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Water resources assessment, irrigation and Agricultural developments in Tajikistan

by

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This paper provides a description of current state of water resources assessment in Tajikistan, their use for the agriculture development and maintenance of irrigation infrastructures. The Vakhsh and Pyandzh River Basins and its tributaries in Tajikistan were directly surveyed during an expedition within the framework of a Joint Research Project: *Investigation of natural resources of Central Asia and reconstruction of agriculture in Afghanistan*, that is supported by the Ministry of Education and Culture of Japan Grant in Aid for Scientific Joint Research, 2003, No. 15252002), that is represented by professor Dr. Tsuneo Tsukatani, Department of Natural Resources and the Environment, Kyoto Institute of Economics, Kyoto University, Japan. The field expedition was carried out in September 2003 according to the Joint Project Research Program to study the natural resources and contemporary state of irrigation in Pyandzh River basin.

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2

Water resources assessment, irrigation and Agricultural developments in Tajikistan

By

Toderich K., Abbdusamatov M. and Tsukatani T.

1. Summary

This article describes the water resources management and use in Tajikistan, along with the on site observations and experience gathered through an expedition along the riparian basin of AmuDarya river from near its origin at Pyandzh in Tajikistan. The peculiarities of the land, its vegetative characteristics, and any irrigation systems or methods used through this vast area are described so that our preliminary studies on the potentials for agriculture using Subsurface Drip Irrigation (SDI) technique on the left bank of AmuDarya river can be further examined. We hope that our collaborative research having involved Uzbek, Tajik, and Japanese researchers, can use the data gathered in expeditions like this to complement the required information and prepare the necessary steps for establishment of sustainable agricultural development in the region and assist with the ongoing process for the development of riparian states in Central Asia.

2. Introduction

In Central Asia, there is a rich supply of water resources in areas near AmuDarya, Zerafshan and SyrDarya rivers. Unfortunately a long history of human interventions has led to the partial degradation of this land due to careless use of water resources. At the beginning of the 21st Century, a new stage has started that may help regenerate this area with less energy and power but through the help of new technologies. Though the AmuDarya is Afghanistan's northern border and 17 percent of the AmuDarya basin lies within Afghanistan, the country has not been a major factor in discussions about distribution and management of the AmuDarya basin's water in the past. New development efforts there could cause Afghanistan to eventually play a larger but so far uncertain role, depending on how it lays claim to AmuDarya River water (Ryabtsev, 2003, Glantz, 2003).

Impact of some industrial sources on quality and ecological state of natural water is also not well known, because of control system lack for its quality and quantity, poor observance system of economic measures for those who pollute water.

In addition, water availability assessment, actual water availability account over AmuDarya basin is carried out on Kerky gauge upstream Karakum Canal to border of Surkhandarya oblasti. This is very typical gauge, which water availability account and forecast was started by Uzglavhydromet in 1974. Recent years, however, this is a single

Keywords: water resources, cropping system, irrigation infrastructure, Tajikistan, Subsurface drip irrigation, SDI, Pyandzh, AmuDarya, Kumsangir, Vakhsh

possible point for AmuDarya water resources assessment, because on rivers Pyandzh, Vakhsh, Kafirnigan located in Tajikistan, flow account is not carried out because of set of reasons. Also it worth to note those recent years Surkhandarya and Sherabad Rivers lost connection with AmuDarya.

Moreover, climate change in this century will alter the equation in ways scientists and governments do not yet fully understand. As of spring 2002, Central and Southwest Asia comprise the largest region of persistent severe drought in the world. That drought has had devastating societal and environmental consequences and has been exacerbated by the rapid disappearance of glaciers in the Pamir Mountains some by 40 percent in recent decades which feed the flow of the AmuDarya (Dukhovnyi, 2003).

We undertook this expedition and organized an international joint research team with such a hope. The main objectives of this survey were:

- To study the landscape and physiographic features of the region;
- To provide a geobotanical description of the usual plant vegetations covering the irrigated and none irrigated lands;
- To analyze the water quality (of drinking, irrigation and collector-drainage water) on the territories of Tajikistan (Kumsangir district);
- To evaluate the current situation of irrigation networks and technologies under usage for agriculture in the region;
- To determine the optimum locations for introduction of SDI (subsurface drip irrigation) technology for crops cultivation;
- To make practical recommendations for revitalization and improvement of degraded ecosystems, as well as reconstruction of the irrigation system.

3. Route of expedition:

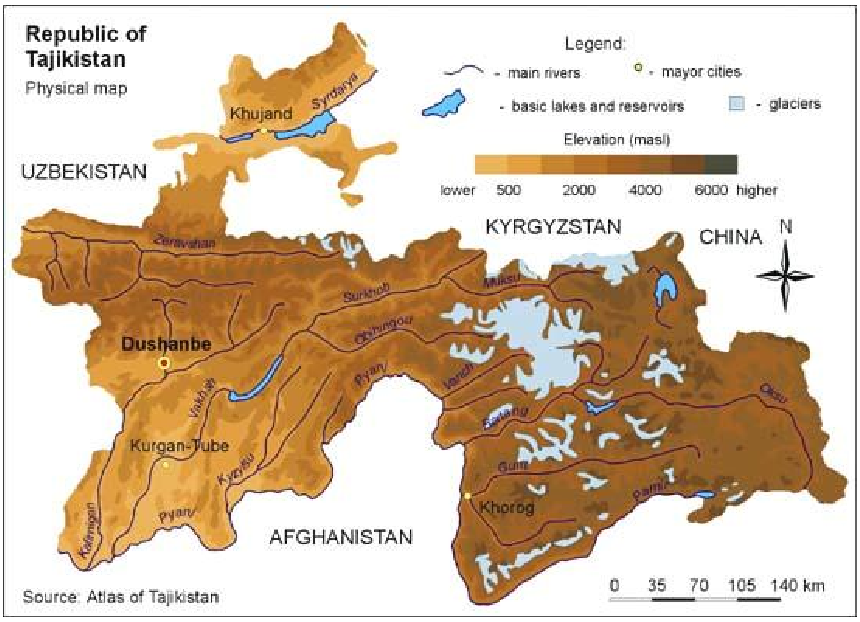
Khudjent – Dushanbe – Kumsangir – Nijne-Pyandz – Imam-Sohib – Kunduz.

4. An introductory assessment of water resources in Tajikistan

With 93% of its territory covered by mountains, shown in Fig. 1, Tajikistan contributes more water to the Aral Sea Basin than all the other Central Asian countries combined. The area of glaciers (8% of the country) exceeds that of agricultural croplands (6%). Tajikistan is second only to Russia in terms of the volume of water resources; and with a population of 6.5 million, Tajikistan's annual water production of 13.000 cubic meters of water per person per year, is among the highest in the world.

There are around 25,000 rivers as the water resources of the country, but the most significant role is played by SyrDarya, Pyandzh, Vakhsh, Murghob, Kofarnihon, Surkhob, Oksu, Zerafshan etc. There are also more than 1,300 lakes (Sarez one of the largest) and nine reservoirs (Nurek, Kairakum, etc.) currently operating in Tajikistan.

Figure 1 Topography of Tajikistan



prepared under UNEP/GRID-Arendal technical cooperation

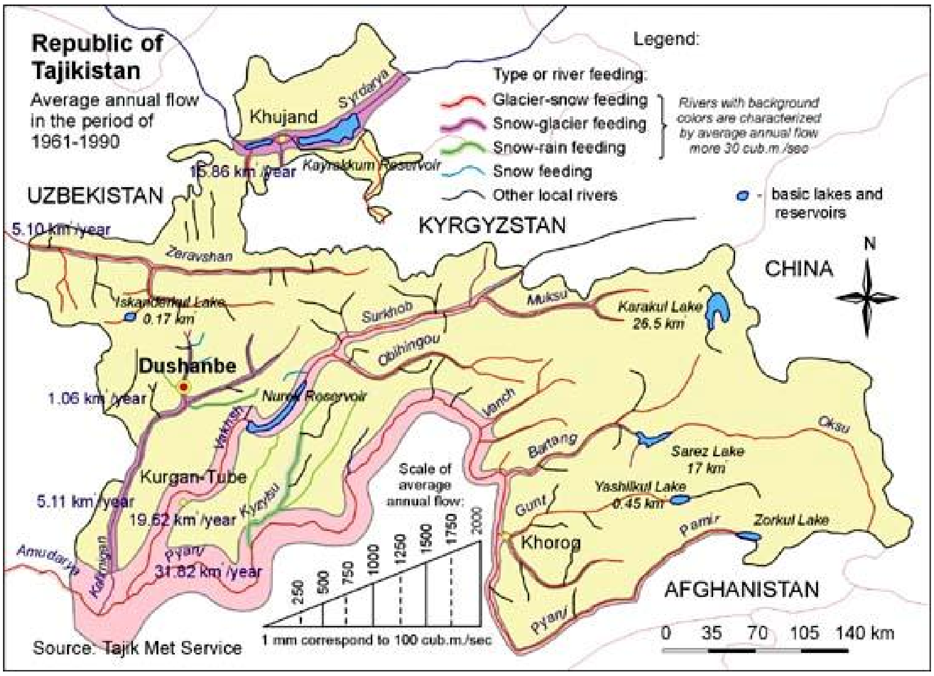
Improving water management is central to the progress of development in Tajikistan. With its predominantly agricultural base, 84% of the water in Tajikistan flows into the fields, while 8.5% of consumption is accounted for by drinking water and communal services, 4.5% by industry and 3% by other users (Table 1). Here a mention must be made of an insignificant percentage of water taken from irrigation channels by about 25% of the population who use it as the main source of drinking water.

