seems to be the inefficiency of drainage channels, excess volume of irrigation water, resulting in rising groundwater level. As a result of high solar radiation and evaporation rates, the salts are brought on the upper surface of soil and result in sharp decline in production of cotton, rice, vegetables and other cash crops, significant decrease in arid forage production and grazing capacity of large open rangelands that leaded to reduction of the number of livestock and dairy industry.

The huge territories of wastelands are covered by wild native halophytes, which are poorly studied yet. These species grow well in association with a variety of species and often offer severe competition to perennial species, both in natural and introduced pastures in saline and degraded sites. Marginal and abandoned farming lands in the Asht massif affected by salinity are mostly located in the upper reaches of the Syrdarya River and on the Tajikistan-Uzbekistan border of the Fergana Valley. Huge territories of these virgin open rangelands have been completely converted into irrigated farmlands. During the last decade due to a rise in groundwater level, resulting from excess irrigation during cultivation of cotton and other crops, high evaporation during hot summer and/or poor drainage, soil salinity has become a serious problem in some of the locations of agricultural irrigated lands.

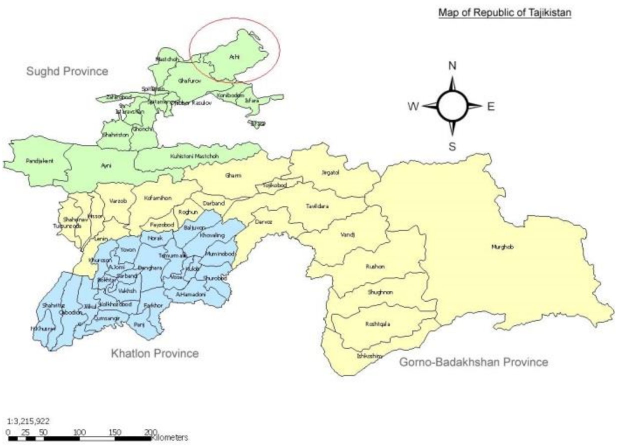
Since maintenance of drainage system is costly, time-consuming and requires annual recurring costs, alternative strategies need to be identified for localized management, ie on-farm management. Biological approaches for reclaiming root zone areas and also for sustaining economic productivity of salinity-prone environments are essential. Both local and introduced germplasm for initially lowering water table, followed by management practices to cultivate salt-tolerant forage and crops, and halophytes, can help to improve the livelihood of the local population in the target areas.

Therefore since the beginning of ICBA's activities in Tajikistan, dated from March 2007, in collaboration with different national research organizations, ICBA is working towards turning these marginal lands into productive ones through (i) management strategies for land and water; (ii) introduction of other salt-tolerant plants and halophytes; and (iii) optimization of integrated approaches for better economic returns. Introduction of a range of deep-rooted annual and perennial forage species, legumes, chenopod and tree species can be used in a demonstration plot to monitor the changes in soil and water to assist with dryland salinity control and to provide options for optimization of cropping-livestock production system in Tajikistan.

Another research project "Introduction of biosaline agriculture technologies for improvement of degraded abandoned farms in Tajikistan" was funded by the Islamic Development Bank (IDB) in 2007-2009.

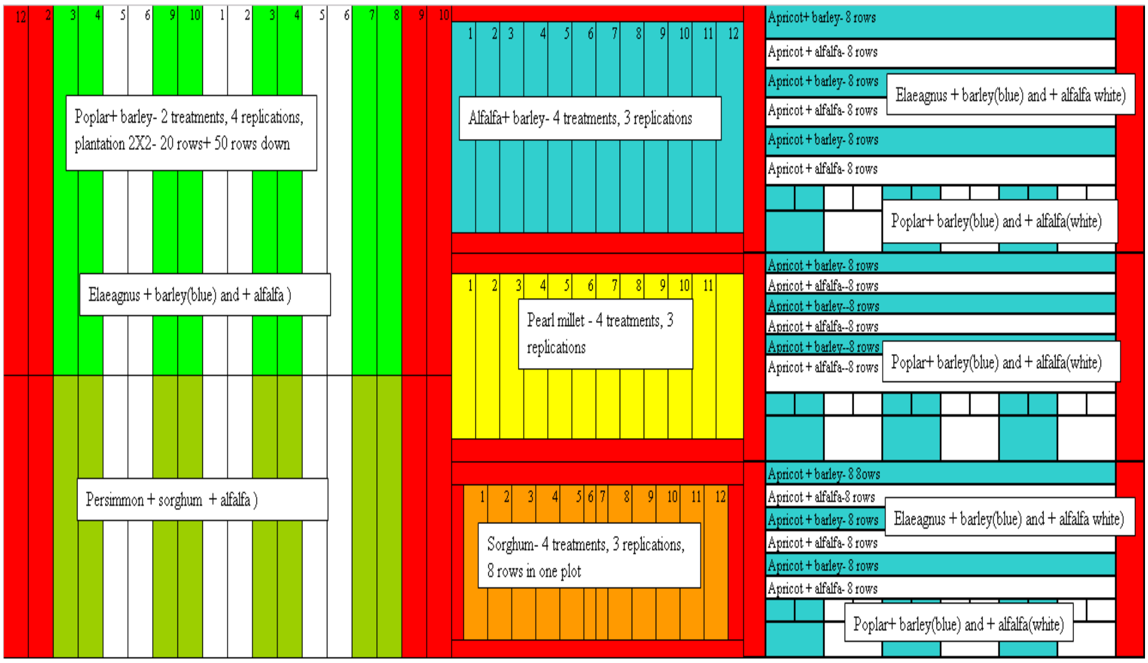
The main goal of this ICBA-TAAS bilateral project in northern Tajikistan, at Yangiobod experimental site, Sughd Region, was to evaluate native wild halophytes and conventional and non-conventional sorghum and pearl millet varieties, technical and fodder crops for their ability to grow and produce economic yields in saline environments. Special attention was given to the development and adoption of innovative management options in order to increase productivity and income generation on salt-affected marginal lands.

Asht District located in northern Tajikistan on the border with Uzbekistan is part of the Fergana Valley. Average annual temperature is 14.1ºC, maximum monthly temperature observed is 25.2ºC in July and minimal -0.9ºC in January. Average annual precipitation is about 350 mm, with variation between 127 and 593 mm. Precipitation occurs predominantly during the cold period, with roughly 39.8% of the annual precipitation falling as rain in late autumn and spring and 37% as snow in winter. Heavy rainfall at this time of the year causes soil erosion. Soil is brown and clayey. An extremely cold and snowy winter was recorded in this region in 2007. The mean temperature minimum of bellow 0^0C was recorded even in April, when vegetation all over rangelands of the Asht massif started. Summer is dry and hot almost without precipitation.



Geographical map of Tajikistan. Experimental Asht District is circled in red. Source: maps.google.com

Experimental trials for strip-alley cropping integrated with agro-forestry system were conducted on Yangiobod farm, Asht District, Sughd Region in the area of about 3.5 ha (three sub plots of 625 m^2 (100 -130 plants), with trees planted at 2.5 x 2.5 m for the four test tree species, replicated three times in completely randomized or block design).



A trial for integrated agro-forestry cropping system on Yangiobod farm, Asht District, Sughd Region, Tajikistan

2.4.3 Agrosilvopastoral model for improvement productivity of marginal salt-affected lands

In order to control the fluctuation of the groundwater table by growing cash crops at the same time, an agro-forestry trial was carried out in 0.5-1 ha of marginal lands (abandoned farmer lands not used for the last 10years) degraded by overgrazing and salinity.Local salt- and drought-tolerant apricot (*Armeniaca vulgare*)-150 saplings, Russian olive tree (*Elaeagnus angustifolia*) -450 saplings, mulberry (*Morus alba*)- 100 saplings, two species of local poplar (*Populus pyramidalis* and *P. diversifolia*)-900 saplings per each and persimmon (*Diospyros virginiana* L.)-350 saplings were deeply planted (sticks tap into the water table) through seedlings transplanting in early February 2008 and 2009. Trees/shrubs plantation requires limited irrigation during the initial stage of growth before sole reliance on available drain water (Ec ≈ 4.0 -6.3 dS/m) resources becomes possible. Herbaceous fodder crops (alfalfa, chickpea, mungbean, perennial sorghum) planted within the inter-spaces of salt-tolerant trees/shrubs plantations improve productivity of salinity-prone soils, solve the animal feed gaps in the lands degraded both by overgrazing and salinity and increase the profits for farmers. The fast growing and high survival rate was observed for local poplar species (about 91.3%);75.2% for apricot (*Armeniaca vulgaris*) and about 54.8 % forpersimmon (*Diospyros virginiana* L.), when cultivated in mixed stands with various salt-tolerant crops. *E. angustifolia, Morus alba* species offerpossibilities as supplementary feed to the low-quality roughages throughout the off-season. The expansion and commercialization of non-timber forest products has the potential to increase the cash income of rural households.

