12 - WATER AND LAND PRODUCTIVITY ANALYSIS

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Abstract: Irrigated agriculture in Central Asia can only be developed through the increase of crop yields and the reduction of water volumes applied per unit of agricultural production. Thus, the objectives of this research are to assess potential and actual land and water productivities in the Fergana Valley; analyze losses of cotton and winter wheat yields due to soil, water, and technological factors; and evaluate control of the key factors in farms. Current productivity was reviewed using statistical data over 1990-1995-2000. The research was carried out in two pilot plots under cotton and winter wheat in the Azizbek farm located in the Akhunbabayev district, in the Fergana province, Uzbekistan. The selected plots were equipped with several measuring devices. Each field was provided with a soil-reclamation passport, which lists basic agronomic and soil characteristics of the field, its specific features and includes reference data and recommendations. Research methods and computational models applied are described in the paper. In computations of land productivity levels, we used estimations of water-physical and agrochemical soil properties and the reduction coefficients against several agricultural production factors which allowed the identification of minimum-factors and for recommendation of practical correctional measures (such as rates of organic and mineral fertilizers for planned crop yield, protection of plans from pests and diseases, organizational and technological operations). The optimal potential cotton and wheat yields were computed and compared with the actual yields achieved in the pilot plots. Moreover, causes restricting productive water and land use were identified. Methods for determination of minimum-factors and their control so that to improve crop yields and profitability are presented as well.

Keywords: Productivity dynamics, Crop yields, Factor assessment, Yield losses, Crop and water management.

Introduction

Current actual land and water productivity was reviewed using statistical data over 1990-2000 referring to the provinces in the Fergana Valley, which is

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located in arid zone of Central Asian region and shared by three sovereign states, such as Uzbekistan, Tajikistan, and Kyrgyzstan. The Fergana Valley is a vast intermountain oval trough, 300 km long and 100 km wide, which is surrounded by Kuramin and Chatkal mountain ranges from the north, by Fergana range from the east and by Alay and Turkestan ranges from the south. The soils are mainly generic and dark sierozems, including automorphic light sierozem in the east and hydromorphic meadow and swampy-meadow soils of desert zone, subjected to salinization, in the west. The selected provinces – Andizhan, Namangan, Fergana (Uzbekistan), Osh (Kyrgyzstan), Sogd (Tajikistan) – are mainly agricultural-oriented since 70% of population is rural and their livelihoods depend on agricultural production.

Crops grown in the Fergana Valley and cropping patterns by province are shown in Table 1. The basic crops are cotton and winter wheat, the shares of which in total cropped area in 2000 were 80% in Uzbekistan's provinces, 70% in Sogd province and 43% in Osh province.

Table 1. Cropped irrigated area (10^3 ha) under main crops in Fergana Valley.

Province, Republic	Year	Total cropped area	Cotton	Wheat	Rice	Corn	Forage crop	Vegetables	Melons and gourds	Other
Andizhan, Uzbekistan	1990	236.2	153.6	8.6	3.4	12.3	38.8	13.4	3.2	2.9
	1995	239.3	110.9	52.6	3.6	11.0	33.2	17.4	1.5	5.5
	2000	231.3	106.2	80.0	1.7	4.1	20.7	11.9	0.6	6.1
Namangan, Uzbekistan	1990	190.2	125.4	10.2	3.9	10.7	21.6	8.3	4.3	5.8
	1995	221.3	94.7	57.6	4.8	3.1	42.9	11.5	1.2	5.5
	2000	220.7	94.3	83.6	4.5	3.8	15.9	9.9	1.2	7.5
Fergana, Uzbekistan	1990	279.3	165.0	16.2	1.4	16.7	52.3	16.6	4.7	6.4
	1995	304.0	128.6	72.3	1.5	6.6	71.1	14.9	1.7	7.3
	2000	297.5	121.2	116.8	2.4	4.5	30.0	13.2	1.8	7.6
Sogd, Tajikistan	1990	253.8	3.4	28.4	3.8	93.1	32.3	80.8	2.2	9.8
	1995	226.4	69.5	99.1	4.3	10.8	34.8	4.7	1.1	2.1
	2000	221.6	60.3	94.7	5.7	11.6	43.2	2.7	1.5	1.9
Osh, Kyrgyzstan	1990	97.4	11.8	10.2	1.8	17.0	50.8	4.7	0.8	0.3
	1995	108.3	13.6	41.4	1.5	10.1	32.1	7.7	0.6	1.3
	2000	110.3	23.5	23.1	1.4	12.7	39.2	8.9	0.5	1.0