Fig. 2 shows that Tajikistan generates around 64 km^3 of water each year, approximately 55% of all the water in the Aral Sea Basin. Glaciers and the underground water sources provide around 25-50% of yearly flow (depending of glacier melt). These glaciers hold a mass of 845 cubic kilometers of water that is seven times bigger than the total annual flow in the Aral Sea Basin. However, the glaciers are retreating at an alarming rate, due in large part to the rise of the annual average temperatures and decreased precipitation over the past twenty years (Fuchinoue et al. 2002, Akhmedov et al. 2003, Muray-Rust, 2003).

Since the vast majority of water in Tajikistan originates from inside the country, Tajikistan is free of many of the problems that typically face downstream countries, such as industrial pollution, mineralization and higher salinity levels from upstream neighbors.

During the soviet era, regions that produced cotton and rice were given priority access to water for irrigation. Under this policy, the largest volumes of water were directed to the downstream republics in the lower reaches of AmuDarya and SyrDarya rivers: Kazakhstan, Uzbekistan, and Turkmenistan. As seen on Tables 2 and 3 there is a large disparity between the allocated flow volumes and the rightful entitlement of each state to the region's water resources. Tajikistan provides more than 55% of the total flow volume to the Aral Sea, while occupying just 11% of the total basin area.

Figure 2 Average annual flow of Tajikistan



State of the Environment in Tajikistan under UNEP/GRID-Arendal technical cooperation.

Table 1 Water uses in Tajikistan (%)

Agriculture	84.0
Domestic use	8.5
Industry	4.5
Other	3.0

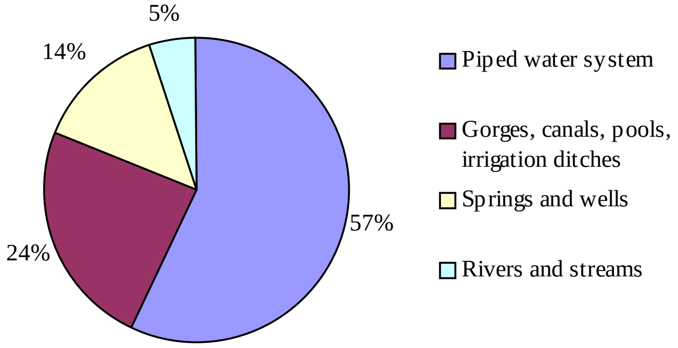
Table 2 Contributor to flow volume in the Aral Sea Basin

Kazakhstan	3.9
Uzbekistan	7.6
Tajikistan	55.4
Kyrgyzstan	25.3
Turkmenistan	2.4
Afghanistan & Others	5.4

Table 3 Flow entitlements on AmuDarya and SyrDarya (%)

Republic	AmuDarya	SyrDarya
Uzbekistan	42.3	50.5
Tajikistan	15.2	7.0
Turkmenistan	42.3	
Kyrgyzstan	0.3	0.5
Kazakhstan		42.0

Figure 3 Sources of drinking water for Tajik people, by percentage of population



Owing to the general economic depression and the post-independence civil war, it is difficult to assess the extent to which agricultural output has suffered as a direct consequence of the degradation of the irrigation and drainage systems.

Though possessing the largest water resources in Central Asia, Tajikistan has been experiencing difficulties in supplying fresh water to its population in recent years. The mountainous topography of the country presents major physical challenges to extension of the water supply network. As seen on Fig. 3 nearly a quarter of the population uses water from gorges, canals, irrigation ditches and pools. The cotton and hydropower issues are of particular interest as they are two of Tajikistan's greatest opportunities for the future, already facing constraints in the water sector, as well as the two areas where wise water policy should play an essential role.

Agriculture is a key component in Tajikistan's economy, exports and its potential remedy for rural poverty. From 851 thousand hectares of arable cropland in Tajikistan, 720,000 are irrigated and these generate 80% of the nation's total agricultural product.

Following independence, subsistence agriculture became a safety net for much of the population as industry and labor markets collapsed. Most of the population is indirectly dependent on irrigation and drainage systems for food production:

rehabilitation of these systems will thus play a crucial role in efforts to compensate the food deficit in Tajikistan.

It was found that food production could be increased either by cutting back on cotton production or by hastening the farm restructuring process, providing the farmers with more options and choices (not having to plant cotton, for instance), facilitating credits and upgrading irrigation systems.

It is also essential to consider the development of a set of measures aimed at protecting water basins from toxic and other wastes disposed by industrial and agricultural enterprises. At the same time it should be emphasized that the problem of water use is really a regional one, affecting the interests of all Central Asian states to almost the same degree. The main impact on irrigation and drainage systems is falling into disuse of a sixth of formerly irrigated lands. If 80% of agricultural product comes from irrigation, this contraction in the sown area to which water is actually delivered, represents lost earnings as of 16% in the agricultural sector.

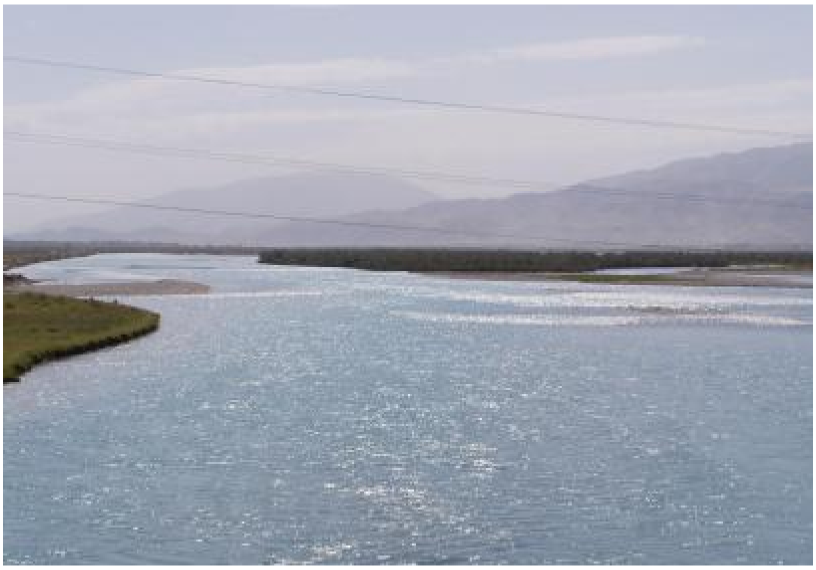
Maintaining technology-intensive systems is proving unsustainable as utility tariffs rise and the skills gap persists. One the main reasons for such a rapid decrease in sown irrigated land is Tajikistan's high dependence on pumping. Around 48% of the country's irrigated land depends on pumping systems, with lift heights ranging from 10 to more than 200m. High lift pumps are found principally in Sughd and Khalton oblasts. Since 1991 more than a sixth of all irrigated lands have ceased receiving water.

While gravity irrigation schemes rely on river intake structures to divert flow into a gravity conveyance system, pumped irrigation schemes lift water from rivers up to main canals or to pipe conveyance systems at high level. Some of the pump schemes used in Tajikistan, known locally as cascades, involve pumping lifts of several hundred meters through a succession of staged pump stations. It was determined that the 445 pumping stations in the country require higher level of electricity and know-how than regular gravity –fed irrigation.

Few farmers can afford the new electricity tariffs required to pay for this infrastructure, and many of the top engineers and technicians who used to service these systems left the country in the aftermath of independence and the civil war. In addition, the lack of spare parts means that cannibalization of other machinery for makeshift repairs is widespread. Further degradation of the rest of the system occurs. It is reported by the Ministry of Irrigation and Water Resources (MIWR) that as much as 65% of pumping systems may be out of operation, while water supplies are down by 40% or more.

