Sustainable Irrigated Agricultural Production of Countries in economic Transition: Challenges and Opportunities (A case study of Uzbekistan, Central Asia)

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ABSTRACT (100-400 words):

For the fulfillment of the thirsty ambition of self-sufficiency of the Soviets for cotton production, the arid Central Asian region and in particular Uzbekistan has been extensively exploited. In fact, vast tracts of deserts have been converted into irrigated agricultural lands without proper consideration to environment and technical standards. As a result trends in natural resource degradation (soil salinity, desertification, water quality) as well as declining crop yields have dramatically increased.

The agricultural sector is the backbone for employment, food security and export revenues of the Central Asian countries. Since the independence of the Central Asian countries (after the breakup of the former Soviet Union) the situation has changed dramatically in terms of institutional, political and technical systems. Political transition, which is defined as a shift from once planned centralized economy to a market-driven one, has introduced ‘new’ concepts like land tenure, water rights and different kinds of ownership. All of such transformations have impacted the agricultural production in Central Asia.

The institutional change can be described as decentralization of the farming systems i.e., transition from the former state collective farms into the smaller forms of private farms. The institutional interventions are aimed to increase agricultural production through improving water management. It is arguable that private production systems are the most effective business driven forces but the situation is quite different in Central Asia due to the irrigated agriculture.

The biggest challenge for a sustainable irrigated agricultural production lies in the recent reforms of water management sector in Central Asia and Uzbekistan. The water users associations have been established for replacing the former collective farming systems for irrigation water distribution and maintenance of irrigation infrastructures at on-farm level. The intention of the national government was to shift the operation, maintenance and management of irrigation infrastructures to non government institutions (decentralization). However, these institutions have not fulfilled their promising tasks because of i) a rapid increase of number of private farms along canals; ii) the cropping structure is mosaic with different crop water requirements against the former monoculture; iii) a poor financial, trained and technical capacities of new established institutions; iv) a state ordered agricultural production quota system (for cotton and wheat).

This paper analyzes the historical aspects of transformation in the farming production institutions in Central Asia with special focus on Uzbekistan and comprehensively overviews the main current challenges facing the farming system and potential opportunities for reversing the situation.

KEYWORDS: irrigated agriculture; water users associations; agricultural water management; soil and water pollution, cotton production; Central Asia

1. INTRODUCTION

After the fundamental and extremely fast political transformation of the Central Asian (CA) region (collapse of the Former Soviet Union and emergence of National States), the land-locked arid countries of Central Asia (Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan and Turkmenistan) have directed their natural resources utilization for the economic development from a previously central-planned economic system to market-oriented one. Once interconnected branches of economies in Central Asia have become fragmented and collapsed (UNEP, 2005). Many thousands of jobs have been abolished. Business and industry sectors with rich oil and gas reserves have shown their flexibility under a new transformation process but the most impacted was agriculture.

In this hard period, agriculture has played a vital role for absorbing employment of rural populations. Kandiyoti (1999) describes the agricultural sector as being a "shock absorber" for surplus of rural labor. In fact in the CA region the agriculture employs about 45% of the total population and its share in GDP (Gross National Product) is 24% on average (FAO, 2009). Some 22 million people depend directly or indirectly on irrigated agriculture in these countries (World Bank, 2003). Besides, the export of cotton contributes to significant foreign cash revenues for Tajikistan, Turkmenistan and Uzbekistan. Sustainability of irrigated agriculture is one of the main platforms for food security, employment, livelihoods and environment protection.

With the independence of CA countries the situation has changed dramatically in terms of institutional, political and technical systems (IAMO, 2008). Political transition from once a planned centralized economy to a market-driven one has introduced 'new' concepts like land tenure, water rights and different kinds of ownership. Institutional reforms have been implemented for arrangements of previously state owned collective farms into new private form of farming system. Ideally the de-centralization of farming systems should have created new opportunities for rural people. Indeed the fast privatization of agricultural lands has created thousands of workplaces with complete privatization of agricultural parcels in Kyrgyzstan and long-term leases in rest of other Central Asian states (Sehring, 2008).

The reform of agriculture was inevitable in the process of political and economic transformation. The private forms of farming system would be better off and contribute for agricultural production and as result tax returns for governments. The climatic conditions and limited water resources of the region impose to practice irrigated agriculture only which makes irrigation water supply and management the major factors limiting crop yields in the region (Ibragimov et al., 2007).