Table 17.Main parameters of apricot trees under different irrigation and fertilizer treatments on Yangiobod farm

Treatment	Height (m)	Diameter of trunk (cm)	Leaves		Number of	
			Width (cm)	Length (cm)	Branches	Leaves
Furrow irrigation/no fertilizers	0.98	1.22	2.9	5.4	33	33
Furrow irrigation/$N_{120}P_{120}K_{90}$	1.36	1.36	3.5	6.7	52	36
Furrow irrigation + inorganic fertilizers	0.92	1.1	2.2	4.7	28	24

Better plant growth, accumulation of green biomass and consequently yield of both fresh and dry matter were significant for alfalfa both in pure stand and mixed artificial agrophytocenous plants, including trees. The optimum integrated agro-forestry-farming system comprising 12% tree cover, 30% alfalfa and 58% annual forage crops of virgin pastures with traditional agriculture practice provides satisfactory drainage control of saline environments preventing salt accumulation in the root zone area.

2.4.4 Improvement of degraded rangelands affected by overgrazing and salinity

Research in 2007-2010 also demonstrated that, when alley cropped barley, triticale and alfalfa, are grown together, they yielded 20% higher green biomass than barley alone in the traditional barley-fallow system. Local varieties of barley showed low resistance to soil salinity and gradually disappeared from grasslands. Growing salt-tolerant, high-yielding legumes in combination with cereals, alternated by strips of aboriginal halophytes such as *Ceratoides ewersmanniana, Kochia prostrata, Salsola orientalis* and *Halothamnus subaphylla,* was found to have great potential for producing more of highly nutritional fodder (both fresh and as hay) and increase the productivity of degraded by overgrazing semi-desert foothill rangelands in the Asht massif, northern Tajikistan.

Licorice (*Glycyrryza glabra*) and *Alhagi pseudoalhagi,* both forage species from *Fabaceae* and *Kochia prostrate (Chenopodiaceae)* can be planted on salt-affected and degraded rangelands for soil bio-remediation and creation of high palatable pure or multi-component pastures by increasing its productivity bytwo times compared with degraded overgrazed pastoral lands. The planting of these two valuable forage crops is encouraged to be done along the saline water bodies, like artificial ponds and freely flowing artesian wells. Even during the remediation period, they have potential to generate income for farmers, since their biomass can be used as high quality forage additive for livestock. Their root material is well known to have very high marketability in many industries, especially in pharmaceutics. *Alhagi peseudoalhagi* and *Kochia prostrata* young stems, leaves and fruits are considered fattening feed for all kinds of animals and can be stored as hay/feed blocsor silage for winter feed. It is extensively collected by pastoralists during flowering stage. Measures should be taken for the domestication of these plants for pastures improvement. Uncontrolled collection and increasing soil salinity has led to reduction of the genetic resources of this species.

A change in land use policies of marginal lands would thus provide direct economic benefits to rural farmers, provide income for the government via taxes, and lead to an overall improvement in ecological conditions in the region.

3. Conservation and Evaluation of Genetic Resources

The CAC Region is a vast geographic area rich in agro-biodiversity, which is today very important to its agriculture. This Region is the home a diversity of crops species that are of global importance. Among the crop gene pools that originated or diversified here are cereals (wheat, barley, and rye), food legumes (lentils, chickpea, faba bean, and pea), forage legumes (medicago, *Trigonella*, *Trifolium*, *Onobrychis*, *Vicia* and *Lathyrus*), vegetables (cabbage, onion, garlic, melons, carrot, radish, and spinach), fruit trees (almond, apricot, apple, pear, pistachio, cherry, plum, walnut, pomegranate, quince, hazelnut, grape, fig, chestnut and mulberry), fibre and oil crops (safflower, flax, cotton, and sesame), and many medicinal and aromatic plants (eg *Mandragora*, *Achillea*, *Glycyrrhiza*, *Valeriana*, and *Ferula*).Therefore, conservation and evaluation of genetic resources is an area of considerable importance in Tajikistan.

3.1 Plant Genetic Resources

3.1.1 Grain crops

As part of efforts aimed at preserving plant genetic resources, the national gene-bankwas openedat the ResearchInstitute of Crop Husbandry of Tajikistanin September2002. Since then, ICARDA assistedin upgradingthe gene-bank. In particular,10,000plasticcontainers forseeds,electronic balances, a moisture meter, a seedmoisture meter, a thermostat for germination, shelves and a storagecooling system have been provided. An emergency generatorforthe gene-bank was also purchased within the projectfunded by the Global Crop Diversity Trust. Gene-bank staff took part in atraining course onthe documentation andconservation of geneticresources.The gene-bank has computers and access to the Internet.

In2007, the government of Tajikistan decided to establish aNational Centerfor Plant Genetic Resources. With the helpof the Government ofSweden (Sida), the buildingofthe gene-bank in Tajikistan was renovatedandallthe necessary equipment forlong-term storage of genetic resources was purchased.Specialists ofthe gene-bankof the Research Institute of Crop Husbandry were hired to work at theNational Centrefor Plant Genetic Resources. The nationalcenter hasqualified personnel and the gene-bankis now fullyoperational.

To date, Tajikistan has5,698accessions, of which 52.76% is grain crops, 16.02% horticultural crops, 8.81% legumes, 7.9% vegetables, 5.39% maize, 3.32% forage crops, 2.51% melons and 1.07% potato. Technical and oilseed crops, medicinal plants, sugar beet and wild relatives of other crops together make uponly 2.23%.

From 2003to 2006and in 2011,ICARDA initiated several internationalexpeditions todifferent partsof Tajikistan.As a result,1,345 local accessions of grain, legume and forage crops including rare, valuable, endangered species, forms and their wild relatives were collected.Currently, the collection is being enriched by the annual expeditions and exchange of traditional variety entries, including the entries from N. I. VavilovAll-RussianResearch InstituteofPlant Industry (VIR), Russian Federation and ICARDA.

The regeneration of rare endangered local accessions of wheat and barley was organized within the program of the Global Trust Fund.In 2011, 1,021 local wheat variety entries and 624 local barley variety entries were sent to VIR for the long-term storage.In December 2011, 1,021 local wheat accessions and 624 accessions of local barley were sent for storage in the global seed vault of Svalbard, Norway.

3.1.2 Fruit crops

Tajikistan is part of the Central Asian genetic center of origin and domestication of many crops and the center of their diversity. Many globally important crops originated here and their wild ancestors can still be found growing in the nature. This great richness in genetic resources is the result of evolutionary processes taking place in diverse physical and climatic conditions. Livelihood of local people is greatly linked with exploitation of plant genetic resources.

Tajikistan is famous for varietal diversity of apple, apricot, pear, almond, currant and grape. The favourable soil and climatic conditions contributed to development of horticulture during the Soviet time. The large horticulture and viticulture collective and state farms cultivated apple, pear, apricot, grape, and delivered them to processing and wine-making factories, whose products were exported outside the republic.

However, socioeconomic problems, induced by the collapse of the Soviet Union and destruction of economic infrastructure, lack of fuel and lubricants, fertilizers, equipment, marketing of grown products, forced local population to cut down large massifs of orchards and vineyards, and to cultivate annual crops at those areas. Lack of fuel sources, unemployment in the cities, followed after the closure of factories, return of unemployed people to their home villages increased pressure on natural ecosystems of nut-fruit forests. Felling trees for firewood, uncontrolled collection of nuts and wild fruits, berries, mushrooms, overgrazing - all this led to degradation of forest ecosystems. As a result, a real threat of genetic erosion of both cultivated and wild fruit resources has emerged.

For conservation of unique diversity of genetic resources of fruit and nut-fruit crops in Central Asia, including Tajikistan, Bioversity International implemented from 2006 to 2013 regional project "*In Situ*/On-Farm Conservation of Agricultural Biodiversity (Horticultural Crops and Wild Fruit Species) in Central Asia" with financial support of the Global Environmental Facility (GEF) and implementation support from the United Nations Environmental Programme (UNEP). The project brought together efforts of five countries to address issues of conservation and sustainable use of local fruit crops and their wild relatives in the Central Asian region

The Institute of Horticulture (former Research and Production Association,Bogparvar) of the Tajik Academy of Agricultural Sciences is the national project implementation agency, responsible for coordination of the project activities among various stakeholders including research institutes, ministerial agencies, farmers, NGOs, universities in Tajikistan.