Expansion **o**f wheat areas resulted from the "grain self-sufficiency" policies adopted by the Governments in the three States. Under present economic conditions, wheat is a less profitable crop as compared, for instance, to cotton. Therefore, attempts to achieve grain self-sufficiency have resulted in considerable material losses in both farms and agriculture in general. However, as compared to 1990, in 2000 the area under cereals increased 9 times in the Andizhan province; 8 times in the Namangan province; 7 times in the Fergana province; three-fold in the Sogd province; and, more than two-fold in the Osh province. Since independence, the total livestock population has been reduced. This entailed considerable drop in forage crop production in Uzbekistan and

Kyrgyzstan.

The crop productivity dynamics over 1990-1995-2000 can be observed from Table 2.

Table 2. Mean crop yields in irrigated lands (100 kg/ha) of Fergana Valley.

Province, Republic	Year	Cotton	Wheat	Rice	Corn	Alfalfa	Vegetables	Melons and gourds
Andizhan, Uzbekistan	1990	28.9	37.4	20.7	52.8	122.8	211.4	114.8
	1995	30.8	43.0	30.9	56.1	345.7	201.3	115.0
	2000	31.8	63.1	31.5	49.2	340.3	219.2	136.9
Namangan, Uzbekistan	1990	31.1	32.8	11.1	49.9	114.8	284.3	130.3
	1995	31.3	34.4	24.4	47.5	347.1	232.3	133.8
	2000	26.2	33.4	20.1	35.0	314.4	228.3	178.9
Fergana, Uzbekistan	1990	29.9	28.2	12.7	39.0	102.3	181.9	112.4
	1995	30.6	30.3	20.4	39.4	219.9	169.8	111.4
	2000	29.9	35.8	25.8	33.5	228.9	174.4	118.9
Sogd, Tajikistan	1990	27.5	25.3	31.6	33.8	109.4	185.0	90.5
	1995	22.9	24.5	25.9	30.7	101.5	154.4	74.9
	2000	24.9	23.6	27.4	32.6	133.7	163.0	95.7
Osh, Kyrgyzstan	1990	27.6	24.9	17.1	45.3	115.8	190.3	120.2
	1995	23.4	18.6	24.4	33.4	104.0	121.8	65.4
	2000	26.0	24.6	26.4	44.5	129.5	176.3	139.0

For all the provinces, it can be noticed a certain decrease in vegetable yields (excluding Andizhan province) and corn yield, and an increase in alfalfa, melons, groundnuts, and rice yields (except for Sogd province). In Uzbekistan, the increase in wheat yield should be underlined as a general pattern for this ten-year period.

Water productivity in irrigation is estimated on the basis of irrigation water use per unit agricultural production and the yield per unit water used. Such estimation was made for main crops in given provinces within the framework of GEF Project (2000) (Tables 3 and 4).

Table 3. Irrigation water use per unit agricultural production ($10^3 m^3/t$) in the Fergana Valley provinces (2000).

Crop	Uzbekistan			Kyrgyzstan	Tajikistan
	Andizhan Province	Namangan Province	Fergana Province	Osh Province	Sogd Province
Cotton	3.19	4.30	3.15	4.45	8.37
Winter wheat	0.84	1.47	1.40	1.43	3.17

The largest amounts of water use in irrigation per unit of production are observed in Sogd province (Tajikistan) - 8370 m^3/t of raw cotton and 3170 m^3/t of wheat (Table 3), while the lowest amounts of water were use for cotton are in

Fergana province (3150 m^3/t) and for winter wheat in the Andizhan province (840 m^3/t).

Table 4. Water productivity (t/10^3m^3) by province in Fergana Valley (2000).