On the other hand, water losses are on increase. Efficiency averages around 60% for most of the country. Considering the predominance in the country of earth irrigation channels (41%) with high rates of silting, evaporation, and filtration (seepage into the ground), rather than lined (29%) or piped channels, more water will need to be pumped to meet demand. But this will only contribute to the risk of increasing tensions with down-stream neighbors, especially in times of water shortages.

Fig. 4 Vakhsh River (near Kurgan-Tube city)



Tajik people do not suffer much from shortages of water because of their poor sanitary conditions and the long forgotten diseases that accompany its use, such as typhoid and hepatitis.

Five different agencies are responsible for monitoring water quality in Tajikistan. The principal agency is the Sanitary Epidemiological Station (SES), which conducts its own monitoring and has authority to take enforcement actions if water is contaminated. Tajikselkhozvodoprovodstroy (the rural water supply authority) at MIWR, Tajik Municipal Authority (the urban water supply authority) and Khukumats are responsible for monitoring supplies to their respective populations. In addition, the Ministry of Environmental Protection also monitors water quality, and, as with SES, has enforcement powers. Meanwhile the water supply authorities are trying to re-establish their water quality laboratories, most of which were destroyed during the civil war. Funding problems are hampering these efforts.

Chemical and bacteriological contamination is clearly a serious problem. With over 2,000 samples taken in each region, the proportion of samples exceeding regulation levels of contamination varied from 20.6% for chemical contaminants in Sughd to a worrying 54.7% for bacteriological contaminants in Khalton.

Results from 1997 to 2000 show that an even greater proportion of samples – around two thirds – were substandard. Substandard water quality resulted in large typhoid outbreaks in 1997-2001 in Dushanbe, Khalton and Sughd Regions. The incidence of acute enteric infections, typhoid fever, malaria and diphtheria, all related to the consumption of poor quality water, remains high in Tajikistan.

According to the World Health Organization, 60% of all diseases are water-related. Illnesses such as typhoid, diarrhea, diphtheria, and hepatitis are caused by the consumption of contaminated water, while swamping sites proved to be the breeding grounds for malaria.

Tables 4 and 5, present the rates of infectious diseases – all water related – in Tajikistan for the period 1998-2000. The incidence of disease is between three and nine times higher in areas of irrigated agriculture, where ditch waters provide the main source of water for most of the population. The heavy dependence on agriculture in Tajikistan and the resulting exposure to chemicals involved in cotton farming and others agricultural waste all impact negatively on the nation's health.

Table 4 Malaria, diphtheria and hepatitis, by comparison with Kazakhstan,

Year	Malaria		Diphtheria		Hepatitis	
	Kazakhstan	Tajikistan	Kazakhstan	Tajikistan	Kazakhstan	Tajikistan
1998	0.58	319	0.49	2.7	267	122
1999	0.36	220	0.11	0.5	106	164
2000	0.25	308	0.08	0.2	186	159

per 100,000 people

Table 5 Infectious diseases in Tajikistan per 100,000 people

Year	Typhoid	Diarrhea	Bacterial Dysentery
1998	171	999	63
1999	120	1,213	60
2000	71	1,377	43

Table 6 Central Asia: Incidence of Selected Diseases and Mortality, 1989-91

	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Viral hepatitis	465.6	710.8	918.3	735.1	1,074.5
Cancer	289.9	219.0	163.1	203.0	169.2
Tuberculosis2	65.8	53.3	44.4	63.6	46.1
Maternal mortality	53.1	42.7	38.9	55.2	42.8
Infant mortality	27.1	29.6	40.0	46.6	35.8

Source: Based on information from Christopher M. Davis, "Health Care Crisis: The Former Soviet Union," RFE/RL Research Report [Munich], 2, No. 40, October 8, 1993, 36.

Currently it is of utmost importance for Tajikistan to create an effective water conservation system by reconstructing existing irrigation networks and canals using new technologies that can minimize water losses, especially in relation to irrigation of agricultural dry lands. Table 8 shows the distribution of salinity within irrigated lands in Tajikistan.

Table 7 Tajikistan: Production of Principal Agriculture 1992-94 (in thousands of tons)

Crop	1992	1993	1994
Vegetables	679	552	490
Cottonseed	415	382	401
Wheat	170	175	165
Fruits and berries	181	135	140
Cotton lint	126	150	135
Watermelons	136	107	105
Grapes	100	88	85
Barley	42	32	34
Corn	32	34	23

Source: Based on information from The Europe World Year Book 1996 , 2, London, 1996, 3077.

Table 8 Irrigated land in Tajikistan affected by low, medium and high salinization

Degree of salinization	Low	Medium	High	Total
Irrigated land affected (ha)	21.032	73.555	21.497	116.200
Irrigated land affected (%)	3%	10%	3%	16%
Estimated loss in cotton yields	20-30%	40-60%	> 80%	

Much of the population in Tajikistan is indirectly dependent on irrigation and drainage systems for food production: rehabilitation of these systems will thus play a crucial role. Besides, poor management and limited drainage infrastructure have resulted in salinization and water logging that both have a considerable impact on soil fertility. As collection and drainage networks cover only 311.2 thousand hectares, i.e. less than half of total irrigated lands, the other part (around 15% of irrigated lands) is over-saturated every year.

As a result, water dissolves salt occurring naturally in the soil and causes it to rise to the surface that consequently leads to retarding of plant growth and falling of yields. Moreover, rising salinity increases water requirements to flush salt out of the soil by applying large volumes of water, a practice knowing in farming economy as leaching. Despite this, the salinization is not as acute in Tajikistan as in the downstream countries; only 16% of the Tajikistan's irrigated lands are affected. The Ministry of Irrigation and Water Resources estimates cotton production losses from salinization at 100,000 tons per year.

It was estimated that all water users, domestic and agricultural alike, suffer from poor management of the water sector. However, as we have seen during our field mission a key problem in maximizing water benefits for many agricultural users concerns not only the constraints and weakness of the water system, but problems in the structure of the agricultural sector itself. The most problematic is the cotton production that still is considered the best agricultural export, after aluminum and electricity (61% and 12% respectively). Cotton is a big business in Tajikistan. Accounting for 20% of the workforce and 11% of exports, it fetches a high price on world markets owing to its special luster. Though Tajikistan with its vast water resources is well suited to produce cotton, this also leads to intensive water use. On the other hand, cotton revenues have enormous potential for poverty alleviation in Tajikistan's agricultural sector. This dependence is most acute in rural areas, where poverty is greatest.

Tajikistan like other Central Asian states has historically favored cotton from other crops, and state farms were obliged to plant this single crop (89% of cotton production coming from state-owned farms). The state is directly and still heavily involved in this lucrative sector. In this sense many farmers lack the opportunity or the skills to diversify into other crops. But with the collapse of the command economy, Tajikistan lost both its main market for cotton as well as its prime source of financing and investment: Russia. This made the current Tajik government independent in the view of international investor organizations from where they take credits in order to maintain cotton production after independence.

Indebtedness and poor knowledge of market information among farmers, however, mean that the considerable potential of cotton as a means of redressing rural poverty continues to go unrealized. Poor irrigation, a major current factor contributing to low crop yields, is but one of many constraints on this potential. Thus, improvement in water management coupled with involvement of new technologies of cotton production with further reconstruction of the cotton agricultural sector can generate benefits that Tajikistan's rural poor so badly need.