"*In Situ*/On-Farm Conservation of Agricultural Biodiversity (Horticultural Crops and Wild Fruit Species) in Central Asia"

Key project objectives are:

(1) provide recommendations to policymakers for strengthening legal and policy frameworks for conservation and use of genetic resources of fruit crops;
(2) assess, document, and manage in a sustainable way local diversity of fruit crops and wild fruit species;
(3) promote broad stakeholder participation, representative decision-making, and strong partnership among them; and
(4) strengthen the capacity to implement all aspects of fruit species genetic diversity conservation at local, national and regional levels.

Assessment of the diversity and distribution level of the fruit crops and their wild relatives in Tajikistan was conducted under the project using traditional eco-geographical surveys, focus group discussions (FGD) and household surveys. The results of the survey demonstrated that the process of evolution of fruit species and development of local varieties is still ongoing in wild and cultivated habitat. Rich diversity of fruit trees is maintained in their fields by farmers in Tajikistan, including 122 varieties and forms of apricot, 79 of apple, 27 of grape, 22 of pear, nine of walnut, seven of food mulberry, six of pistachio and three of peach.

Many of these local varieties and forms of fruit trees possess unique traits of drought and frost resistance, excellent taste, fruit size and appearance. For example, two forms (#1 and #2) of apricot tolerant of diseases and frost were found in Shamtuch village, Ayni District, Sughd Region. An apricot form discovered in the orchard of farmer Saidmurod Saidov in Rarz village bears fruits every year. Two apricot varieties in Varz village are high-yielding and their dried fruits are of excellent quality. Local apple varieties 'Atlasniy' and 'Kulmat' were identified in home gardens of H. Yususpov and K. Kodirov in Vigoni village, Istaravshan District. These apple varieties are early-ripening, resistant to pests and diseases, and have an attractive appearance.

Local apple forms ('Chuvaseb', 'Zardseb', 'Surhseb', 'Sebi tiramohi', 'Sebi kosimsarkori', 'Sebi rahshak', 'Kabudseb') and drought-resistant and high-yielding forms of pear ('Noki Tarak', 'Amrudi shaking', 'Amrudi abusaidi') were identified in wild populations of fruit species and abandoned orchards in Sarihosor Nature Orchard, Baljuvon District. High-yielding grape varieties such as 'Anguri surh', 'Safedangur', 'Anguri govak', 'Chashmi gov', 'Anguri obak' and 'Angushti arus' were also found there. Unfortunately, many of these local varieties and forms are represented only by one or two trees in the home orchards of the farmers or the wild populations from where they were brought to the farmers' orchards are facing anthropogenic pressure and so, are under the threat of disappearance.

To conserve this unique diversity of fruit trees and increase its distribution in farmers' fields and forests 11 fruit trees nurseries in a total area of 3.37 hawere established under the project in Tajikistan for multiplication of local varieties of target fruit crops and promising forms of wild fruit species. Planting material of 87 local varieties comprising 22 varieties of apple, 25 of apricot, eight of pear, eight of peach, six of walnut, nine of grapevine, six of mulberry and three of pistachio were produced in these nurseries and distributed among farmers at Fruit Trees Saplings Fairs organized every year in all regions of Tajikistan. "List of fruit tree nurseries for multiplication of local varieties of fruit and nut crops and grapevine in Tajikistan"was produced to disseminate information about the source of planting material of fruit crops varieties among farmers.

Publications resulting from the project:

- "List of fruit tree nurseries for multiplication of local varieties of fruit and nut crops and grapevine in Tajikistan"
- "List of demonstration plots with local varieties of fruit and nut crops conserved on farm and *in situ* in Tajikistan"
- "Roster of local varieties of fruit, nut-bearing crops and grapevine, conserved in situ/on farm in Tajikistan"

In total, 18 demonstration plots/matrix orchards with a total area of 32.38 ha were established in all agro-ecological zones in Tajikistan. These demonstration plots are used for organizing training for farmers on fruit trees management practices, demonstration to farmers of various local varieties of fruit trees and their distinguished traits, fruit processing and storage technologies both traditional and advanced. A total of 15 demonstration sites in a total area of 26.33 ha where diversity of 135 local varieties,including 41 varieties of apple, 35 of apricot, 14 of pear, 12 of grapevine, 12 of walnut, seven of mulberry, six of peach, four of almond and four of pistachio were established in farmers' orchards. Three demonstration plots for wild walnut, pistachio, apple and pear werealso established in forestry enterprises in an area of 6.05 ha. There is a National Orchard in Sughd Region established by presidential decreein an area of 493 ha where 55 traditional varieties of fruit crops are conserved. "List of demonstration plots with local varieties of fruit and nut crops conserved on farm and *in situ* in Tajikistan"was published and disseminated among farmers about the source of mother plants for grafting and producing planting material of local fruit crop varieties.

The national "Roster of local varieties of fruit, nut-bearing crops and grapevine, conserved in situ/on farm in Tajikistan" was also published. The roster includes contact details of 118 farmers-custodians of diversity of fruit trees who are conserving on farm 219 local varieties and forms of eight target fruit and nut crops in their orchards. Based on the results of study of local fruit trees diversity 15 manuals and guidelines were published. The publications present information about local varieties of horticultural crops and wild fruit species, their description, traditional skills and knowledge of farmers and local communities on maintenance, processing, and storage of products of horticultural crops, methodologies on cultivation and reproduction of local varieties of fruit trees, recommendations for using local varieties of horticultural crops and wild fruit species for breeding and non-breeding purposes, technologies for producing fruit crops products and adding value.

A regional training center on apricot genetic resources was set up at the Sughd branch of the Tajik Institute of Horticulture to provide training to researchers and farmers on management of apricot trees diversity, technologies of processing, drying and storage of apricots. The Institute has 50 years ofexperience and knowledge on apricot trees and keeps 180 accessions of apricot trees in its field collection. A total of 70 researchers and farmers from Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan were trained on apricot trees cultivation technologies, producing dried apricot products at the training center.

Two national training centers on fruit trees were established at the Tajik Institute of Horticulture in Dushanbe and Pamir Biological Institute in Khorugh to provide training to larger groups of researchers, famers and forest dwellers on various aspects of fruit trees diversity conservation. In total, 390 researchers and farmers participated in regional and national training sessions on advanced methodologies and technologies in study and conservation of fruit trees diversity, including computer application DIVA-GIS, molecular markers technologies in plant genetic resources assessment, development of public awareness materials, data documentation, communication with farmers and documentation of traditional knowledge, conducting market research and development of marketing strategy, processing and storage of fruit products, fruit trees grafting and pruning, pest and diseases management etc.

The national legislation and policy framework was strengthened in the area of *in situ* conservation of wild fruit species in protected areas, supporting farmers in their activities on maintenance of local fruit trees diversity (conservation on farm), protection of farmers' rights and aspects of access and sharing benefits arising from use of fruit trees genetic resources. National partners contributed to the development of national law "Conservation and Sustainable Use of Crop Genetic Resources" which is being reviewed by the Lower Chamber of the Parliament of Tajikistan.

Two Farmers' Associationswere established in Tajikistan: in Istaravshan District in Sughd Region and in Rasht District. These associations unitefarmers (fruit tree growers)and help them to lobby for their interests in getting access to land and water resources, seeds, and marketing their products. The project assisted in submission of fruit crops varieties developed by farmers to the State Variety Testing Commission of the Republic of Tajikistan. Currently farmers' varieties of apricot 'Nishoni' and grapevine 'Shohona' are included in the State Register of Released Crop Varieties in Tajikistan. Apricot variety 'Nishoni'was developed by farmer Mr Nishon Shukurov from Kulkant village in Isfara District, Sughd Region. His apricot variety has fruits with an average weight of 61-65 g. The variety is tolerant of diseases and does not require pollinators to produce fruits. The variety is suitable for producing tasty apricot juices and dried apricots. It contains 18-20% of sugar and 22% of dried substances. Productivity is 10-16 t/ha. The variety has long shelf life and is good for transportation which makes it very suitable for export as fresh fruits.