Crop	Uzbekistan			Kyrgyzstan	Tajikistan
	Andizhan Province	Namangan Province	Fergana Province	Osh Province	Sogd Province
Cotton	0.31	0.23	0.32	0.22	0.12
Winter wheat	1.19	0.68	0.71	0.70	0.32

The highest irrigation water productivity under cotton cultivation is achieved in Fergana province-0.32 t/10^3m^3 and the lowest one is observed in Sogd province-0.12 t/10^3m^3. In case of winter wheat, the largest water productivity is reported for Andizhan province-1.19 t/10^3m^3, while the lowest irrigation water productivity is in Sogd province–only 0.32 t/10^3m^3.

This review points out some considerable differences in land and water use throughout the Fergana Valley and suggests that limitations should be identified and potentials to improve land and water productivity should be sought.

The objectives of the research conducted in 2003 were as follows:

- To assess potential and actual land and water productivities in the Fergana Valley;
- To analyze yield losses of the main crops (cotton, winter wheat) due to soil, water-management, organizational and technological factors; and
- To develop key factors in methodology control in order to improve water and land productivities.

Material and methods

Agrochemical analyses were made for soil samples, taken from five points at each plot from every plough-layer and plough-pan. Laboratory analysis methods are classical and used both in foreign and local practices. The specific weight (or apparent soil density) was estimated by bottle method; soil texture by sedimentation method (Kachinskiy, 1963). Soil salinity was determined by measuring electrical conductivity of soil suspensions at a ratio of 1:1 between soil and water. Measurements were made in dS/m by electric conductivity meter, which had electrodes with expansion ring. Organic matter (humus) content was estimated by Tyurin (1977) method; contents of nitrogen, nitrate, and ammonia, as well as available phosphorus were determined using colorimetric methods (Machigin, 1977), while exchange potassium was measured using flame emission photometer.

Land productivity was determined using yield programming method (Dukhovny and Nerozin, 1989), according to which the highest possible yield (MVY) is computed with the Nechiporovich's formula (1963), the potential yield (PY) is computed on the basis of the basic soil fertility, which takes account of soil formation type, melkozem thickness, granulometric composition, automorphy and the reduction coefficient against humus content, while really possible yield (DVY) is computed using the reduction coefficients against salinity, macroelement content, crop disease, weed and pest infestation, and ground evenness. Yield losses due to water factor are computed with the CROPWAT program. Expert evaluation was applied to organizational and technological yield losses. Crop watering dates and depths were calculated using the ISAREG model, using as basic climate input the daily field evaporation measurements and the Ryzhov's formula (1981) based on daily soil moisture measurements. Land productivity was assessed on the basis of harvestable yield (100 kg/ha, t/ha), while irrigation water productivity was determined by the ratio crop yield to water use (kg/m^3).

Results

General characteristics of pilot plots

The key criterion for selecting a farm and pilot plots was their representativeness in terms of soil-climatic and economic conditions and relative equidistant location from the head canal. The plots are comprised of light-loamy sierozem-meadow soils subjected to transformation into meadow and with presence of gley horizons (Table 5).

Table 5. Key characteristics of pilot plots.

Crop	Province	District	Farm	Area (ha)	Soil texture FAO	Bulk density (g/cm^3)
Cotton	Fergana	Akhunbabayev	Azizbek	10	SL-ZL	1.32 -1.45*
Winter wheat	Fergana	Akhunbabayev	Azizbek	10	SL-ZL	1.31-1.42

* - the first figure – plough layer (0-30cm),
the second figure – plough-pan (30-70cm)

The soils are slightly saline in the plough layer and medium-saline in plough pan. Ca and SO_4 prevail in ion composition and chemical salt composition shows no alkalinization.

Agrochemical soil properties are shown in Table 6 and characterized by low phosphorus and potassium contents.

Table 6. Agrochemical soil properties.

Crop	Farm	Degree of salinity	Humus (%)	$N\text{-}NH_4$ (mg/kg)	P_2O_5 (mg/kg)	K_2O (mg/kg)
Cotton	Azizbek	low/medium	1.57-1.07	38.3-41.4	24.5-24.3	170-152
Winter wheat	Azizbek	low/medium	1.40-1.17	43.5-45.2	21.4-20.9	169-170

The content of humus in the soil varies from 1.57 - 1.40% in plough layer to 1.07 - 1.17% in plough pan. Content of $N\text{-}NH_4$ is slightly higher in lower horizons (41.4 - 45.2 mg/kg), while it is smaller, from 38.3 to 43.5 mg/kg in the 0 - 30 cm layer.