About 7.9 million ha of the total irrigated lands in Central Asia of which about half (4.2 million ha) is irrigated in Uzbekistan (World Bank, 2005). Over a period of 90 years (1913-2003) the areas under irrigation have increased by 3 times on average in the CA region, e.g., from 4.51 million ha in 1960 to 6.92 million ha in 1980 and to 7.85 million ha in 2000 (UNEP, 2005; Sattarov et al., 2006). This increase was due to a gigantic Soviet hydraulic program through the construction of dams, irrigation canals, pumping stations and various hydraulic facilities. This hydraulic infrastructure is considered as one of the most complex in the world (O'Hara, 2000; Ximing et al., 2000; UNDP, 2007).

Additionally there has been a general warming up in the CA countries on the order of 1–2^{0}C since the beginning of the 20th century that might have a strong potential impact on the regional temperatures and precipitation regime but also on natural ecosystems and agricultural crops (Lioubimtseva et al., 2005).

From a technical point of view the major bulk of hydraulic infrastructure (irrigation and drainage) are in poor conditions and government financial programs for the maintenance have been substantially reduced (UNESCO, 2000; Sokolov, 2006; UNDP, 2007).

The aim of this paper is to comprehensively review the two sets of problems that most impact the sustainability of irrigated agricultural production systems in Central Asia with special focus on Uzbekistan. The first set of problems is reforms in agricultural production systems (de-collectivization), i.e. transformation of former collective farming into current private farming systems. The second set of problems is the on-farm irrigation water distribution and infrastructure management by recently created local institutions such as the Water Users Associations (WUA).

Along with de-centralization in agriculture, water management system was also transformed in Uzbekistan at two levels (Abdullaev et al., 2008). In this paper we will deal with only irrigation water management on-farm level. The irrigation water management was transformed from once a territorial-based management to a hydrographic principle at the basin level. The second level is creation of WUA at on-farm level. A WUA is a self-managing group of farmers working together to operate and maintain their irrigation and drainage network (only inter-farm or on-farm level) to ensure fair and equitable water distribution and increase crop yields (Abdullaev et al., 2009; Kazbekov et al., 2009).

At the watershed level main irrigation water distribution management and hydraulic infrastructure was left for the government for operation and maintenance. At on-farm level (secondary and tertiary) irrigation canals were shifted to WUAs. However, these institutions have not fulfilled their promising tasks because of i) a rapid increase of the number of private farms instead of a few former collective ones along a single irrigation canal; ii) along a irrigation canal the cropping structure is a mosaic with different crop water requirements, irrigation regimes in comparison to the former monocultural cropping structure; iii) a poor financial, capacity building and technical capabilities of the new established institutions; iv) a state ordered agricultural production quota system (for cotton and wheat).

Last but not least there are environmental concerns such as land degradation (elevated land salinity and waterlogging) of irrigated lands. Poor incentives of farmers to preserve the irrigation water, physical deterioration of the irrigation and drainage networks exacerbate the sustainability of irrigated agriculture. As a result the crop yields have declined by 50 percent (UNESCO, 2000). The continued soil degradation would jeopardize the sustainability of irrigated agriculture and impact the livelihoods of million people.

2. UZBEKISTAN

Uzbekistan is located in the heart of Central Asia with a population over 27 million and borders with Kazakhstan in the north, Kyrgyzstan in the north-east, Tajikistan in the east, Afghanistan in the south and Turkmenistan in the south west (Figure1). Administratively, Uzbekistan is divided into 12 provinces (viloyat) and one autonomous Republic of Karakalpakstan. The deserts (Kara Kum and Kyzyl Kum) and plains (Turan and Ustyurt) stretch from south-east to north-west and constitute roughly 80% of the landscape, the mountain systems of western Tian Shan and Pamir Alay occupying the rest of its territory (Shultz, 1949; Irrigation of Uzbekistan, 1979).

The average monthly air temperature for January ranges from +3^{0}C in the south (Termez) to -8^{0}C in the north (Usyurt plateau) and in the summer temperatures can reach 45-49^{0}C. The average annual precipitation in the desert zone is less than 200 mm while in the piedmont and highland zones it can be of 400-800 mm with maximum of 2000 mm in the mountain areas (Goskompriroda of Uzbekistan, 2005; UNDP, 2007). The annual average evaporation is about 1600-2200 mm. Thus agricultural production is impossible without irrigation.