Dissemination of Project's Findings

A website was developed in Tajikistan (www.bogparvar.tj) to share the project's findings with national, regional and global communities. The website is linked to the regional web portal of the project at http://centralasia.bioversity.asia, which also hosts the central database on the fruit trees diversity in Central Asia, its evaluation and management data

Grape variety 'Shohoni'was developed by farmer Mr Hoji Nemat Usmonov from Boghinav village in Tursunzoda District. His grape variety has big bunches which weigh 2-4 kg, and the size of berries is 40 mm. Berries have nice pink colour with crispy flesh and productivity of this grape variety is 40 t/ha. The results of the project's implementation in Tajikistan were shared by national partners through their participation in various international forums including International scientific wrap-up conference "Conservation and use of agro-biodiversity of fruit crops in Central Asia" (23-26 August 2011, Tashkent, Uzbekistan), Third international conference "Ideas of Acad. N.I. Vavilov nowadays" (6-9 November 2012, Saint Petersburg, Russia), Global conference on women in agriculture (13-15 March 2012, New Delhi, India), Global consultation meeting on gene-bank management (13-16 February 2013, New Delhi, India).

The project "Reviving biocultural heritage: strengthening the socioeconomic and cultural basis of agro-biodiversity management for development in Kyrgyzstan and Tajikistan"was implemented by Bioversity international in Tajikistan in 2005-2009 with support of The Christensen Fund. In Tajikistan the work of the project was focused on the western Pamirs, considered the country's most important area in terms of biological and cultural diversity. The project also covered the Afghan side of the Pamirs, which is a remote area where fruit growing is central part of livelihoods and culture.

"Reviving biocultural heritage: strengthening the socioeconomic and cultural basis of agro-biodiversity management for development in Kyrgyzstan and Tajikistan"

The goals of the project were:

(1) to identify remaining pockets of human-influenced tree crop biodiversity;
(2) to assess human-influenced tree crop biodiversity for promising material for meeting subsistence, marketing and other use objectives;
(3) to support the custodians of pockets of fruit tree diversity by facilitating linkages between farmers and their communities, by fostering exchange and collaboration among farmer-custodians, scientists and germplasm institutes; and
(4) to promote wider partnerships with national organizations that use local biodiversity as a resource for development.

The project carried out field research on the diversity of traditional varieties of fruit and nut crops in Kyrgyzstan and Tajikistan, and on how this diversity is shaped and maintained by farmers. The study developed, tested and implemented methods to strengthen the social, economic and cultural basis of communities to manage agricultural biodiversity.

Fruit tree diversity and related farmers' knowledge was documented in over forty villages in Tajikistan during focus groups discussions and individual interviews. Twenty-eight farmer-custodians were identified and a network was established that connects these custodians and their communities to each other, to scientists and to germplasm institutes. A preliminary set of environmental, economic and socio-cultural determinants of fruit and nut tree diversity were identified through which custodians may contribute to conservation.

On the basis of the work and the findings of the research, an approach to crop genetic research conservation was formulated that is human-centered, grassroots-based, and that relies for a large part on the knowledge, skills, and needs of farmers. The approach applied by the project represents a way of reconciling local development needs with the conservation of biocultural heritage that is new to the region and that local institutions and development organizations have shown interest in adopting. Project partners made more inclusive and methodical attempts to address the community management of native fruit tree varieties by making sure to broaden earlier narrower focus on community management processes and agronomic aspects by incorporating cultural and economic dimensions. In addition to the fruit trees diversity data, a large number of traditional recipes, culinary anecdotes and poems were collected in the Pamirs in collaboration with a group of enterprising women. This garnered support from the Slow Food Foundation for Biodiversity which established a Presidium for Mulberry Products in December 2009.

In 2013 Bioversity International started a new collaborative project "Conservation for diversified and sustainable use of fruit tree genetic resources in Central Asia", supported by Centre de Recherche Public Gabriel Lippmann (CRPGL), Luxembourg. Three countries of the region: Kyrgyzstan, Tajikistan and Uzbekistan are participating in the implementation of the project.

The project is aimed to improve the availability and quality of fruit and nut tree genetic resources to farmers in Central Asia, to sustain their livelihoods in the context of a more diversified and sustainable agriculture by generating knowledge and better understanding of genetic diversity patterns and nutritional properties, and efficient conservation of fruit and nut tree genetic resources. By documenting the potential contribution that genetic diversity can make to dietary diversity and healthier foods, the importance of plant genetic resources will be better recognized by the public and by policymakers.

Knowledge, methodologies, strategies and other tools will be developed within the project for the better conservation and diversified use of fruit tree genetic resources in Central Asia. A dissemination strategy will also be developed for effective delivery of project results in Central Asia and more broadly in the international context.

To support the development of information management and systems, and conservation actions the Global Crop Diversity Trust and Bioversity International supported project "Regeneration of Barley and Wheat Collections in Tajikistan", implemented by Tajikistan National Center of Genetic Resources in 2008-2011. In total, 300 accessions of barley and 500 of wheat conserved in the national gene-bank of Tajikistan were regenerated and duplicates were deposited in the seed vault in Svalbard, Norway.

4. Socioeconomic and Public Policy Research

Socioeconomic, policy and institutional studies are part of the collaborative efforts. These studies are aimed at helping to increase agricultural production, improving rural livelihoods, and boosting incomes of the local farmers. As in many other post-Soviet Central Asian countries, much of the socioeconomic and policy research is done the old way in Tajikistan. To assist NARS partners in their efforts to further develop agricultural economic research in Tajikistan, the Program introduces appropriate social and economic studies, as well as capacity-building for socioeconomic research, in most of its projects.

While most transition countries in eastern Europe and former Soviet Union experienced considerable economic decline in the 1990s, the magnitude of decline in gross domestic product and agricultural production was significantly higher in Tajikistan than those in other countries in the region. Despite considerable economic growth in last decade, poverty and food insecurity, especially in rural areas, remain important challenge in the country.

4.1 Socioeconomic and market research aspects of small ruminant management

The socioeconomic and market research part of the project "Community Action in Integrated and Market-oriented Feed Livestock Production in Central and South Asia" clearly revealed the high importance of strengthening the skills of households in all aspects of small ruminant management and marketing and the potential advantages of collective actions. The project goal was to develop and promote community-based actions to support productive and sustainable livestock systems, access to market opportunities, and sustainable management of the natural resource base in the region.

The goals of the project were:

(1) to develop and promote community-based actions to support productive and sustainable livestock systems;
(2) access to market opportunities; and
(3) sustainable management of the natural resource base in the region.

Analysis of livelihoods and access to resources:

- The weakly developed forage and feed base (especially in winter) is a major problem for all livestock producers. The forage deficit is a consequence of decreased forage cropland area, cessation of subsidies and shift from forage crops to commercially more profitable cereals in irrigated arable land areas.
- The household farms practice extensive small-scale production mainly to satisfy the needs of family members.
- Many households and small farms keep livestock as a form of savings to ensure their welfare rather than as an income generating asset.
- In Tajikistan the remaining big farms (different types of state farms, cooperatives, and big registered farms) and collective farms do not play a significant role in increasing livestock production. Households are the major producers and suppliers of meat, milk, eggs, and honey to the markets in Tajikistan.
- The household farms have only limited access to croplands and to remote seasonal rangelands, especially summer rangelands in mountainous areas.
- Existing constraints (including complicated access to forage/feed, rangelands, and veterinary services; underdeveloped rural infrastructure, bad access to water, etc.) prevent a more intensive and efficient livestock production, create conflicts between different farmer groups (e.g. farms and households), and exacerbate degradation of pasture areas around the villages.
- Mainly women and children are involved in keeping and feeding animals in households and small farms.
- In sheep production, the highest share of income in households is generated from selling animals, little income is generated from selling other products like wool; only a very small %age of produced products are processed at household level (in central Tajikistan about 3%).
- The level of farmers' and households' knowledge of livestock production and in particular feeding and breeding practices as well as rangeland management needs urgent improvement.

Sheep markets in Tajikistan:

- A high number of animals are sold at the farm gate to middlemen without prior fattening. Fattening is mainly done by farmers specialized in fatting animals.
- In most livestock markets a number of different agents are active, including producers, middlemen, farmers involved in fattening animals**,** wholesale buyers, butchers, exporters and consumers creating different market channels.
- Livestock markets are mainly located around cities, in the district centers, and in big villages. They operate separately from the food markets.
- There was a general lack of information and analytical data on sheep markets and market prices. Therefore the project collected price data from the different markets to analyze market integration.