Field Soil-Reclamation Passport

Soil-reclamation passportization of fields was developed by SANIIRI (Dukhovny and Nerozin, 1989) and has been implemented in agriculture since 1990. Over 1990-1995, more than 120 thousand hectares were covered with passportization in various provinces of Uzbekistan. Within the framework of the Copernicus Project, passports were developed for the pilot plots of farm Azizbek, where cotton and winter wheat were grown.

Soil-Reclamation Passport (SRP) is intended for a farmer or technicians of collective dehkan farms and contains the basic agronomical documentation for particular plots, as well as specific reference data, norms and recommendations, which are necessary for arranging scientifically sound measures to develop crop production, raise land productivity, program crop yields, draw up current and long-term plans. Information contained in electronic version of SRP is used in assessing yield losses, modelling irrigation schedule and fertilizer application and for agroe-conomical analysis of agricultural activities.

Field Soil-Reclamation Passport (Fig. 1) is comprised of 18 pages and contains the following data:

- Areal estimation (gross, net, unsuitable land, areas under roads, irrigation system, and buildings);
- Cropping patterns and level of crop productivity;
- Basic agrophysical and agrochemical properties of soil;
- Average annual climatic data of given zone;
- Topographic map (planar and spatial representation of field geometry);

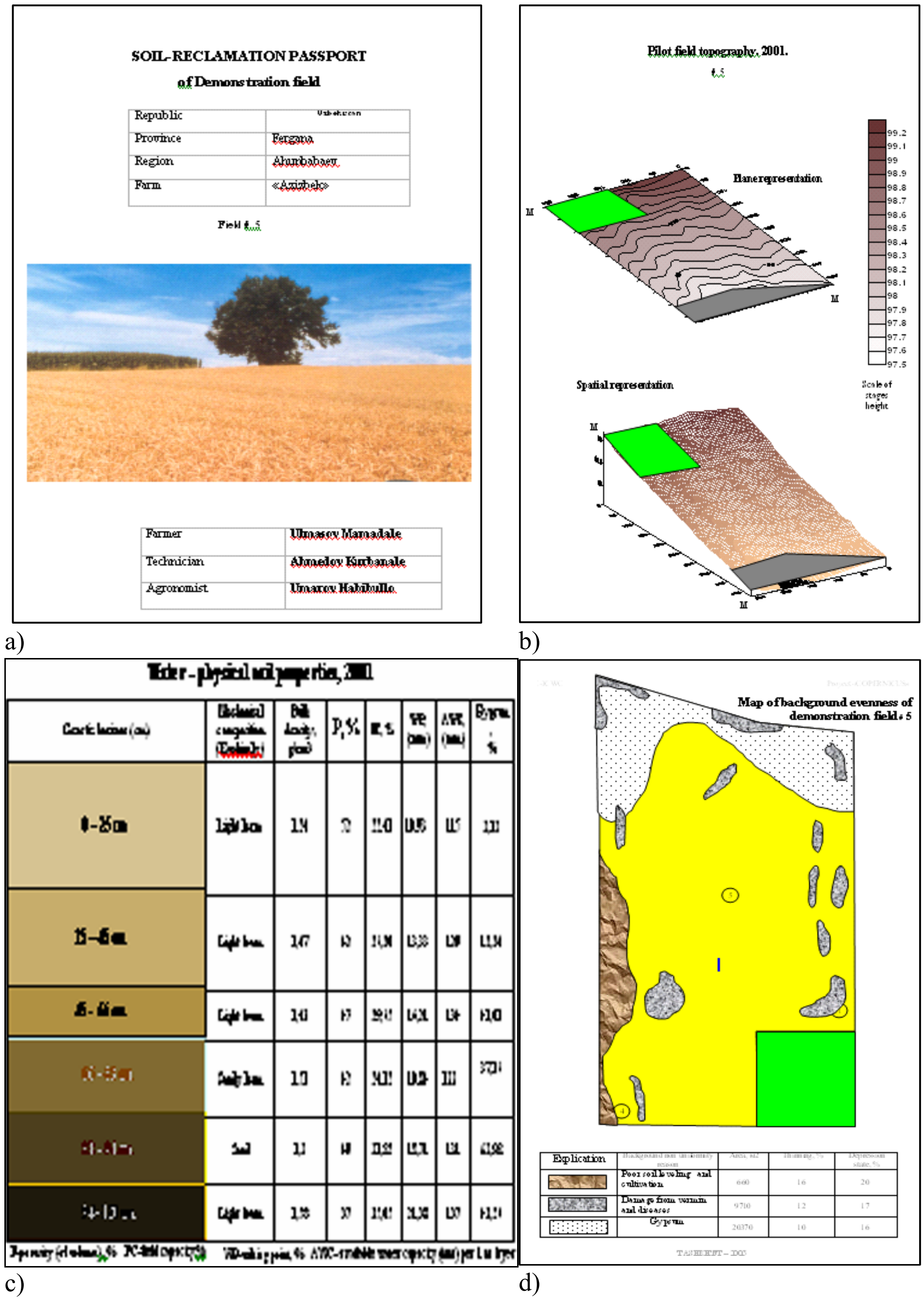

Fig. 1. Example pages of field soil-reclamation passport, farm Azizbek: a) field identification; b) field topography; c) soil water and physical properties; d) map of soil problems causing non-uniformity.

- Maps of humus, nitrogen, phosphorus, and potassium contents, soil salinity and soil texture for plough-layer (0-30 cm) and for plough-pan (30-100 cm);
- Map of planted ground evenness;
- Map of actual and recommended irrigation plot layout within the field;
- Information on crop yields (by separate harvest), sowing data, crop density;
- Cost-effectiveness of agricultural production (gross output, fixed and variable costs, gross and net profit).

Informative part of the passport is filled up after areal estimation, levelling survey by typical profiles, soil sampling from plough-layer and plough-pan followed by chemical analyses, as well as after collection and processing of regular observations over weeds, plant diseases and pests in the fields.