5. Kumsangir

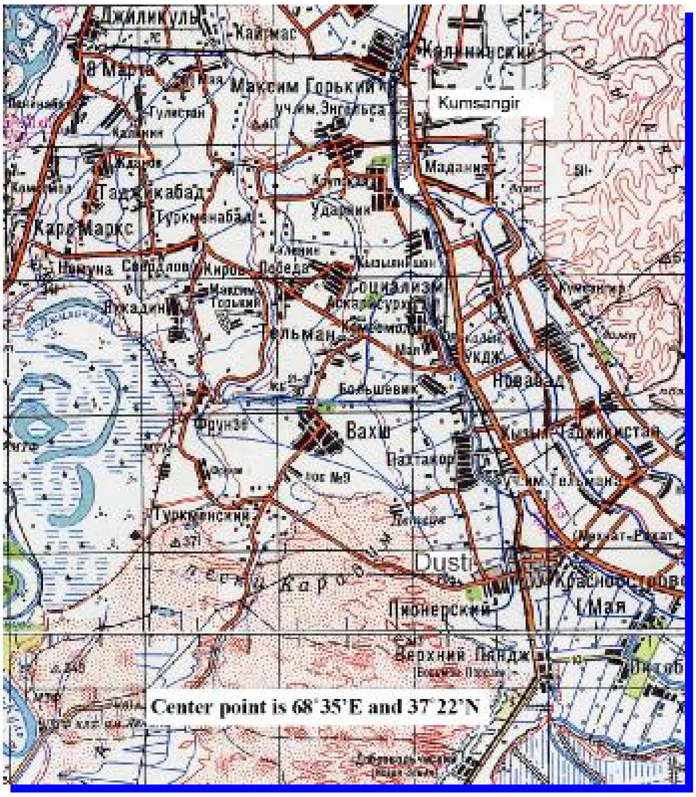
A survey of farming and irrigation systems on the right bank of AmuDarya River (from Tajik side) during our mission was carried out in the Kumsangir district, spread along between Vakhsh and Pyandzh River. Kumsangir district with a population of 93.0 thousand owns 22.3 thousand hectares of land from which about 14.0 thousand are irrigated. On farms is secured (discharged) 2,759 has.

River Vakhsh is the basic source of water for irrigated agriculture in the Kumsangir district. In the lower part of Kumsangir district not far from the worldly known biosphere reserve "Tigrovaya Balka (Tiger Valley)", the fusion of these two large regional rivers - Pyandzh and Vakhsh into AmuDarya takes place.

The lift irrigation in the region is taken from the main canal named Kumsangir, especially from its caudal part (Figs. 5 and 6). The length of the main canal is more than 65 km from which 25 km flows in the territory of Kumsangir district.

The distributive network consists of earthen shaped canals and is supplied with hydraulic engineering structures. The irrigation network scheme of the district is shown in the Fig. 6.

Fig. 5 Map around Kumsangir



Land reclamation has begun after 1950th. About 50 % of lands are irrigated through the pump stations in the 4th rises. The basic agricultural crop is cotton, with an area of more than 11.6 thousand hectares and a total annual total yield in the range of 20.0-23.0 thousand tons. A little space is left for grain, fodder crops, vegetables, melons and volatile oil containing plants, especially geranium. The livestock industry in the district is also well developed.

Long-term intensive irrigation of lands, lack of engineering control on watering process and bad operation of collector-drainage network has lead to the deterioration of soil conditions. Besides, water losses in the territories investigated by us were on the increase. The efficiency (the proportion of water diverted from rivers or other sources that actually reaches the fields) averages around 60 % for all regions.

The predominance in this region of earth irrigation channels with a high rate of silt and filtration (seepage into the ground), rather than lined or piped channels, accelerates the degradation of lands significantly. This situation is most aggravated in the lowers areas of Kumsangir district, i.e. towards floodplain of Pyandzh River. For example, in the Emam-Ahmadova collective farm, 280 hectare of the land is affected by the process of salinization while 400 ha in Hasanov farm and 380 ha in Eshhanova.

Fig. 6 Scheme of irrigation network in the collective farms of Kumsangir district

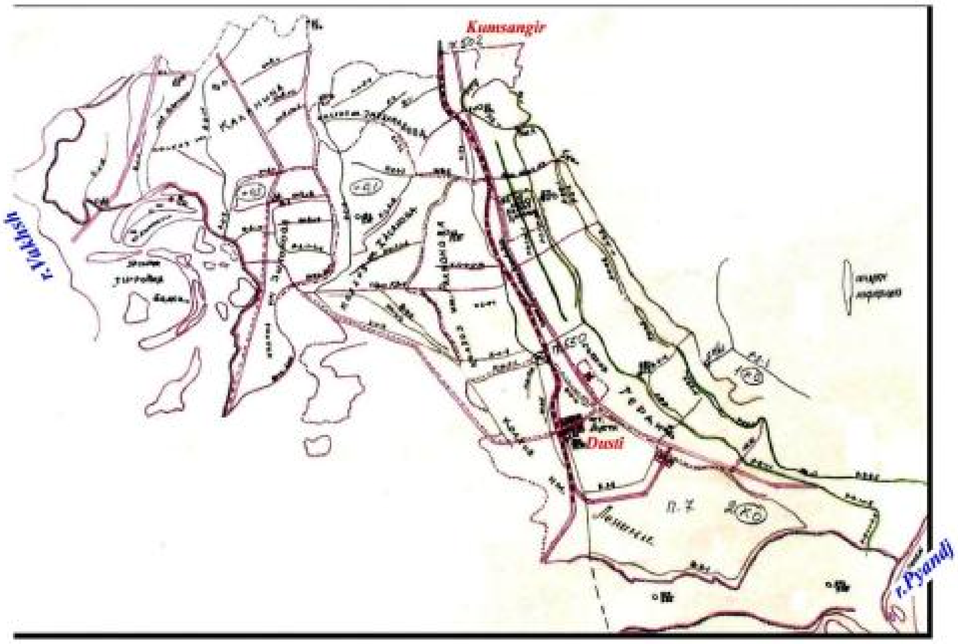


Fig.7 General view of Kumsangir canal (right bank of AmuDarya)

Due to the high salinization of soils and rising of water table, the majority of lands in these three farms have been gradually removed from cultivation of traditional agricultural crops. Data on salinity of soils and surface water from various sources (open canal, drinking water and collector-drainage water) indicates an increase in the salinity levels of collector-drainage water. A positive correlation exists between the water table levels and the spread of salinization over different irrigated lands.

The worst land is seen in Hasanov, Emam-Ahmadova and Eshhanova collective farms, while the best soil conditions with a low level of salinization is demonstrated in the Lenin farm. Many fields of this collective farm, however, being located far from main water source (Kumsangir canal), have fallen out of use because the almost dilapidated irrigation systems are no longer able to deliver water. Cotton fields on these sites suffer for shortage of water. Instead of 6-8 times of watering during the cotton growing season water is allocated only for 2-3 times. As a result, seen in Fig. 8, the cotton fields have been occupied by stunted and underdeveloped plants.

The total yield of cotton from such areas does not exceed 0.10 ton per hectare in average of productivity, in a range of 0.25.0-0.27.0 t/ha. Lack of access to pumped water and a shortage of sprinkling water are also observed in the neighboring 300 hectares of lands of Rahmonova collective farm. Self-flowing irrigated lands of these two farms heavily depend on water pumping systems that are either inoperative or poorly performing, except for the still functioning pumped irrigation station No. 6 in the territory of Rahmonova collective farm. This pumping system lifts water from main Kumsangir canal up to the fields through a succession of staged pump stations (Fig. 9).

Fig.8 Stunted and low Cotton fields growing plants, resulted from water shortage

The ideal tool for urgent rehabilitation and further agricultural reclamation of lands in Lenin state farm seems to be the introduction of new water allocation technologies and farming systems. Subsurface drip irrigation (SDI) will be potentially applicable for high fertility of soils with a low degree or absence of salinity, and deep water tables (Fuchinoue et al., 2002). SDI could play a crucial role in efforts to redress Tajikistan's food deficit. In addition, these sites are supplied with a well-developed sprinkling network, electric power and human resources that together can support the promotion of subsurface drip irrigation (SDI) in the upper part of Pyandzh River

Fig. 9 Water pumping station at Kumsangir (partly functioning)

Even this gravity irrigation scheme, however, requires high levels of electricity and know-how compared with gravity-fed irrigation. But only a few farmers can afford the new electricity tariffs required to pay for these infrastructures, and many of top engineers and technicians who used to service these systems left to highly paid jobs.

We found that the pH value and salinity of water collected from Pyandzh and Vakhsh rivers is significantly different from similar parameters of water samples taken from collector-drainage channels.

It was demonstrated that the mineralization of collector-drainage water changes from 0.001 up to 0.1 %, while the salinity level of water in the territory of Eshhanova farm is in the range of 0.3-0.6%. Poor management of collector-drainage networks and limited drainage infrastructures, as well as the lack of well-timed clearing (from thickets of Phragmites and different plants) or de-silting work could be one of the main reasons for a rapid decrease of sown irrigated land in Tajikistan in the near future (Fig. 10, 11).

There are many artificial lakes in the southwest part of Kumsangir district on the territory of Biosphere reserve “Tygrovaya Balka”, but the majority of nearby lands of Koradum settlement located around this reserve are not completely irrigated. The construction of lift pumping stations from Vakhsh River for water supply of the Koradum virgin lands is labored because of transit of water pipes or canals through the Reserve territory.

Fig.10 Drainage without canal cleaning at Eshhanov's collective farm

(measurement of water quality).