Role of middlemen:

- Middlemen have developed a very good livestock procurement system from households at their farm gates and thus link livestock producers in remote areas having a few animals for sale to the livestock markets.
- By selling fattened animals in the periods of weak supply on the livestock markets traders ensure more stable prices and prevent supply shocks on livestock markets.
- There was no indication of high market concentration of few traders; the market is rather open for many traders which means that prices are competitive.
- The livestock producer survey found that middlemen also act as a source of price information for smallholders. At the same time, some of the livestock producers consider these traders as agents causing problems for their free market access mainly attributed to the control of prices on livestock markets, creation of deficit in space where farmers can hold their livestock while waiting for sales at market outlets, and low procurement farm gate prices offered to households.

4.2 Participatory market chain approach in potato

CIP conducted a new marketing strategy called "Participatory Market Chain Approach (PMCA)" in the Zeravshan Valley of Tajikistan in collaboration with staff of Welthungerhilfe (German for World Hunger Aid) working on Project "Economic development through a comprehensive seed production, marketing and extension service system in the Zeravshan Valley", funded by the EU in 2010-11. The main purpose of PMCA was to establish principles and practices of fair trade among all the participants. This is particularly sensitive in a country like Tajikistan where barter exchanges are still common in the mountain sites, making potato growers extremely weak against middlemen.

The major objective of PMCA in the Zeravshan Valley was to bring small-scale potato growers together with other market chain actors, researchers, service providers to produce and share knowledge, build trust, and develop innovations that would benefit potato growers as well as other market chain actors. The districts of Ayni and Kuhistoni Mastchoh were selected as target districts for conducting PMCA process. The interviewing process was split into two parts with the first part aimed at interviewing market chain actors in Ayni and Kuhistoni Mastchoh districts while the second part targeted major end-user markets, ie wholesale markets of Dushanbe and Khujand.

The obtained results of the interviews were then presented in the first PMCA workshop organized in January 2010 which gathered together all interviewed participants. The event started with the introduction of nature, objectives and structure of PMCA process and continued with general discussion of the market chain findings while at the end of the event different thematic groups were formed. The second PMCA meeting was organized in May 2010 and aimed at continuing discussions and collaborative work in thematic groups, which were formed during the first PMCA meeting.

Work was concentrated on improving the existing value chain. The major issue raised throughout the discussions was aimed at how to differentiate potatoes produced in the Zeravshan Valley from those originated in other parts of Tajikistan in order to be able to create a brand name that could give an added value to the potatoes produced in the two targeted districts.

The major constraints to the development and further expansion of the existing potato chain were identified in a sequential order as follows: (1) the presence of barter trade and consequent lack of monetization; (2) the poor quality of seed planting materials; (3) the unfair relationships among different market chain actors all along the market chain; (4) difficulty of transportation; (5) the current price formation due to the scarce bargaining power of potato growers in general; (6) lack of storage facilities that would allow farmers to sell potatoes during more convenient periods of the year; and (7) insufficient marketability of potatoes in the sense that potatoes are not often well sorted and graded, thus reducing their marketable impact.

4.3 Policy Advice

International Food Policy Research Institute's (IFPRI's) recent research funded by United States Agency for International Development (USAID) reviewed recent economic and agricultural developments in Tajikistan and examined impact of the recent food and financial crises on food security in the country using macro-, sectoral, and household-level data from national and international sources.

Since Tajikistan has a highly mountainous terrain, it has limited arable land resources and only about 5% of its land area is suitable for agricultural production. As a result, the country has one of the lowest amounts of arable land per person (about 0.1 ha), which has been declining over time due to high population growth and land degradation. This makes Tajikistan heavily dependent on food imports to meet its domestic food demands. Net imports account for more than 50% of cereal consumption, nearly half of meat consumption, including about 30% of bovine beef and 80% of poultry meat. The heavy dependence on food imports means that Tajikistan is highly vulnerable to possible periods of food insecurity arising from external shocks such as turbulences in international commodity prices, food availability, and policy directives of its trade partners.

The findings of this research showed:

- The combination of the recent global food and financial crises has had severe negative consequences on food security in Tajikistan both at macro and household levels;
- High dependence on food imports has made Tajikistan extremely vulnerable to increasing global food prices;
- Volatility and transmission of global food prices were important dimensions of the food price crisis in the country; and
- Excessive reliance on labor remittances exacerbated Tajikistan's food insecurity and vulnerability of its households.

The ratio of food imports to total foreign exchange earnings from exports of goods and services and remittances, which reflects the relative cost of access to food available on the international markets, is often used to measure food security at the macro level. The lower this ratio, the more protected the country is in terms of macro-level food security. Based on this measure, from 2005 to 2008, on average, Tajikistan used more than 12% of its total foreign exchange revenue from exports and remittances to finance its food imports. Moreover, this ratio has increased significantly in recent years, exposing Tajikistan's vulnerability to rising food prices and global financial crises. On the one hand, rising global food prices increased the costs of Tajikistan's food imports. On the other hand, financial crisis led to lower remittances because demand for migrant labor in Russia plummeted. Consequently, the value of food imports reached as high as 20% of Tajikistan's total foreign exchange earnings in 2010.

The study also provided formal empirical evidence on price transmission from international markets to domestic food prices in Tajikistan using monthly time-series data for international wheat prices from the International Monetary Fund (IMF) Primary Commodity Prices data set[1] and domestic price series for wheat, wheat flour, bread, and aggregate food and consumer price indices from the Agency on Statistics of the Republic of Tajikistan, and the data on monthly exchange rate movements from the National Bank of Tajikistan[2].

The results obtained using co-integration analysis and moving-average first-difference regression models suggest that there is strong empirical evidence of price transmission from international wheat markets to the domestic food markets in Tajikistan. During a global food crisis period, 1% increase in international wheat prices caused more than 1.1% increase in domestic wheat prices. In addition, the results suggest that fluctuations in international wheat prices not only have significant causal impact on domestic wheat and wheat product prices in Tajikistan, but the overall food and consumer price inflation rates in the country are also noticeably affected.

[1] This data set is available at www.imf.org/external/np/res/commod/index.asp. The focus on international wheat prices is justified by the fact that more than 60 % of daily calorie intake in Tajikistan comes from wheat and wheat products.
[2] Seasonal components of price data were removed using the X12-ARIMA procedure.

Further, the analysis of the food and financial crises impact on household consumption was conducted using data from the 2007 and 2009 Tajikistan Living Standards Surveys and the 2010 EBRD–World Bank Life in Transition Survey. The findings suggest that the 2007-2008 global food and financial crises had a considerably greater effect on Tajik households than on households in other Central Asian countries. While approximately 60% of affected Tajik households reduced their food consumption, more than 50% of households in Tajikistan reported reducing staple food consumption as a result of the global crisis, as compared with 38% in all transition countries and 35% in other Central Asian countries. Some provinces within Tajikistan, such as Khatlon and Mountainous Badakshan Autonomous regions, were harder hit by the crisis and saw significant increases in extreme poverty rates and food insecurity.

The key findings of this research were reported to the donor and used in the preparation of multi-year strategy for USAID's Feed the Future program. The results of the study were presented in a national workshop conducted on October 14, 2011 in Dushanbe and at the "Technical Workshop on Knowledge Tools and Lessons for Informing the Design and Implementation of Food Security Strategies" in Asia on November 14-16, 2011 in Kathmandu, Nepal. Also, main findings of the research were published in different outlets, including a peer-reviewed journal article, edited book volumes, and IFPRI discussion paper.

Current IFPRI activities in Tajikistan include (i) research on labor migration, remittances and household decision-making, (ii) study on agriculture-nutrition linkages with a specific focus on the relationships between agricultural biodiversity, dietary diversity, and nutritional outcomes, (iii) research on agricultural markets and value chains from nutrition and food safety perspective, and (iv) case study analysis on agricultural input policies focusing on inorganic fertilizer and improved seed.
IFPRI's activities in Tajikistan are conducted in collaboration with government institutions and national research institutions including the Tajik Academy of Agricultural Sciences and Institute of Agricultural Economics. In recent years, representatives from Tajikistan participated in various international and regional conferences and workshops organized by IFPRI.

4.4 Climate Change

Climate change poses a major threat to the agricultural sector of Tajikistan. The German advisory council on global change - WBGU (2007) and Stern-Report (2006) both regard Central Asia as an area with one of the highest risks of conflicts worldwide in the course of climate change. In view of climate change Tajikistan is the most vulnerable country out of 28 European and Central Asian countries, because it is very sensitive to shocks and has limited capacity to adapt and recover (The World Bank, 2009a).

In 2008 Tajikistan's Second National Communication to the United Nations Framework Convention on Climate Change (SNC-TAJ, 2008) was published. This profound and comprehensive document of the Tajik government addresses vulnerability, adaptation and mitigation issues and is a main basis for setting the strategy of CGIAR research in Tajikistan.