The practical value of the passport is that most information is represented in graphical form that allows for visual identification of field characteristics. Thus, in a topographic map, a user may see field slopes (that are difficult to determine by non-instrumental observation) and, according to available elevations, more correctly choose location of "ok-aryks" (irrigation ditches) and arrange appropriately irrigation sites. Areal representation of fields identifies microhills and microsinks and favours to remove such irregularities during levelling. Such information helps to avoid excessive levelling efforts and to achieve efficient water distribution in a field and uniform wetting of the letter. Data on soil texture are used to decide how complex mechanical land treatment should be, while knowledge of soil structure, permeability and soil water holding capacity is particularly important for choosing correct irrigation depths. Maps of salinity in plough layer and plough-pan identify zones that need to be leached, allow farmer to estimate leaching areas and required leaching norm for each profile. Selective leaching of salty spots by flooding small checkrows allows for desalination of such zones and, at the same time, for water saving. Whether planned crop yields would be achieved or not depends on adequate application of organic and mineral fertilizers during the growing season.

Information on humus contents and soluble nitrogen, phosphorus and potassium helps to set adequate amounts of fertilizers and, moreover, to equalize soil fertility throughout the field. Thus, using the humus content map, one should firstly estimate low fertility areas and then, in the same map, according to the given recommendations, calculate required amounts of organic fertilizers. Maps of nitrogen, phosphorus, and potassium contents also help to identify profiles that lack those macroelements and to balance the nutrient content by using recommendations given in the passport on mineral fertilizer application rates under various NPK contents (Fig. 1).

A map of land/crop uniformity shows some information on the crops state, characterizing mainly spots of plant blindness or plant depression with specification of relevant causes. Land uniformity is estimated through direct inspection of the whole field and measurement with a tape the spots and contours that differ on low plant density or signs of depressed plant growth and development from the general average background of the field. Experts identify causes of such deviations (poor levelling, shallow water table or gravel presence, salt spots, weeds and pests infestation, diseases, poor quality of seeds, land treatment faults, etc.). The identified contours are shown in different colours that enable farmers to find causes of land non-uniformity by looking at the map legend and, further, to take necessary agronomic or organizational measures to remove the causes.

The soil-reclamation passport can be used during a 10 years period provided that it is annually updated. It is an agronomic data pool helping farmers to make proper farming decisions, get unbiased analysis of agricultural production dynamics and improve farming cultivation. If necessary, the passport may be supplemented with new schemes and recommendations in order to improve land and water productivity.