Fig. 11 A view of the drainage system commonly seen in Kumsangir district

6. Subsurface drip irrigation

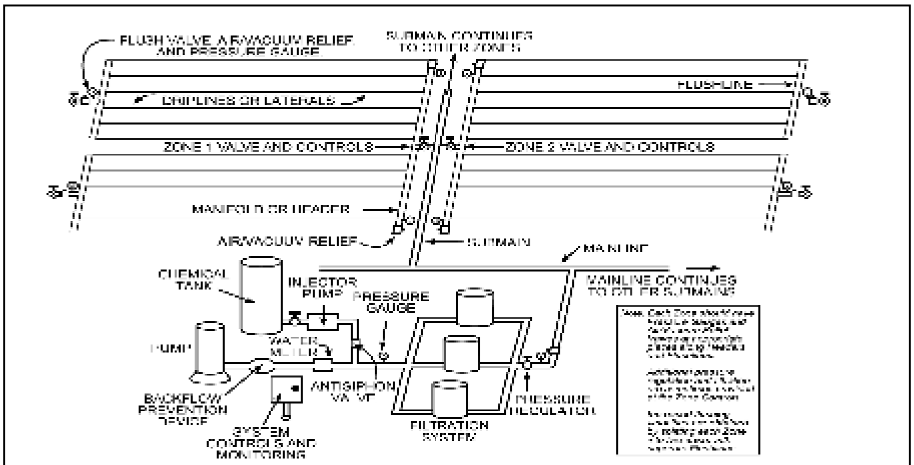
Subsurface drip irrigation (SDI) is a low-pressure irrigation system that uses polyethylene drip lines that are permanently buried below the soil surface. SDI is the slow, frequent application of small amounts of water to the soil through driplines located beneath the soil surface. SDI does not use unnecessary water evaporation into the atmosphere and does not use underground water that contains salt and cause of desertification. SDI allows for highly productive crop production without leaching or runoff. Only the amount of water needed by the crop on a daily, or other very frequent basis need be diverted from a stream or reservoir, thus helping to also protect water quality.

Water drips to the surrounding soil through built-in emitters. Unlike other irrigation systems, subsurface drip applies water directly to the crop root zone using buried polyethylene drip tapes that come in various diameters and thicknesses. The smaller diameter tapes are used for short length. As the run length increases, larger diameter tapes are needed. The thickness of the tape wall is directly related to its durability. Thin tapes are mainly used for temporary installations such as surface drip irrigation of high value crops. The thicker tapes are used for permanent installations. The cost of the tape is directly related to both diameter and thickness.

Small holes called emitters are spaced every 8 to 24 inches along the length of the drip tape. When the tape is pressurized, water passes through the emitters to the soil, drop by drop. The movement and wetting pattern will depend on physical characteristics of the soil. For instance, in a heavy soil water will tend to move laterally and upward to a greater degree compared to a sandy soil where it tends to move downward. The amount of water that can be delivered through the system depends on tape diameter and spacing, operating pressure, and emitter spacing, size, and design. We can choose from a variety of tapes to fit specific design requirements. SDI places water directly into the root zone of the crop that increases water use efficiency, provides water & nutrients to plants while maintaining a dry soil surface. Drippers are positioned within the soils to conserve water, control weeds, increase longevity of laterals & emitters, ease use of heavy equipment in the field, prevent human contact with low-quality water, and save extensive labor (lay-out & retrieving). Driplines are injected 7 – 30 cm below the soil surface. It is sometimes found as deep as 100 cm. The water contains fertilizer depending on soil hydraulic properties, dripper characteristics, inlet pressure, outlet-soil interface geometry & size, and root uptake.

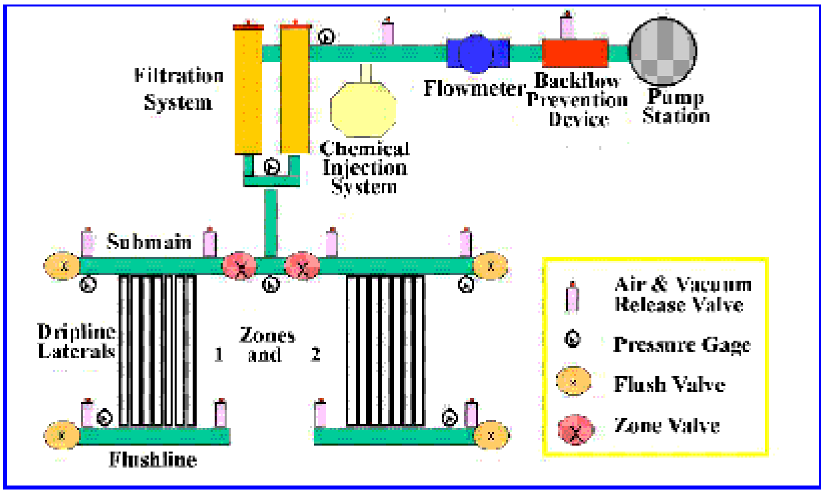
Desired wetting patterns are obtained by manipulating drips. Length of laterals, drippers and emitters space will be determined according the crops and vegetable, topography, land aridity, and water salinity and its accessibility. Before determining them, we may have to investigate into the conditions of land as well as satellite that use NDVI, as well as to enforce the pilot plant. Extremely important for agricultural utilization is the prevention of surfacing the waste water, especially in an arid land. Root distribution can be influenced by irrigation regime and by emitter placement. SDI is a tool for alleviating problems of health hazards, odor, contamination of ground water, runoff into surface water, while it is a unique opportunity to manipulate root distribution and soil conditions in order to better manage environmental variables: nutrients, salinity, oxygen, and temperature. Recent efforts attempt to come even closer to matching of water & fertilizer application to actual plant consumption through very high frequency of pulsed irrigation events or by extended application over time at low flow rates.

Figure 12 Schematic of a basic microirrigation system



Credt to Kansas State University

Fig. 13 Schematic of subsurface drip irrigation (SDI) system



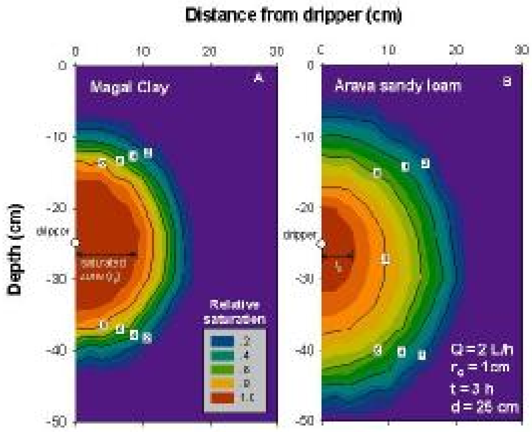
Credit to Kansas State University

High frequency irrigation positively affects water use & yield. The place where the wind is strong that is called desert sandy storm, has been proposed to protect so that a properly designed tree windbreak or shelterbelt provides protection for livestock, crops and farmsteads. A windbreak can also mean significant energy savings for heating a rural residence.

40% of the world's vegetable crops are grown under SDI (mostly under shallow injection). Table 9 shows the variety of crops harvested by SDI. Crops & countries in which SDI is common practice.

Figure 14 Structure of drippers

Figure 15 Soil moisture under the ground



Soil moisture (as relative saturation) distribution for 2 soils under SDI by Hydrus-2d

Q = dripper flow rate
r0 = cavity radius
t = time
D = depth
rs = saturated radius

Main advantages are as follows.

Water saving advantages: Improved efficiency of water usage due to lower rates of evaporation and run-off from soil surface.

Environmental advantages: In-soil disposal of wastewater from municipalities by their re-use for irrigation of forests, gardens and agricultural crops. Prevention of sanitary problems & odors is one of the requirements in the re-use of wastewater for agricultural crops. SDI is recognized as one of the conditions for approving wastewater use for irrigation of agricultural crops and public landscaping. Use of SDI enables utilization of recycled water for a wide variety of crops. It reduces leaching of chemicals to the ground water. Dry soil surface reduces soil diseases.