The climate change influences firstly the thermal conditions (heat availability), which in many respects determines opportunities of various crops cultivation. Distribution of the areas with various heat availability will be essentially changed till year 2100. According to the model ECHAM4/OPYC3 (Potsdam Institute for climate impact research, Germany) statistical estimations, the increase of mean annual temperature by 0.2-0.4^{o}C (0.1-0.2^{o}C in decade) is expected in most areas of Tajikistan by 2030 in comparison with the period 1961-1990 (SNC-TAJ, 2008). The maximum increase of temperature is expected in winter: by 2^{o}C and higher. In some areas the reduction in precipitation can be observed (Eastern Pamir, south lowlands), whereas in others (Western Pamir) one can witness just the contrary. The vulnerability assessment reveals that reduction of agricultural productivity is observed in some areas experiencing increase in temperature and decrease in precipitation.

In consequence of the expected high rise of temperature, IPCC estimates a decrease in crop yield between 2.5-10% by 2020 and 5-30% by 2050 in the region. With view to expected higher rainfall and runoff in winter and spring, the expansion of winter crops and more drought-resilient crops might be favourable. EDB expect grasslands to become less productive by 30% (EDB, 2009). Also, changes in the seasonal patterns will affect agriculture in mountainous areas more, because even if the agricultural season will be prolonged by climate change, water scarcity will increase due to higher temperatures, evaporation and loss of glaciers. Ecosystems will change rapidly (Christmann et al., 2009).Changing climatic conditions will also expand the area of plant diseases, weeds and pests.

4.4.1 Climate change adaptation strategies

In 2009-2011, ICARDA in partnership with IFPRI and scientists from the national agricultural research system implemented the multi-disciplinary project entitled "Adaptation to Climate Change in Central Asia and People's RepublicofChina". The project builds on the notion that the majority of the rural population in Central Asia rely on agriculture and that climate change (CC) could negatively affect rural livelihoods. Regional studies of the impacts of CC are sparse, and those available rely on crude assumptions on the biophysical characteristics of crops, soils and climate, as well as the agronomic management practices in the region. Few details are known about the vulnerability of the rural population and food security/crop production in Central Asia in response to climate change.

The overall objective of the project, thus, was to increase knowledge in the field of CC and its potential impact in Central Asia. Knowledge helps to achieve sustainable, equitable, and productive use and conservation of natural resources including water, soils and biodiversity within an ecosystem. The project was implemented through three major research components, including GIS mapping, crop modeling and socioeconomic assessment.The specific objectives of the research project were:

- to analyze the current status of selected agro-ecosystems, their ecological significance and threats posed by human-induced non-climatic factors such as land degradation and inefficient water use;
- to develop climate change scenarios for the selected agro-ecosystems;
- to assess the vulnerability of the selected agro-ecosystems to threat resulting from climate change, particularly drought, on the basis of the developed climate change scenarios and to develop scenarios for socioeconomic impacts on poverty and food security in the countries in the study area;
- to develop options and strategies to adapt to climate change so as to build climate resilience in development planning in the target countries;
- tostrengthen the capacity to conduct socioeconomic and policy research related to sustainable land management in the region.

Climate change predictions based on two emission scenarios, A1b and A2, were considered in the investigation, alongside projections on atmospheric CO_2 concentration. From the outputs of 23 global circulation models (GCM), on which the IPCC report is based, seven GCM results were selected by ICARDA's GIS Unit. The study considered three time horizons; immediate future(year 2011-2040), mid-term future (2041-2070), and long-term future(2071-2100).

A climate change impact assessment on the productivity of wheat, cotton and potato in Tajikistan was carried on the basis of experimental data from different locations in Tajikistan using two crop models (CropSyst for wheat and DSSAT for cotton and potato).

Considering wheat, out of five sites (Bakht, Fayzobod, Khuroson, Shahriston and Spitamen) only at one site (Spitamen) climate change had a negative impact on crop yields (-3%) while at other remaining sites had a positive impact on crop yield (+4-+27) increasing towards the long-term future. A positive impact of CC was also simulated for the two rainfed sites in Fayzobod and Khuroson and for the irrigated site in Shahriston. The overall increase, averaged across all sites and future management scenarios, was 13-14%. This is in line with results published earlier.

WHEAT

The shortening of the wheat life cycle caused by temperature increases did not negatively affect biomass accrual and yield.

In response to warmer temperatures, the life cycle - planting until maturity - of all three simulated wheat varieties ('Navruz', 'Jagger' and 'Kazakhskaya-10') shortened considerably. Management practices did not have any effect on the life cycle of the simulated wheat varieties. The days required for the crop to complete emergence until maturity (DEM) were considered in more detail since this is the period when the crop is exposed to environmental factors such as low (frost) and high temperatures, as well as water and N-stress. This period shortened for all sites, increasing from immediate to long-term future. In comparison to historical conditions, DEMs shortened on average across all sites by 5, 8, and 14 days for immediate, mid-term, and long-term future respectively. A trend towards an increase of Tmax (maximum air temperatures) during flowering for Khuroson and Spitamen sites while Fayzobod is the only site where CC triggered a decrease in Tmax during flowering.

That means that high temperatures during flowering would become more problematic at Khuroson and Spitamen sites while flowering was predicted earlier for Fayzobod site when temperatures were also still comparably colder irrespectiveof an increase in temperatures in response to CC.Climate change had little effect on average irrigation amounts assessed for project sites at Shahriston site, and some positive effect at Bakht and Spitamen sites.

The moderate increase in rainfall had only a minor positive impact on crop yields under rainfed conditions due to the increasing evaporative demand of the crop under higher temperatures. However, in combination with an improved transpiration use efficiency in response to elevated atmospheric CO_2 concentrations, a reduction in irrigation water requirements was observed for sites where irrigation management was simulated, taking into consideration an improved moisture regime. Overall, the reduction in irrigation water requirement was small, and thus hardly notable given the year-to-year variation in climate. On the other hand, simulations could not confirm increasing demand for irrigation water for winter crop wheat; this therefore seems to be a problem for fully irrigated summer crops only such as cotton, maize, and rice. Overall, the shortening of the wheat life cycle caused by temperature increases did not negatively affect biomass accrual and yield.

Often, a short-season variety is lower yielding than a long-season variety because the crop has less time for photosynthesis and biomass build-up. However, simulations conducted for Tajikistan showed that a potentially negative effect from the shortening of crop life cycles under climate change conditions in the future would be counterbalanced by more favourable growth conditions in spring. However, in combination with an improved transpiration use efficiency in response to elevated atmospheric CO_2 concentrations, a reduction in irrigation water requirements was observed for those sites where irrigation management was simulated adaptive, ie taking automatically into consideration an improved moisture regime. So, to mitigate negative impact of Climate Change more advanced water-saving technologies (drip irrigation, sprinkler irrigation etc) should be adopted to maintain optimum soil moisture regime in the root zone.

COTTON & POTATO

Climate change effects are not alarming in the immediate future, but will become severe in the far future.

As for cotton and potato production, simulation under climate change conditions carried out for Tajik sites showed that these crops seems to gain from future carbon dioxide fertilization effects. This will mitigate the negative effects of future climate change. Although climate change effects on cotton and potato in Tajikistan are not alarming in the immediate future (2011-2040), they will become severe in the far future (2071-2100).According to results of socioeconomic analysis, agricultural production in Tajikistan is based on small-scale farms, with limited machinery availability and have lower efficiency when compared with Uzbekistan and Kazakhstan. Analysis demonstrates the vulnerability of small-scale farmers to climate change due to high resource losses during the production process. Therefore, improving the resource use efficiency of small-scale farmers enables their adaptation to climate change.

This calls for action to improve delivery of farm advisory services including extension and weather information, and access to credit to acquire needed inputs and machinery.Increased wheat yields positively impacted farm revenues. Expected income is about USD 160 per hectare under base scenario. It increased more than twice under late future scenarios due to abovementioned yield increase.

However, increase of expected income might not indicate increased utility of the farmers in this region since variance of income is also expected to increase in the late future. The variance is nearly doubled especially under A2 scenario during the period 2070-2100 which might create some problems for agricultural producers, especially to poor farms. Increased trends of excessive rainfall, floods and other weather extremes may cause loss of farm assets under unfavourable climate conditions if there is a lack of access to credit markets.