Land productivity analysis

The highest possible crop yield (MVY) may be obtained only under ideal growing conditions that are very difficult to create in field practice. Nevertheless, in the theory of programming, computation of crop productivity starts just from this parameter. MVY is computed by the Nechiporovich's formula (1963):

$$MVY = \frac{\Sigma Qfar}{q} = \eta_f \cdot K \qquad [1]$$

where

- $\sum Qfar$ – inflow of photoactive radiation over the growing season (kcal/cm2);
- q – yield caloricity (kcal/kg);
- η_f - efficiency of photosynthesis (%);
- K - coefficient of conversion from phytomass to yield.

Data on inflow of photoactive radiation (PAR) per 1 ha of cropped area over the growing season were obtained from the observations of actinometric stations at Hydrometeorological Service. Coefficients for MVY are shown in Table 7.

Table 7. Biological coefficients for MVY computations.

Crop	Yield caloricity (kcal/kg)	Efficiency of photosynthesis (%)	Coefficient of conversion from phytomass to yield
Cotton	4800	3.5	0.20
Winter wheat	4500	2.5	0.46

Within the Fergana Valley zone, MVY was 7550 kg/ha for cotton and 11000 kg/ha for winter wheat. The potential yield (PY) was determined as the difference between MVY and yield losses through the slow changing in time of physical soil properties and humus content. The actual-possible yields (DVY) were estimated as the difference between PY and the losses through several controllable agricultural production factors, such as salinity, nutrients content, weed infestation, crop diseases, pests, and field levelling. The degree of yield loss depends on quantitative values for every factor (reduction coefficients against every factors were derived from summarized reference and experimental data). Yield losses through the agricultural production key factors in the pilot plots in 2003 may be visually estimated using Tables 8 and 9.

The potential cotton yields averaged 62500 kg/ha, while the actual-possible productivity equals 39700 kg/ha. Maximum yield losses were caused by lack of humus in the soil (720 kg/ha), poor P_2O_5 content (700 kg/ha) and physical soil properties (580 kg/ha).

Table 8. Cotton and wheat yield losses (100 kg/ha) through the key agricultural production factors (2003).

Factors	Azizbek	
	Cotton	Wheat
MV	75.5	110
Physical properties	5.8	8.0
Lack of humus	7.2	12.0
PY	62.5	90.0
Salinity	3.3	4.0
Low P_2O_5 content	7.0	9.0
Low K_2O content	2.6	4.2
Weed infestation	2.9	4.8
Crop diseases	1.6	4.7
Pests	4.2	3.9
Ground unevenness	1.2	4.1
DVY	39.7	55.3
Organizational losses	8.7	6.7
Actual crop yield	31.0	48.6

MVY: the highest possible yield;

PY: potential yield;

DVY: actual-possible yield

Table 9. Organizational and technological crop yield losses (100 kg/ha) in the pilot plots (2003).

	Azizbek	
	Cotton	Wheat
Irrigation water supply	1.6	1.3
Lack of agricultural machinery and equipment	0.0	0.5
Lack of labour resources	1.0	1.4
Poor quality seeds	0.0	0.0
Decreased seeding rate	0.0	0.0
Deviation from zonal technological recommendations	2.6	1.5
Poor quality of technological operations	3.5	0.9
Harvesting losses	0.0	1.1
Total org. and technological losses	8.7	6.7

The potential winter wheat yield equalled 9000 kg/ha, and the really-possible yield amounted to 5530 kg/ha. Yield losses through lack of organic matter in the soil were much higher – 1200 kg/ha - as compared to those of cotton. Besides, the losses amounted to 800 kg/ha through physical properties and 900 kg/ha through P_2O_5 content. Organizational and technological losses were quite high for cotton (870 kg/ha). This type of losses for winter wheat amounted to 670 kg/ha. Primary losses are caused by poor farm operations (Fig. 2), deviations from zonal technology recommendations and irrigation water supply. Quantitative representation of yield losses allows farmer to identify factors that can be then considered as major causes of low productivity and choose agronomic or organization measures reducing the negative impact of those factors.

Fig. 2. Cotton irrigation in Azizbek farm.