Table 9 World's vegetable crops

Shallow Injection Depth of 5 to 10 cm	Regular Injection depth of 25 cm	Deep Injection Depth of 30 to 45 cm
Carrots	Sugar cane	Cotton
Onion	Herbs	Corn (Maize)
Potatoes	Pineapple	Sunflower
Yams	Eggplants	Industrial tomatoes
Spinach	Pepper	Beet root
Strawberries	Paprika	Alfalfa
Garlic	Cauliflower	Melons
Peanuts (Groundnuts)	Cucumbers	Watermelon
Lettuce	Celery	Asparagus
Industrial tomatoes	Okra	Coriander
Various vegetables	Sugar beet	Tobacco
	Beans	Soya

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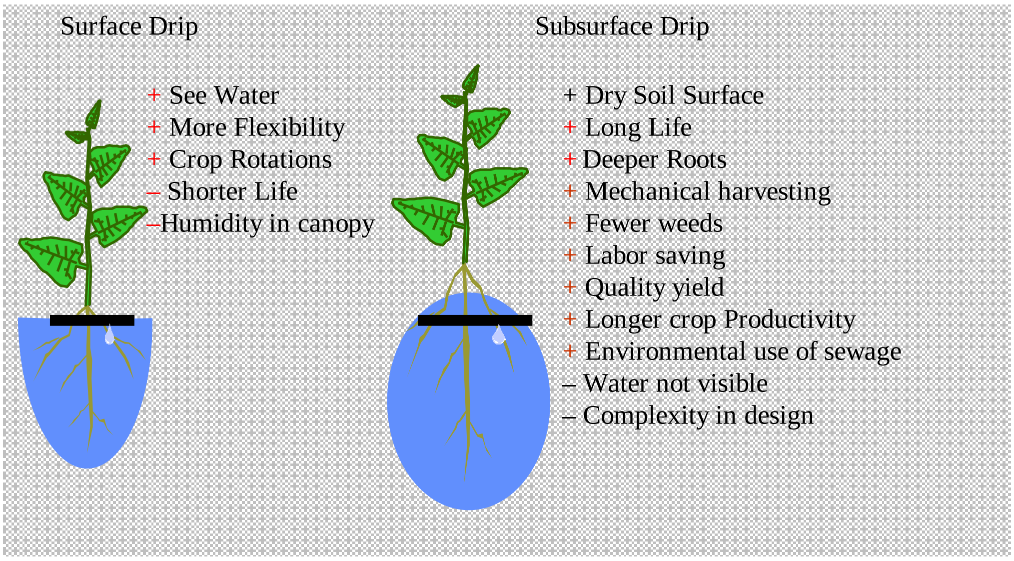
Figure 16 Benefits of subsurface drip Irrigation



Technical advantages: Prevention of damage to irrigation equipment caused by machinery during cultivation and harvesting. It prevents equipments and land from damage caused by animals & birds. Movement of agricultural vehicles and machines minimize soil compaction along the rows. At the end of each season there is no need to lay-out, retrieve and re-connect the irrigation system. Irrigation of grazing land will be protected without causing obstructions (unlike sprinkling or flooding).

Any technology has some disadvantages that should be solved in future. Difficulty in repairing drip lines once injected into the soil. Detection of drip line location is also one of the disadvantages. Use of SDI must take in consideration potential re-emergence of salts in soil's upper layers. These must be leached back into the deeper soil layers. Root thickening or migration of stones may cause pinching ("choking") of drip lines.

There must be more things to discuss.

Water savings: How much water can be saved by switching to subsurface drip irrigation? Furrow irrigation efficiency is usually 65% or less. Assuming that the net seasonal irrigation requirement for corn is 15 inches (taking into account water inputs from rainfall and residual soil moisture), the furrow system would need to apply 23 inches while the subsurface drip system would need to apply 16 inches, a savings of 7 inches

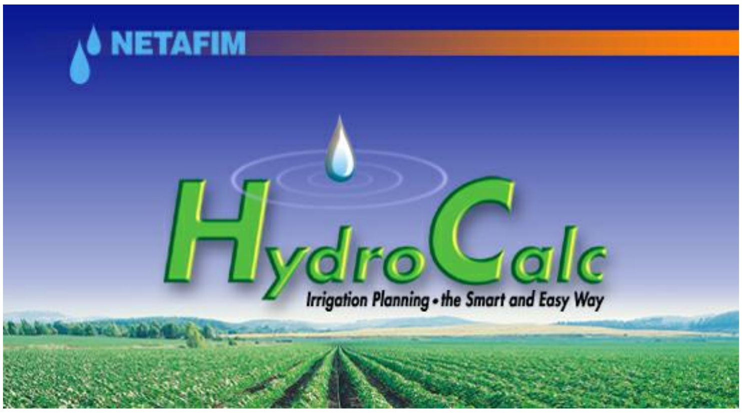
Energy savings: Energy savings is another advantage of this irrigation method. Subsurface drip irrigation systems operate at low pressure and deliver small flow rates. Emitters usually require a pressure of 4 to 15 psi and flow rates of 0.16 to 1 gallon per hour. Less energy is required to achieve the low water pressure and a smaller pump than those used for either center pivot or furrow irrigation is needed to achieve the small flow rate.

Cost: Subsurface drip irrigation could be a good alternative for small, odd-shaped fields, especially when irrigation water is limited. Future cost-share programs may make subsurface drip irrigation more economical as the need to save water increases and as concerns about the environmental impacts of irrigation becomes more important. Lamm compared the advantages and disadvantages of subsurface drip irrigation (SDI) as to alternative irrigation systems are conceptually discussed. Each category (advantages and disadvantages) is subdivided into three groups: 1) Water and soil issues; 2) Cropping and cultural practices, and 3) System infrastructure issues

The use of HydroCalc (http://www.netafim.com/index.php3?page=1&stId=447) allows the designer, dealer or end-user to evaluate the performance of micro irrigation in-field components, such as:

Main lines (PVC, PE, etc.)	Sub mains and manifolds
Drip laterals and micro sprinklers	Valves

Fig. 17 Cover of HydroCalc



Download the HydroCalc and run it for the daily tasks, as a matter of course, requires small computer. Those who manage SDI should be trained not only in agriculture but also in computer manipulation. The computer itself operate by solar energy and does not need any electricity network.

Canyon County Extension Educator Jerry Neufeld from University of Idaho concludes that some of the most advanced irrigation technology is subsurface drip irrigation (SDI). SDI is the slow, frequent application of small amounts of water to the soil through emitters located on a delivery line placed beneath the soil surface.

SDI allows for highly productive crop production without leaching or runoff. Only the amount of water needed by the crop on a daily, or other very frequent basis need be diverted from a stream or reservoir, thus helping to also protect water quality. Gravity irrigation is one of the most common irrigation methods currently being used in the Treasure Valley. Problems with gravity irrigation systems that can be substantially reduced with SDI include erosion within the field, loss of nutrients and sediment from the field to drains or streams, washing of bacteria from fields into runoff water, and deep percolation of water and dissolved chemicals toward ground water. Runoff water from gravity irrigation is often enriched in sediment and phosphate. The incremental amount of water added at surface irrigation is usually large compared to sprinkler or low-flow systems, so the risk of leaching of nitrate is greater with gravity irrigation. Some of the benefits of SDI which have been identified by researchers are:

§ Increased water use efficiency
§ Reduced water percolation through the root zone
§ Reduced runoff from the tail end of a field
§ Reduced evaporation from the soil surface
§ Increased water distribution uniformity throughout a field
§ Reduced energy usage
§ Reduction of moisture stress to plants because of frequent irrigation resulting in an increase in crop quality

Water Use Efficiency (WUE) is defined as crop yield per unit of applied water. In a SDI study conducted on cotton, it was found that out of eight irrigation methods SDI had the highest WUE. Lamm et al. (1992) conducted a SDI study on field corn and found that maximum yields were achieved at 75 percent of evapotranspiration (ET). ET is the combined loss of water by evaporation from the soil surface and by transpiration from the plant's leaf surfaces. In another study, it was found that yields of tomatoes were nearly doubled over conventional irrigation methods when SDI and proper fertilization practices were followed. On a clay loam soil with drip tubes placed .45 meters below the soil surface, the data indicate that except for directly beneath the drip tubes the direction of the soil hydraulic gradient is upward. In other words, soil water remains in the root zone for utilization by growing plants, not lost to deep percolation. In a study conducted on alfalfa, soil water data suggest little or no potential for deep percolation losses. Additionally, it was found that after 3 years of raising tomatoes (high users of nitrogen fertilizers) and cantaloupes, some accumulation of nitrate-nitrogen occurred at the soil surface. Only a small amount leached below the root zone. Since soil water remains in the root zone groundwater contamination and runoff from non-point sources containing agricultural contaminants is reduced if not eliminated entirely.