2.1. Water resources

With an annual rainfall of 100–300 mm and a mean evaporation of 1600-2200 mm, Uzbekistan has a continental climate of the dry mid-latitude desert, characterized by hot summers and cold winters (Shultz, 1949; FAO, 2009). Its climate is largely arid and its water resources are unevenly distributed both in space and time. There is a strong dependency on winter and spring rains and snowmelt from the Tian Shan and Pamir mountains. In fact these mountains are major contributors to the watersheds of the CA countries (World Bank, 2005; Hagg et al., 2007).

The streamflow is characterized by an extreme intra-annual variability and also unevenly spatially distributed (Rakhmatullaev et al., 2009). Two main river basins are found in Uzbekistan – the Amu Darya and the Syr Darya (Dukhovny, 2007). The transboundary rivers Amu Darya and Syr Darya satisfy 82% of the total water demand for irrigation, whereas only 18% of the same demand is satisfied by the internal Kashka Darya, Zerafshan and Surkhan Darya rivers in Uzbekistan (Figure 1) (Shultz, 1949; Nezlin et al., 2004). Uzbekistan heavily depends on transboundary sources of water and on average only 9.52km^3 of water resources are generated within the country whereas 94.8km^3 comes from outside (Statistics Committee of Uzbekistan, 2006; Rakhmatullaev et al., 2009).

2.2. Soils

The soils of Uzbekistan vary according to the latitude and altitude zones which in turn are associated with climatic conditions and vegetation cover (Figure2 and Table1). Due to climatic conditions and aridity about 14.6 million ha (32% of all soil types) are represented by desert type of soils (grey-brownish desert, sandy and takyr with its subtypes). These soils cannot be used for irrigation because of their inherited characteristics, available water resources for irrigation, salinization and harsh relief; they are instead mainly used for cattle breeding of camels and sheep (Talipov, 1992).

Saline soils (solonchak and subtypes) are distributed in Karakalpakstan and near the Aral Sea area, and occupy about 1.3 million of ha (3%) and prevail in the local depressions located in lowland plains, lake basins and between mountains (UNDP, 2007). With appropriate irrigation and drainage systems can be used for agriculture. Sands cover more than 12 million of ha (about 28% of the total surface) in Uzbekistan and are unsuitable for agriculture. About a total 63% of soils (out of total of 44.89 million of ha) in Uzbekistan cannot be used for irrigation due to their inherited soil characteristics, available irrigation and drainage facilities.

The hydromorphic soils (meadow, meadow-takyr and its subtypes) are distributed over 3.8 million ha (9% of the total surface) in all regions of Uzbekistan but can be found particularly in the middle and lower river reaches of Amu Darya, Syr Darya, Zerafshan, Kashka Darya, Surkhan Darya, and in Aral Sea wetlands. These soils have a high humus content 2.5-10% with high absorption capacity and used widely for rice cultivation (Goskompriroda of Uzbekistan, 2005).

The soils of the serozem belt (light, typical and dark) are distributed over 6.7 million ha (15%) on lower margin of the piedmont plains with an altitude of 200 to 700-900 m above sea level. These soil types have a high humus content (2-4%) and are less subject to salinization and can be used for rain-fed and irrigated agriculture. With the application of agronomic measures (e.g. fertilizers and conservation tillage) these soils can be used more productively for agriculture (Statistics Committee of Uzbekistan, 2006).

About 2% of the land surface in Uzbekistan is occupied with water bodies (reservoirs, lakes, rivers) and 6% by rocks. About 5% of the lands (2.2 million ha) are represented by chestnut, brown and light brown soil types in mountains in altitude from 1200 to 1600 m above sea level and subjected to erosion. The main usages of these soils are plantation of trees and pastures (UNEP, 2005).

2.3. Irrigated agriculture and cotton production

The total cultivated land in Uzbekistan is estimated to be 5.2 million of ha, of which 4.2 million ha is irrigated (UNESCO, 2000). Figure3 depicts the evolution of the irrigated lands in Uzbekistan for the last century. The irrigated lands almost increased by 3 fold over the last century; about 1.3 million ha in 1900, 2.6 million ha in 1950 and 4.2 million in 2000 (UNEP, 2005). However, Uzbekistan has witnessed a population boom; in fact there was an increase of 4 fold of the total population i.e., from 6.5 million in 1940 to over 26 million in 2007. As a result, the irrigated lands per capita has reduced from 0.41 ha/person in 1940 to only 0.16 ha/person in 2008 (UNDP, 2009) (Table2).