Water productivity analysis

Based on the GEF Project' data (2002) and the recent evaluation of irrigation water use in Fergana province, it was established that actual amounts of water supplied to the field are higher than required and standard ones and that considerable share of water is lost through runoff and deep percolation. The causes of excessive water supply within farms and relate to hydraulic-physical soil properties, gravel horizon level, furrow length, water table level, as well as to inadequate irrigation dates and depths. The Azizbek farm reported an available irrigation water runoff of 10.2% of unit inflow from the cotton field and percolation losses of 10.0% that totalled 20.2% of unproductive water losses (Table 10).

Table 10. Efficiency of irrigation water use in the Azizbek pilot fields (2003).

	Cotton	Wheat
Gross unit inflow (m^3/ha)	7268	7193
Runoff losses (m^3/ha)	741	986
Percolation losses (m^3/ha)	729	720
Net unit inflow (m^3/ha)	5798	5487
Water efficiency in the field (%)	80	76
Number of irrigation events	6	5

Research in 2003 showed that runoff from a winter wheat field was higher (13.7%) and total irrigation wasted water amounted to 23.7%. Nevertheless, comparative assessment of water productivity in 2002 and 2003 (Table 11) indicates that the level of water management in 2003 is appreciably higher.

Table 11. Comparative assessment of water productivity in the pilot plots (2002-2003).

			Azizbek	
			Cotton	Wheat
Gross unit inflow	(m^3/ha)	2002	9568	9025
		2003	7268	7193
Number of irrigation events		2002	7	5
		2003	6	5
Used water	(m^3/kg)	2002	2.59	1.88
		2003	2.34	1.48
Water productivity	(kg/m^3)	2002	0.39	0.53
		2003	0.43	0.69
Increase of productivity	(kg/m^3)	2003	0.04	0.16
	(%)	2003	10.2	30.2

As compared to 2002 (Table 11), the unit gross inflow was reduced by 2300 m^3/ha to the cotton field and by 1832 m^3/ha to the winter wheat field. Water volumes used per unit production decreased considerable (by 0.25 m^3/kg for cotton and by 0.40 m^3/kg for wheat), and water productivities increased by 10.2% and 30.2% in cotton field and winter wheat field, respectively. The data shows that it is possible to reduce volumes of water used in the fields through water conservation methods and by following irrigation depths and dates produced by the simulation models.

Conclusion

The review of statistical data over 1990-1995-2000 in the provinces of Fergana Valley, as well as the SIC ICWC's experiments carried out in farms for evaluation of land and water productivities indicate that there are capabilities and opportunities for improving the agricultural production and related water and land productivities. The key factors restricting the potential crop yield at field level in given provinces are low rates of organic and mineral fertilizer application, less control of weeds, pests and diseases, and untimely agronomic operations with low quality. The monitoring showed less rational organization of irrigation, excess supply of irrigation water, incorrectly selection patterns and parameters of irrigation technology, and considerable water wastes through runoff and deep percolation.

The assessment of field productivity helps to identify key-factors, evaluate actual crop yield losses under current conditions in relation to soil and management conditions, and to recommend specific agronomic practices for improvement of land productivity. Moreover, one should take into account the farmer's ability to implement the recommended measures and, based on such measures, estimate levels of planned crop yields.

By using some elements of the yield programming theory such as intensive technologies and integrated agricultural production methods, the following approach to land and water productivity management in farms may be offered:

- Collection of information on field characteristics;
- Development of soil-reclamation field passports;
- Calculation of crop productivity levels;
- Assessment of yield losses due to various factors;
- Assessment of farmer's capacities (financial, technical, technological) to control factors causing yield losses;
- Choosing measures to reduce negative effects of a minimum-factor;
- Development of an individual scheme of agronomic practices for the growing season, based on agricultural production conditions and field characteristics; and
- Implementation of measures aiming the improvement of crop yields and irrigation water savings.

Implementation of such approaches in demonstration plots located in

Uzbekistan, Tajikistan, and Kyrgyzstan enabled farmers to increase yields on average by 350 kg/ha and 1120 kg/ha for cotton and wheat respectively; to improve water productivity by 16 to 88%, and decrease runoff and deep percolation. The approach is expected to disseminate through the extension services for farmers.

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