Studies have been conducted in Nevada to determine the amount of water needed to produce a ton of alfalfa hay. Jensen and Miller (1988) conducted a study near Wadsworth, Nevada during the 1984 and 1985 growing seasons. Their work indicates it takes from 6.1 to 8.4 inches of water to produce a ton of alfalfa. Unpublished work in Nevada in 1997 and 1998 with a three acre SDI system showed it can take as little as 1.94 to 2.33 inches of water to produce a ton of alfalfa hay.. Unfortunately, they were not monitoring the amount of water used to produce these yields. I am currently undertaking a collaborative project funded by the Idaho Alfalfa and Clover Seed Commission, the U.S. Bureau of Reclamation, and Netafim Irrigation Company in which eight acres of alfalfa seed is being irrigated on a Caldwell, Idaho farm with a SDI system. The main items being investigated in this project are yield, water use, and soil moisture status. In addition, Oregon is conducting work to determine the optimum amount of water needed to produce a pound of alfalfa seed with a SDI system.

There are many opportunities for SDI in the Pacific Northwest, but the technology has not yet been adapted to its fullest potential. For Idaho's irrigated crop acreage in 1998 (4,104,600 acres), gravity irrigation was utilized on 38.3%, sprinkler irrigation was used on 61.5%, and low flow systems (all types of drip and micro sprinkler systems) accounted for only 0.2%. For Oregon’s irrigated crop acreage in 1998 (1,833,000 acres), gravity irrigation was utilized on 46.6%, sprinkler irrigation systems of all types were used on 52.4%, and low-flow systems accounted for only 1.0%. The 1997 Census of Agriculture reports lower total irrigated acres with similarly low proportions of drip-irrigated crops. Given the economic importance of the many high value seed crops in southwest Idaho, the need to increase irrigation efficiency, and increasing environmental concerns, SDI needs further research and demonstration as a possible irrigation alternative for our producers.

7. The Educational Element Family Drip System (FDS)

– Drip Irrigation System for Small Holders.

Netafim's agronomic R&D Dept. has put great effort into developing a user-friendly irrigation system that will fulfill the needs of family farm owners who are unable to attain advanced systems that require electricity, pumps, automatic filters, etc., but will allow the farmer the same advantages as a sophisticated irrigation system:

- Higher yields, better quality, efficient water and fertilizer management.
- The results received with the Family system have proven its reliability, strength and flexibility.
- The uniform water distribution has resulted in immeasurably higher yields than with traditional irrigation methods (flooding, furrows).

The FDS is used for irrigation of small plots, backyard gardens, etc. FDS is used for irrigation of vegetables, orchards, fruit trees, row crops and greenhouses. The FDS, being gravity-based, does not require any energy source for its operation. FDS is suitable for all types of soils, climates and water sources. FDS is suitable for use in flat land or slight slopes. Unlike other irrigation systems, subsurface drip applies water directly to the crop root zone using buried polyethylene drip tapes that come in various diameters and thicknesses.

The smaller diameter tapes are used for short lengths. As the run length increases, larger diameter tapes are needed. The thickness of the tape wall is directly related to its durability. Thin tapes are mainly used for temporary installations such as surface drip irrigation of high value crops. The thicker tapes are used for permanent installations. The cost of the tape is directly related to both diameter and thickness. One of the main advantages of subsurface drip irrigation is that it has the potential to be the most efficient irrigation method available today. The word potential should be stressed because irrigation efficiency not only depends on the type of irrigation system, but also on its design and management.

8. Discussion and recommendations

8-1 Future Challenges for Regional Agriculture Development

The collapse of Soviet Union and the subsequent civil war have forced a large part of Tajik population to remain dependent on agriculture as the main sector of food and income. However, agricultural activities are hampered by scarce availability of productive land, limited agricultural inputs and dilapidated machinery and irrigation infrastructure. The situation has been also aggravated by two consecutive years of drought in 2000 and 2001, which farther limited households' access to food.

Lack of government funds had also left rural settlements without adequate domestic water-supply systems, as a result of which only one-fifth of the population had access to safe drinking water. That had led to a high incidence of typhoid and hepatitis in rural areas. Serious waterborne-disease outbreaks have occurred in every region of the country since 1991- a phenomenon which had substantially reduced the earning capacities of rural families, and thereby contributed to high poverty levels.

With poverty levels estimated at 83 percent, efforts to address poverty should focus on rural areas, where livelihoods rely heavily on agriculture, it added. Tajikistan had decontrolled agricultural prices, abolished mandatory crop sales to the government and transferred state and collective farms to private management and that serious impediment remained for the rural economy.

The long-term reconstruction and rehabilitation of domestic agriculture in the upper stream of AmuDarya river basin, especially Afghanistan and Tajikistan is critical for the resolution. Actually, several rehabilitation plans are ongoing. The United Nations Food and Agriculture Organization (FAO) have distributed 1,500 tons of wheat seed to approximately 30,000 families in rural areas of northern Afghanistan. According to the special report of FAO cereal imports totaling of 784,000 tones were required for the marketing year 2000/01 in Tajikistan, especially for those people living in remote border areas and mountainous regions. USAID/CAR takes advantage of several centrally managed programs, including the agreement with the Centers for Disease Control and the Monitoring and Evaluation to Use and Assess Results (MEASURE)/Evaluation Program. New initiatives include broader community development, an irrigation management pilot, micro-credit training and legislation. The Office of Foreign Disaster Assistance has given disaster grants and has had a presence in Tajikistan since October 2001. The Farmer-to-Farmer program, managed by USAID/Washington, is also active. The Eurasia Foundation has a modest small grants program in education, small business and civil society. The Departments of Defense, Agriculture (food aid), and State also manage programs complementary to USAID field activities in various sectors. WFP is also set to shift the focus of its operations from relief to rehabilitation and reconstruction of the country.

The World Bank is Tajikistan's largest donor, providing loans in health reform and private sector development. The second biggest bilateral donor is Japan, which provides assistance for rehabilitation of the agricultural sector, and food security and poverty reduction programs through international NGOs, many of which are also partners of USAID. The European Union supports a number of humanitarian programs through the European Commission Humanitarian Office (ECHO). Other bilateral donors include Switzerland, Germany and the United Kingdom. Multilateral donors include the Asian Development Bank (social service sector rehabilitation, transportation, irrigation, hydroelectric generation) and the European Bank for Reconstruction and Development (telecommunications and airport navigation). A technical assistance grant of US $600,000 is being prepared by the Asian Development Bank (ADB) to develop and repair irrigation facilities in order to help poor farmers in Tajikistan. A loan of about $20 million would cover between 60,000 and 80,000 ha, or about 10 percent of the country's irrigation command area adding that twofold project goals envisaged the prevention of operational failures of key irrigation facilities, as well as capacity-building for local government and farmers to run the water systems on a sustainable basis.

Agricultural development using Subsurface Drip Irrigation (SDI) for crops cultivation both on the Left Bank (Afghanistan) and Right Bank of AmuDarya is what we suggest. Our proposal is to build permanent food production systems on dry lands of all riparian countries that will not only help to feed local people, but also will provide them with jobs. The objective is to improve farm diet diversity and income generation through the introduction of alternative seed crops into the existing crop rotation, for family consumption, market sale and possible use as animal feed. Special attention will be paid to assessing the comparative advantages and drought resistance crops.

Subsurface drip irrigation can be considered as a unique opportunity to manipulate root distribution and soils conditions in order to better manage environmental variables, such as nutrients, salinity, temperature etc. In addition subsurface drip irrigation provides water and nutrients to plants while maintaining a dry soil surface. There are a lot of advantages for the subsurface irrigation use system in the region. For example soils conservation advantages includes prevention of run-off; efficient water penetration into the soil; suitability for use both in flat lands and on slight slopes, unlike other irrigation methods. SDI is recognized as one of the conditions for approving wastewater use for irrigation of agricultural crops and public landscaping. Use of the SDI enables utilization of recycled water for a wide variety of crop, simultaneously reduces leaching of chemicals to the ground water and reduces soil diseases.

Subsurface drip irrigation technology increases yield (usually more than 20%). It decreases water intake to 1.3-1.5 times less than that of furrow irrigation. It decreases evaporation that disturbs the treatment of soils under irrigation area. It can simplify the treatment of plants. It increases the efficiency of water-soluble fertilizer and oversimplifies its drilled fertilizing. The seasonal watering is automatically and easily controlled. The subsurface irrigation technology allows for control of the soil aerial-moisture regime. Long-term use of polyethylene pipes would save maintenance costs. Besides this type is a sustainable and technically viable irrigation method that can be applied for farming crop cultivation of steep slopes (>0.05m) to prevent soils and water erosions. Inter-row non-wetted space can be used for vegetable crop growing that will eliminate common negative local farmer's perception on vine production under drip irrigation. As normally they cannot generate any income during first 3-4 years of grapes growing. Using this technology, during first year's farmers will be able to benefit from producing vegetable and melon. These are examples of advantages for the subsurface irrigation system.