This expansion is supported by the complex irrigation hydraulic infrastructure consisting of more than 14,000 different scale pumping stations, over 28,300 km of inter-farm ditches and main irrigation canals and more than 137,000 km of on-farm irrigation ditches, 42 water diversion structures (with a capacity of 10-300 m^3/sec), 55 water reservoirs and about 30,000 km of drainage systems (Royal Haskoning, 2001) (Table3).

In order to increase the area under agricultural production, large scale hydraulic projects were started in soviet Uzbekistan. For example, in 1939 during 17 days, an irrigation canal named Lyagan with a total length of 32 km was manually dug with daily participation of more than 13 000 – 14 000 persons (Talipov, 1992). The Big Ferghana irrigation canal which stretches over 270 km was dug in less than 45 days with the assistance of 160 000 persons (Rakhmatullaev et al., 2003).

In later periods, there have been gigantic projects to construct irrigation canals, water reservoirs, pumping stations and other hydraulic structures with strong support from Moscow by enormous financial and technical resources.

However, environmental concerns were ignored by the centralized Moscow administration and today several known ecological catastrophes such as the Aral Sea catastrophe are witnessed. The detailed discussion on the historical evolution of irrigation in Central Asia can be found in O'Hara (2000).

Talipov (1992) reports that the Soviet Union imported about 80% of its cotton products in 1920s and in order to be self-sufficient for its textile industry by internal cotton production, the Central Asian region was used as a cotton producing platform. The area sown under the cotton has increased by 7.5 fold from 1924 to 1990. Figure4 depicts the evolution of area sown under cotton and its yield in Uzbekistan for the last century. For example, in 1913 the area sown under cotton constituted roughly 35% (out of total sown area) whereas at the end of 1990 it accounted to more than 56%. The area under cereal was reduced from 48% (out of total sown area) in 1913 to only 13% in 1990.

The operation and maintenance of this complex hydraulic infrastructure was supported by central Soviet administration. After the breakup of the Soviet Union, the financial flows have been ceased substantially for rehabilitation works. For example, over a 10-year span (1991-2001) the government investment portfolio for irrigation infrastructure rehabilitation has decreased from 27% to 8% and the capital investment for construction to the water sector being reduced by 5 times (UNDP, 2007).

This reduction in investment portfolio has further worsened the operation and maintenance of existing infrastructure and everlasting increase of electricity prices. The increase for electricity costs have ramifications for the sustainability of irrigation infrastructure because as early mentioned about half of total irrigated lands (2.2 million ha) in Uzbekistan are operated via various lift and diversion facilities. Indeed about 80% of the total Ministry of Agriculture and Water Resources of the Republic of Uzbekistan budget is devoted to electricity costs for operation of lift infrastructure.

2.4. Irrigated land quality classification system

An irrigated land quality classification system in Uzbekistan is termed as *bonitet*.[1] Bonitet Score reflects the soils potential productivity (i.e., yield potential of cotton) based on inherent fertility and quality (Noble et al., 2005). It is expressed as a score on the scale of 1 to 100 (Table4). Assessment of irrigated land quality is conducted over every 10 year span in Uzbekistan.

This assessment system is based on the relationship between indicators and characteristics of soils such as the humus content, soil texture, salinity level and erosivity with its productivity. The generalized characteristics of irrigated land quality is quantified by relative quantity values-bonitet score (Talipov, 1992;

[1] Bonitet is used by Government officials to classify land into classes based on their potential productivity and quality to set annual production targets for a farm.

Shadibaev, 2009). The bonitet score is conducted relative to cotton yield of the best soil quality in Uzbekistan, (e.g., cotton yield of 0.04 tons per 1 bonitet score and wheat yield of 0.06 tons per 1 bonitet score). Thus, the classes 1-4 are lands that need amelioration and remedial actions to be undertaken for improving the soils.

The recent official average value of bonitet score for Uzbekistan is estimated to be 55. However, the actual value is estimated to be 52-53. Figure5 depicts the evolution of bonitet score for Uzbekistan. Almost the bonitet score decreased from 60 in the 1970s to 52 in 2000s. As the principle of bonitet classification system was designed to estimate the cotton yield from the field plot. The bonitet score is still used a major indicator for potential crop yields of an agricultural land plot and thus lands with higher bonitet score are more attractive for farmers.