Taking into account expected shortage of water resources, crop allocation, expected income and risk change were also simulated under climate change scenario with 30% less water available. The results demonstrated that expected income of the representative farm was not much sensitive to 30% reduction of irrigation water. Thus reduction of water may not cause many problems for farmers who have diverse crops similar to representative farms. However, this result may not hold for the farmers who are specialised in high water demand crops (eg cotton). Therefore, crop diversification is needed to have higher risk coping potential. There is significant difference between results obtained for semi-arid and arid zones of Tajikistan. Climate change might reduce expected farm returns for more than 40% in the late future in the arid zones. This is mainly expected decline of yields of all crops in the arid zones of Tajikistan. Reduction of irrigation water supply might reduce expected farm returns to 10-15% depending on the scenario in the future. This is mainly caused by reduction of the cultivated area due to scarcity of irrigation water which in turn yields lower income under water scarcity scenarios.

Similar to semi-arid regions, humid zones of Tajikistan may also benefit from climate change especially in the far future scenarios. Expected farm income may increase up to 80% in the later future scenarios due to increased crop yields in the future. However, reduction in water availability seems to be still an issue even in the humid areas. The 30% decline in irrigation water availability may reduce revenues about 30-40% depending on the scenario. This is mainly due to the reduction of the vegetable areas which usually require higher amount of irrigation water when compared to other crops.

This project was only an initial first step towards preserving and increasing food security, which can be affected by predicted climate change. The research is continued within the framework of the CRP Research Program on Climate Change, Activity 1.2.1 "Model-based assessment of the impacts of climate change and the effects of adaptation technologies on crop water availability and productivity and farmer's livelihood".

4.4.2 How can mountain villages adapt to glacier loss?

An ICARDA participatory pilot study showed that mountain villages are highly exposed and sensitive to glacier loss, but they also have high potential to adapt if the rising problems are addressed in time and adequately and if combined research and development projects assist in realizing adaptation.

All glaciers in western Tajikistan are forecast to melt entirely by 2050 -just as many other glaciers in eastern Tajikistan and further countries in CAC. Glacier melt, triggered by climate change, will lead to water scarcity in the cropping season. This puts irrigated mountain agriculture at a very high risk or makes it even impossible. Glaciers delay snow melt and balance yearly and monthly down flow of precipitation; they provide additional water in summer. Loss of this water from glacial areas might terminate the production of potato and even of some other irrigated crops, because increasing temperatures will also raise evaporation and water demand of crops. Climate change and glacier loss might also lead to increased soil erosion on slopes, mudflows, loss of infrastructure, reduced forage production, loss of medicinal plants, loss of pollinators etc. All mountainous pastures might change significantly.

An ICARDA participatory pilot study assessed the vulnerability (exposure, sensitivity and adaptive capacity) of mountain villages to climate change and adaptation options. The project focused on environmental, economic and governance aspects and on local capacity to adapt to climate change by developing sustainable economic and environmental activities. Qualitative research was mainly based on SAS[2]-methods, but transformed into drawings. These drawings on climate change scenarios appeared to be crucial to develop a common purpose in the village(s).

Two villages that took part,Imbef (2,800 m, Kuhistoni Mastchoh District) and Darg (2,300 m, Ayni District) are remote mountain villages in the Zeravshan range of Tajikistan. Both are located beneath glaciers and have no access to piped water from the valley. Darg and Imbef rely mainly on pastoralism and irrigated agriculture (mainly potato; in Darg also apricots). Also labor migration contributes to family income in all strata; in the lowest income group families have up to four labor migrants. As labor migration is predominantly male, the absence of men in labor age can hinder adaptation (like building terraces, collective water reservoirs etc), but income from labor migration can fund adaptation options.

The project found that villagers were not aware of the need to adapt their economy to water scarcity within one generation as presently they enjoy plenty of water. They were not aware of the impacts of climate change on male labor migration and on their own adaptive capacity. Through this participatory research project, each village developed comprehensive and realistic short-term and long-term action plans.

The best local researchers from Imbef village with their certificates.

The local strategies include (1) means to increase skills on all relevant levels for both genders; (2) environmental adaptation; (3) economic alternatives; and (4) management instruments. Imbef even started to promptly involve further stakeholders like neighbor villages, which rely on the same glacier, to develop an adaptation strategy for the entire water catchment.

The results showed that the mountain villages are highly exposed and sensitive to glacier loss, but they also have high potential to adapt if the rising problems are addressed in time and adequately and if combined research and development projects assist in realizing adaptation. Fast glacier melt and increasing labor migration necessitate urgent action. According to this project in mountainous regions, women are more exposed and sensitive to climate change than men, but highly disadvantaged concerning decision-making and adaptive capacity. In both villages the participatory research resulted in high affirmation that women will play an important role in adaptation, that girls' education should get higher attention and that women should participate more in decision-making. In Imbef, women and men worked together for the first time.Based on villagers' contributions ICARDA developed a broad Research for Development approach.

4.5 Capacity Building

The Program pays special attention to building the research and technical capacities of NARS partners and improving farmers' and breeders' skills in the CAC Region, including Tajikistan. As an integral part of almost every activity and project in Tajikistan, capacitybuilding is aimed at creating new and strengthening existing potential of research institutions to ensure their abilities and efficiency in facing the research challenges in reforming the agricultural sector. It is also aimed at improving the skills of rural populations involved in farming and livestock breeding to increase agricultural productivity and thus incomes and livelihoods.

For instance, an IFAD-ICARDA project helped to increase employment and income opportunities for small farmers and rural women through value-added processing and export of cashmere, wool and mohair. The project set up a value chain focused on fiber goat production and fiber harvesting, processing and marketing. The target groups were small producers of cashmere, mohair and wool and fiber processing women's groups. InSughdRegion, northern Tajikistan, it focused on breeding Angora goats and processing mohair into yarn and products, and in Badakshan Region, eastern Tajikistan, on breeding cashgora goats and processing cashgora and cashmere into yarn and products. Some 300 women and 200 farmers/livestock breeders benefited from the project in Tajikistan alone.

The Program also continued to organize training sessions, workshops, meetings and field days to strengthen the NARS and disseminate best practices. For example, a Farmers' Field Day was conducted by ICBA on 19 August 2009 in Asht District, northern Tajikistan, where achievements and future plans for up-scaling biosaline agro-forestry production in marginal farmer abandoned lands were analyzed.

Between 2007 and 2013, Farmers' Field Days were also conducted annually by AVRDC in the Research Institute of Horticulture and Vegetable Growing, Tajikistan, to demonstrate promising and released varieties of vegetable crops and strengthening collaboration with farmers on introduction into vegetable production new varieties, increasing vegetable production and seed multiplication and promoting utilization and consumption of nutrient-rich vegetables. More than 100 people participated in these field days. Among participants were representatives from farmers associations, scientists, farmers, processing firms' representatives and businessmen. AVRDC also arranged six international and regional meetings, as well as 13 training sessions, which were attended by 15 Tajik researchers.

ICBA organized a regional training workshop on "Seed production and maintenance of technologies packages for sorghum and pearl millet in Central Asia" on 28 September 2012 on Gafurov farm, SughdRegion.

The event was attended by 45 farmers, plant breeders, biotechnologists, livestock keepers, researchers and local officials, women leaders and project partners.The workshop aimed to promote highly productive sorghum and pearl millet cultivars, crop management technologies and development of an appropriate seed production system of these valuable cereals in marginal areas.

Other Centers were also actively engaged in capacity-building efforts in Tajikistan.As partof a program to introduce ecologically-based IPM approaches, Michigan State University (MSU) incollaboration with the Tajik Academy of Agricultural Sciences (TAAS), Institute of Zoology and Parasitology of the Academy of Sciences of Tajikistan, the Tajik National University, ICARDA and a number of NGOs disseminated research results through more than 10 workshops and various papers, and a television documentary.

The project built an excellent research team of partners in Tajikistan to promote landscape ecology and biocontrol approaches in local agricultural systems.The project component on IPM outreach and education focused on both academic and non-academic stakeholders through student field schools (SFS) and farmers field schools (FFS) in collaboration with local NGOs, government institutes and local universities in Tajikistan.

To enhance university education, an inventory of IPM educational programs at Tajik universities was conducted. These existing IPM programs were used to design course programs for student field school (SFS) and also for publishing new IPM materials (books, booklets, extension bulletins, etc).

To increase the awareness of ecologically-based IPM and for sharing the research results of the Central Asia, 43 papers and extension bulletins were published in English and local languages and distributed widely. Prominent among these publications is the "Proceedings of the Central Asia IPM CRSP project" from the Central Asia IPM Forum organized in May 2007 in Dushanbe, Tajikistan. The proceedings were distributed to more than 200 stakeholders and partner institutions in the Central Asian region as well as to all of the IPM CRSP regional and global theme programs. Moreover, two training manuals for master trainers of farmer field schools (FFS) and student field schools (SFS) were published in Russian in 2008 and distributed to 500 stakeholders. Under Phase II of the Central Asia IPM CRSP Project, one student from Tajikistan is currently receiving long-term training at Michigan State University focusing on biological control aspects of wheat IPM.