Disadvantages of subsurface irrigation system in all riparian states would be still high cost for construction and installation, as well as difficulty in repairing drip lines once injected into the soil. Insufficient moistening of upper soil layer sometimes deteriorates the germination and growth of seedlings, especially in the early stage of plant ontogenesis. Use of SDI must take also in consideration potential re-emergence of salts in soil's upper layers that must gradually be leached back into the deeper soil layers. Pinching of drip lines by root thickening or migration of stones could be considered as disadvantages of SDI promotion.

Despite of above indicated disadvantages today SDI is a common practice in USA, China and Australia (cotton), Mexico (nuts crops), Central America (sugar cane) USA, Israel (vegetables). Subsurface irrigation for gardening improvement is largely use in Spain, France, Greece, fodder and hay making from various crops are well developed in India, China and other Asian countries. As shown by Netafim (A.C.S.) Ltd., About 40% of the worlds' vegetable crops are grown under SDI.

In this regard as particular case we propose to start with small investment to:

1 - repair and improve the irrigation and drainage systems on the territory of Hasanov, Emmahmadov, Rahmanov and Eshhanov collective farms covering a total area of 3,320hectares.

2. - develop and use SDI (subsurface drip irrigation) in the self-flowing irrigated zone of Lenin collective farm, on an area of 250 hectares and in the territory of Hasanov farm in the vicinity of the lift pumped station Nr 6, on an area of 180 hectares.

Use of the Subsurface Drip Irrigation technologies for the land reclamation in these collective farms in Tajikistan would ultimately make the water supply of the Kumsangir district less dependent on the Pyandzh River use.

8-2. Opportunities by Improving Water Resources Management

Current difficulties in the water sector stem largely from the dependence of areas on transnational water sources – that of the AmuDarya river in the south and SyrDarya river in the north, and in turn, on downstream countries (Uzbekistan, Turkmenistan and Kazakhstan) water demands.

There are several problems associated with water management in Tajikistan rouging from economic to social and from domestic to international levels. The major difficulties indicated mostly by experts include: pollution and overuse of water resulting from supply-driven water consumption and the almost luck of crop rotation; weakening of water user's organizations (WUOs), lack of investment into irrigation sector and rehabilitation of irrigation infrastructure and finally, poor cooperation with downstream riparian countries.

Unsatisfactory monitoring system that is still functioning in the region means lack of common unified methods of water sampling, standards and criteria of assessment, classification of water from consuming point of view and ecological functions. All these things don't allow giving an adequate assessment of water quality, though it is the first and most important step in pointing out the problem, demands and measure planning. There is no united standard-legal basis and much more economic mechanisms are imperfect.

Besides there is no common database about pollution and their sources, registration of water facilities, water distribution among countries is occurred without taking into account water quality.

Technical solutions in terms of both agricultural technologies involvement and water infrastructure reconstruction for water consumption and preservation are crucial needed. To improve current relations between the all Central Asian riparian countries it is also important to work out a uniform water strategy for the Amudarya/Syrdarya River Basins based on acknowledging the interest of every state in water resources development, protection and use. The establishment of an adequate legal framework work is essential for the development of water sector. In amending its legislation, these riparian countries should aim of full compliance with the Helsinki Convention on the Protection and use of Transboundary Watercourses and International Lakes, which in adopted in 2001.

Further steps needed in the irrigation management transfer strategy include: upgrading the water management legislation administrative measures its implications for the districts in irrigation water management, as well as administrative reforms to redistribute responsibilities among the state water management bodies and empowering farmers and water user's organizations. Another important aspect involves the establishment of monitoring systems and reorganizing the governmental water management institutional makeup and increasing governmental and international donor investment.

As it should be expected, problem solution of water quality in the Central Asia would require investments into specific projects, and also help in management system reorganization of water quality. At present when production level was decreased temporarily, this period is the most suitable for working out regional reliable juridical, economic and other laws, programs, rules and mechanisms to prevent water pollution by industrial waste and sewage. Special attention should be given to system water use change in industry, introduction of ecologically pure technologies, reduction of water consumption volumes, and sewage treatment efficiency.

Main investments should be directed to purchase of equipment, development of infrastructure and restoration of control system for pollution sources (waste, sewage etc.). In spite of detailed information lack, analysis conducted up today proves that industry; national economy and waste accumulators are responsible for quality water deterioration and water ecosystem degradation as a whole. The provision of life support facilities including clean water for the people in the all region of Amudarya River Basin should be a priority in water resources allocation.

The provision of information is another key element in the irrigation management transfer strategy in the AmuDarya River basin. Water users' organizations (WUOs) are a new concept in the area and almost all of them are characterized by lacking of relevant experience and information. Therefore training in managerial, financial and conflict resolution skills is important to establish WUOs as genuine bottom-up institutions. Non-governmental organizations can play a crucial role with regard to providing information and education for farmers.

In our opinion the following measures are necessary for successful introduction of the political agreements in water resources use and management between Central Asian Basin states:

development of normative-legal base of rational water use;
conclusion of bi- and multilateral treaties and agreements on rational use of transboundary water resources;
elaboration and application of water save technologies and modern irrigation methods and water transportation;
river bank strengthening works and liquidation of flood, mud-floods and river banks degradation consequences;
inspection-control raids to find poachers of water use regime and apply the proper fine sanctions;
adoption of agreements on optimal water distribution among all countries of the basin for rational management of the Aral water resources. Agreed and reliable models of water resources management based on mass balance rules and worked in real time scale are necessary means, and also approved database;
open exchange of the data on rivers, lakes, reservoirs and group waters of the basin;
measures on provision of effective utilization of deficit water resources

arrangement of water consumption standards for irrigation, hydro-energetic, water losses registration;

The operation will also fund a series of rapid impact programs designed to reconstruct basic infrastructures such as irrigation systems. Nevertheless, these irrigation systems require much water from watercourses including AmuDarya and its tributaries such as the Kunduz River (in Afghanistan); the Pyandzh and the Vakhsh Rivers (in Tajikistan). Therefore Afghanistan should participate in any interstate agreement for trans-boundary water resources of AmuDarya. Otherwise conflicts between Afghanistan and the Central Asian Republics may occur. In the worst case, these conflicts might bring another tragedy to Afghanistan. So, it is inevitable to arrange the interstate coordination for trans-boundary water use among all riparian states before the rehabilitation plan for Afghan Agriculture and irrigation systems is promoted.

We believe Afghanistan should be integrated within the framework of AmuDarya Basin water resources agreement to avoid inter-state water conflicts and to provide a stable and reasonable political climate for further reconstruction efforts in the region.

Thus, the commitment, equal participation and open dialogue in all riparian countries, including Afghanistan, will promote human security and stability in the region. We (scientists, policy markers, governmental and non governmental leaders, farmers etc.) must share responsibility and take measures in order to prevent serious water shortages in the Aral Sea Basin in the coming decades.

This execution will save the water usage in Tajikistan produced in Pamir and flowing into AmuDarya. It will provide the unpolluted water resources both in north Afghanistan (left bank) and Kyzylkum desert including Zerafshan and Surkhandarya basins (right bank). It is not a mere silly dream to save Aral Sea.

9. Participants

The main participants of the expedition were the following people:

Munimjan Abbdusamatov – Chief of Specialized Inspection of the State Control on Water Use and Preservation of Water Resources, Ministry of Nature Protection of the Republic of Tajikistan; member of the Engineering Academy of the Republic of Tajikistan.

Kristina Toderich – Dr., Department of Desert Ecology and Water Resources Research, Samarkand Division of Academy of Sciences of the Republic of Uzbekistan.

Abdulatif Rahimulloi -Third Secretary of the Embassy of Afghanistan in the Republic of Tajikistan.

Marziya Nasredinshoeva - Deputy Director of the Tajik Branch of the Regional Center of Ecology of Central Asia.

Timur Khujanazarov – M.Sc, Tashkent State Technical University.

The following Tajik authorities also got involved in the field expedition work and played a role in some way or another in its completion:

Musayabsho Nazriev – Chairman of Kumsangir district.
Nuriddin Sadridinov- Chief, Department for Reconstruction and Management of Irrigation System of Kumsangir district.
Zainullo Kadirov – Chief Engineer, Department for Reconstruction and Management of Irrigation System of Kumsangir district

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Text was prepared by Kristina Toderich, Tsuneo Tsukatani, Munimjan Abbdusamatov, and Timur Khujanazarov. Timur Khujanazarov, MSc of Tashkent State Technical University, provided the photographs.

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