3. ENVIRONMENTAL THREATS

According to UNESCO (2000) the average percent of irrigated land affected by salinization in Central Asian region is about 23% with a range of the low 6% in Kyrgyzstan and the high 50% in Uzbekistan. In addition, the groundwater table has increased and the area of irrigated land with high groundwater levels (less than 2 meters below the surface) exceeds 30% of the total irrigated land in the region (Toderich et al., 2008).

Sustainability of irrigated agriculture in Uzbekistan is threatened by the salinization of land and water resources (Tookey, 2007). The land and water quality degradation is observed as a result of the excess water withdrawal over the actual crop requirements that impact the crop yields, decreased aggregate national income and affect the livelihoods of population (Murray-Rust et al., 2003).

These problems are the result of seepage from unlined canals, inadequate provision of surface and subsurface drainage and poor water management. Approximately, half of the irrigated area falls under different types of salt-affected soils and average yield of cotton losses may be as high as 50 percent. The annual economic losses due to land salinity and its abandonment are estimated to be more than US$43 million in Uzbekistan (World Bank, 2003; UNDP, 2007). Though the loss of crop production due to soil salinization is important, salinized land is generally still cultivated since no alternatives are available at present time.

4. INSTITUTIONAL MANAGEMENT

There have been various main transformations in agricultural production system through primitive nomadic agricultural practices to the sophisticated and heavy mechanized agricultural production in Central Asia region. Table5 depicts the major transformation phases in agricultural farming systems in Uzbekistan for the last century.

4.1. Ancient period

The earliest material evidence of irrigated agriculture is dated to the sixth millennium BC, in the simplest form of liman (flood-land) farming (Mukhamedjanov, 1978). The evidence also demonstrates a shift from simple use of water resources to increased regulation of seasonal river flows though melioration of individual plots, diverting surplus water and cleaning silt from riverbeds. This allowed increasing the area under irrigation.

In the latter part of the VII century when the region came under Arab control, extensive and sophisticated irrigation networks were constructed which could deliver water for many kilometres from its source to irrigated lands (Irrigation of Uzbekistan, 1979; Mukhamedjanov, 1978; O'Hara, 2000; Rakhmatullaev et al., 2003). In this period, the world famous remnants of civilization such as Samarkand, Bukhara, Khiva, and Kokand (Uzbekistan), Merv (Turkmenistan) have emerged.

There were three *khanates* (kingdoms) – Kokand, Khiva and Bukhara from the XIII to late the XIX centuries in the territory of modern Uzbekistan. The Figure6 depicts the hierarchy over water management in ancient times in Uzbekistan.

The *khan* (king) was in the head of the water delivery hierarchy. Each of them had a board of *khokim* and *bek* – local rulers who were appointed by the khan. Each administrative territory was managed by a khokim or bek. Each khokim or bek had appointed *aryk bashi* on the main irrigation canal. The aryk bashi is a person who reported on the water level in main irrigation canal and decided what water intake gates to be opened or closed (Mukhamedjanov, 1978; O'Hara, 2000). On the level of irrigation ditches, a *mirab* was responsible for water allocation and operation of irrigation ditches. The mirab was elected by local people in general and local farmers from respected persons within the community for water allocation and distribution. The *dekhkans,* peasant farmers, were the end users of irrigation water (Rakhmatullaev et al., 2003).

The land belonged to the khan and the dekhkans had a long term rent for their plots. The size of the land rented to dekhkans depended on the family size. The tax or rent payment was in the form of raw materials, mainly quarter part of the grain harvest. The average assessment fee was 1/10 of the harvest and it usually went to the mirab. However, the payment was never a consistent percentage of the crop, as the farmer paid depending on how satisfied he was with the job that the mirab was doing (Irrigation of Uzbekistan, 1979; O'Hara, 2000). Then the mirab estimated the needed amount of water and paid for the water to the arik bashi. Therefore, the mirabs and dekhkans had no interest in taking any extra amount water that exceeded their needs (Muhamedjanov, 1978).