During the period, another Center, CIP, arranged over 10 international, regional and national meetings, and five training sessions. One scientist from Tajikistan attended a one-month training course on Potato Physiology and Screening for Resistance to Abiotic Stress at the Institute of Research on Crop Resistance and Stress Tolerance, Federal Research Centre for Cultivated Plants - Julius Kühn-Institute, Rostock, Germany, and another one a training course on Potato Breeding and Hybridization at the Central Potato Research Institute (CPRI), Shimla, India.

Two scientists from Tajikistan attended short training courses on Potato Breeding and Selection under Abiotic Stress and Potato Growth Modeling, organized by CIP and CPRI in Modipuram and Shimla in India. A total of 15 scientists attended five annual meetings organized by CIP in Tashkent and India under two BMZ/GIZ-funded projects. A total of 90 people, including advisors, agronomists, farmers, were trained in Dushanbe, Gharm, Jirgatol and Muminobod.

Training of young scientists in germplasm evaluation has been an important aspect of capacity building effort of ICARDA in Tajikistan. This has been achieved through short-term training courses and participation in seminar and workshop organized within and outside Tajikistan.

As part of activities on grain crops, a regional training workshop on "Plant Genetic Resources Management and Germplasm Characterization" was held in Dushanbe, 21 to 26 November 2011. The workshop was organized by ICARDA with a financial contribution from UNESCO. A total of 29 scientists participated in the workshop.

Several researchers from Tajikistan participated in winter wheat travelling seminars organized in June 2009 in Ukraine, in June 2011 in Turkey, Bulgaria and Romania and in May 2013 in Uzbekistan. Researchers from Tajikistan also participated in yellow rust regional conferences in 2002, 2006 and 2010 and an international yellow rust conference in 2011.

Conclusion

In Tajikistan as in other countries of Central Asia and the Caucasus, collaboration between the national agricultural systems and international partners during the past seven years has brought considerable progress in the productivity of agricultural systems; conservation and management of natural resources; and the conservation and evaluation of genetic resources; and socioeconomic and public policy research.

To make agricultural systems in Tajikistan more productive, the CGIAR and non-CGIAR agricultural research centers and their national partners have pursued germplasm enhancement; the improvement of national seed supply systems, livestock production systems and integrated feed/livestock management; and integrated pest management.

Cooperation on germplasm enhancement focuses on cereals, potato, food legumes, sorghum and pearl millet, and vegetable crops. As a result, new improved varieties of wheat 'Ormon', 'Alex', ‘Sadokat’ and 'Chumon', potato 'Dusti' and 'Faizabad', barley 'Pulodi', chickpea 'Hisor-32' and 'Sino', pearl millet 'Durahshon', and many vegetables were developed on the basis of the new genetic material introduced in the country, tested and adapted to local conditions. The released varieties demonstrate higher yield and tolerance to stress factors.

For example, new chickpea varieties are frost-tolerant and can be sown in autumn, increasing yield by 15-20% compared with spring planting. Currently, several hundred farmers in the country cultivate these varieties. More effort is now being focused on making seed of improved varieties available to farmers for all these crops. Each year, scientists in Tajikistan receive more than 1,000 entries of different crops from the international centers, and work jointly on their further testing and improvement.

Centers’ researchers and their national counterparts also worked on improving livestock production, an important income earner for rural households. For example, a recently completed four-year international initiative increased employment opportunities and income options for poor rural populations, particularly vulnerable women, by training artisans and livestock breeders in value-added fiber production. A three-year study identified two salt-tolerant, high-yielding varieties of alfalfa 'Eureka' and 'Sceptre', which increased fodder options for livestock owners. To address the problem of pests and diseases, ecologically-based integrated pest management packages for field and vegetable crops have been developed and delivered in Tajikistan.

To facilitate more sustainable management of water and soil resources, scientists also introduced new technologies and worked on improving crop management practices; irrigation, drainage, and water basin management; conservation agriculture; and rangeland rehabilitation and management. For example, a sustainable land management research project was completed in 2009. A new project was launched in 2013 in Tajikistan to promote conservation agriculture practices. Work is also progressing to introduce new species and improved varieties of forage crops for rangeland rehabilitation and management. Integrated Water Resources Management has been in place in the Fergana Valley since 2001 to ensure more sustainable use of irrigation water by Water User Associations.
Research efforts also focused on conservation and evaluation of genetic resources. Through two separate projects, considerable work was done to preserve local varieties particularly in fruit trees - apple, apricot, pear, almond, currant and grape. A national gene-bank was organized at the Research Institute of Agriculture, maintaining cereals, legume and forage crop collections.. This work also facilitated the creation of the Tajikistan’s National Centre for Plant Genetic Resources in 2007.

Through its socioeconomic and public policy research, the consortium helped the country better understand what action is needed to mitigate the challenges it faces in the continued transition to a market economy. Researchers offer policy recommendations, help to tailor policies and build necessary capacities. pecial attention is paid to building the capacity of Tajikistan’s research and technical staff and improve farmers' and breeders' skills. Capacity building is an integral part of most projects in Tajikistan, aiming to strengthen the potential of research institutions to deliver high quality research to face the challenges of agricultural sector reform.

But there is still work to be done. The centers continue their efforts with a sharp focus on vulnerable rural communities and small farmers, and are progressing toward these goals thanks to continued support from donors and partners.

These efforts have produced positive results, but the consortium now needs to move to a more integrated approach to sustainable development in rural areas. Until recently, many activities were not well connected. Despite their individual merits, more impact on the ground – for rural communities – can be achieved by better integration between the project components. The centers believe that better results will be achieved by weaving the activities together in a fabric of sustainable agricultural development.

Central Asia hosts one of the five Action Sites worldwide for the global CGIAR Research Program on Dryland Agricultural Production Systems (cgiar.drylandsystems.org). Dryland Systems is the first large-scale research program to use an integrated agro-ecosystems approach to improve productivity and livelihoods in the dry areas. It engages in large-scale action research and the sharing of knowledge and expertise between five action sites in the world's major Drylands regions. The goal is to develop, test and encourage the adoption of new technology and policy packages that improve productivity and income in dry areas food production systems. The program is creating an innovation platform, to bring together all relevant partner groups from research, government, universities, farmers' associations, the private sector and civil society, to encourage the uptake of science based solutions for food security.

Building on its past work with Central Asian partner countries, the consortium of international agricultural research centers will continue to support the region to achieve its strategic goals of increased productivity, food and nutritional security, by developing and applying new agricultural production technologies, while encouraging the sustainable use of natural resources. This approach will bring more efficient policies, strategies and approaches for the benefit of the population of Central Asian countries.

About ICARDA and the CGIAR

Established in 1977, ICARDA is one of the 15 centers supported by the CGIAR. ICARDA's mission is to improve the livelihoods of the resource-poor in dry areas through research and partnerships dedicated to achieving sustainable increases in agricultural productivity and income, while ensuring efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small ruminant production. In Central Asia, West Asia, South Asia, and North Africa regions, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and toenhance the uptake and maximize impact of research outputs.

CGIAR is a global agriculture research partnership dedicated to reducing rural poverty, increasing food security, improving human health and nutrition, and ensuring more sustainable management of natural resources. It is carried out by the 15 centers who are members of the CGIAR Consortium in close collaboration with hundreds of partner organizations and the private sector. www.cgiar.org

ABOUT THE REGIONAL PROGRAM FOR CENTRAL ASIA AND THE CAUCASUS

The Regional Program for Sustainable Agricultural Development in Central Asia and the Caucasus is part of this global partnership with a regional focus. The Program aims at reducing poverty and hunger, improving human health and nutrition, and enhances ecosystem resilience through high-quality international research, partnership and leadership in Central Asia (Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan) and the Caucasus (Armenia, Azerbaijan and Georgia). It assists the countries in developing the research capacities for sustainably increasing the productivity of crops and livestock through development, adoption and transfer of technologies; natural resources management, conservation strategies and socioeconomic knowledge. It fosters cooperation among the countries in the Region and promotes their collaboration with the wider international community. The Program is overseen by a Steering Committee comprised of the heads of the National Agricultural Research Systems and directors-general of the International Agricultural Research Centers.