The dekhkans were free to move to other kingdoms. Therefore, more dekhkans in the kingdom was in the direct interest of each khan. In VI and VII centuries, the region experienced the economical growth in the routine of the Great Silk Road. The taxation system was organized in a very smart way. One-fourth part of the harvest was base whatever the dekhkans grow (Rakhmatullaev et al., 2003). This system was successful because the dekhkans decided what to grow. Usually the agricultural production was market driven. Alternatively, whatever agricultural goods were expensive and needed in the local markets (bazaar), the favor was given to those crops in a given year. Therefore, the state's policy was dependent on market concepts.

For the maintenance and rehabilitation works of the existing irrigation canals and construction of new hydraulic infrastructure the *hashar* was practiced in the region. Hashar is the action that pulls community to accomplish maintenance, rehabilitation and construction works on voluntary basis in Uzbekistan. This form of actions still widely practiced in Uzbekistan. The hashar accomplished two things. First, it acts as a mobilization mechanism for labour input and material resources within community. Second it was a means of maintenance of infrastructures (O'Hara, 2000; Rakhmatullaev et al., 2003). Figure7 depicts the hasher work for cleaning irrigation canal in ancient Khorezm.

For example, for the construction or rehabilitation of irrigation canals, mirabs or aryk bashi called for hasher works. Each village had to mobilize their labor force for hashar. Villages at the upstream of the irrigation canal who would expect to receive more and cleaner water were expected to contribute more in terms of time and resources. Hashar was obligatory to all water users to take part in this annual maintenance works. Individuals who refused to participate were fined or denied access to water. Thus, "hashar was a system that linked benefits to duty" (O'Hara, 2000).

Prior to be in part of the former Soviet Union, Uzbekistan came under Tsarist control after the invasion of Russia. With the new administration, irrigation reforms were attempted to be introduced. However, these reforms failed because of many appointed irrigation officials were unaccustomed to the traditional methods of management and the authorities declared that irrigation would be run "by custom" (Thurman, 1999).

4.2. Soviet period

There have been two main types of farming systems in the former Soviet Union *kholkhoz* [2] (cooperative farm) and *sovkhoz* (state farm). The principal

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[2] Kolkhoz (Russian). A large collective farm comprises several agricultural experts and farm laborers responsible for agricultural production and delivery targeted outputs for cotton and

difference between these two forms of ownership was that a sovkhoz was a state enterprise whose workers were employed at fixed wages. By contrast, a kolkhoz paid its workers from its own annual earnings (Yalchin and Mollinga, 2007). According to Talipov (1992) by 1940 the collectivization of former private farms (around 800,000 farms) into collective farming systems (kolkhoz) was accomplished through the establishment of 7629 kolkhoz. However, by the end 1990's the proportion of sovkhoz has been increased due to the fact that sovkhoz was considered as more socialist production entity in contrast to the cooperative ownership of kolkhoz. As a result, by the end of 1990's only 9.5% of the total agricultural lands were managed by kolkhoz and sovkhoz – 63% respectively.

The kolkhoz type was mainly specialized for production of cotton, fruits and vegetables, tobacco and other (lemon and fishery). On the other hand, the sovkhoz was specialized for production of husbandry, poultry, vineyards, rice, wheat, cotton and others. In 1991, the total number of kolkhoz was 941 with a total irrigated area of 1.5 million ha whereas the total number of sovkhoz was 1017 with a total irrigated area of 2.1 million ha (Talipov, 1992).

In order to increase the agricultural production, the soviets have implemented various progressive measures such as mechanization, agronomic practices, development of irrigation infrastructure. As all kolkhoz and sovkhoz were specialized for production of certain agricultural produce, the central management body compromising with trained irrigation engineers, agronomists, veterinarians and other professionals was put into place. Irrigation water distribution was carried out by professionals and much of subsidies were granted for collective farms. However, the processing and manufacture aspects of agricultural produce were neglected in favor of inter-republic trade in the soviet times (Yalchin and Mollinga, 2007).

4.3. Post-independence period

Since the independence of Uzbekistan the situation has changed dramatically in terms of institutional, political and technical systems (Veldwisch, 2007). Political transition from planned economy to market has introduced "new" concepts like land tenure, water rights and different kinds of ownership (Morgounov and Zuidema, 2001; Yakubov and Ul Hassan, 2007).

In 1990, the former collective farms were transformed to collective family farming units called *shirkat*. The shirkat is a collective farm which pays a fixed monthly salary and supplementary dividends from its annual profits for its workers (Yalchin and Mollinga, 2007). The organizational management of shirkat was similar to the former kolkhoz system with significant difference in contract

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wheat to the government. A typical area under management of kolkhoz ranges in size from 10,000 to 20,000 ha (Noble et al., 2005).

arrangements for crop production. Shirkat has single management unit comprising of head, professionals (engineer, agronomist, accountant and etc). Shirkat contracted several brigades (working units) for agricultural production on annual basis for meeting state quota for cotton and wheat yields. In addition, every year the workers would sign a contract with shirkat management for leasing a plot with his/her state quota for cotton and wheat.

As shirkat farming system has shown its inefficiency, private farm system (*fermer* and *dekhkan*) has been advocated. The main difference between the two types of farming systems is that fermer farms have contract with central government to meet the targeted cotton and wheat production whereas dekhkan farms do not have such contracts for meeting targeted cotton and wheat crop production and only produce for meeting their own needs. This is true for only cotton and wheat productions (Yakubov and Mathrithilake, 2009).

Fermer is a private farm, successor of kolkhoz and responsible for targeted production of cotton and wheat to the government. The fermer can lease the plot in size ranging from a minimum of 10 ha to several hundred ha, with an average size of approximately 20 ha (as of 2000). These fermer farms have flexibility in the hiring of labor and access to other subsidized inputs from government (such as fertilizers, lease of machinery and access to bank credits). According to the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan (2009) as of 2009 there are about 220,000 fermer farms in Uzbekistan.

Dekhkan farmers have an average plot size of 0.12 ha and do not have the right to hire workers: only family members can work on the plots, which are given to the dekhkan farmers on a lifelong lease and can be passed on as inheritance to their children. There are more than 3.5 million dekhkans in Uzbekistan (UNDP, 2007). Those who are not employed by the new farms (fermer) are officially classified as dekhkan farmers, and work on the small plots allocated to them in the process of land distribution.

All agricultural land is still technically owned by the state and is not tradable or transferable. Leases of private farms (fermer and dekhkan) are in principle valid for a minimum of 10 and a maximum of 50 years. Fermer farms have often been subject to arbitrary decisions on the part of local authorities. For example, their land plots can be taken away and reallocated if they do not comply with local authorities' decisions about its use or have shown poor performance over targeted production of cotton and wheat.

The further reforms have been initiated in agricultural production system such as enlargement of fermer farm units in 2008 in Uzbekistan (MAWR of Uzbekistan, 2009). The main objective of recent reforms is to consolidate smaller poor performing fermer farms into efficient large fermer farms. Before this reform there were about 220 000 fermer farms in Uzbekistan with an average agricultural land of 27 ha per fermer farm whereas after the consolidation process the average size of fermer farm becomes 57 ha totaling of 104 000 fermer farms (MAWR Uzbekistan, 2009).

5. CURRENT CHALLENGES AND PERSPECTIVES

The major current challenge facing irrigated agriculture in Central Asia and specifically Uzbekistan is weak water management institutions, i.e., water users associations at on-farm level. It is known that water management is a political process and important part of overall development policy of a given country (Abdullaev et al., 2009). Many international donor assistance programs have been launched and implemented for institutional interventions in water management in the region. However, interrelated aspects such as financial, technical and governance issues have been bottlenecked for proper progress of such interventions. Prior to discussion of WUA challenges first the farmers current challenges will be discussed in regard to irrigated agriculture.

5.1. Challenges for farmers

Land tenure

As previously stated the agricultural lands are not privatized and technically owned by government in Uzbekistan. The farmers are interested in investing their resources for amelioration of lands and improving the irrigation infrastructures in order to increase the agricultural production and their incomes. However, there is no guarantee that their lands can not be taken out and re-allocated to different farmers on arbitrary decisions of local authorities. As a result, farmers fear to lose their invested capitals. In Uzbekistan, under the following conditions the farmer land can be taken away and re-allocated: 1) not meeting the targeted cotton and wheat state quota; 2) bankruptcy of farmers; 3) non transparent administrative procedures.

In addition, the farmers fear to invest their own financial resources because the re-allocation can only be carried out by state authorities and farmers cannot sell their land leases to other farmers in order to partially compensate already invested funds. In contracts between the state and farmers there is no clear identification of mutual rights for co-financing of irrigation infrastructures rehabilitation works. In addition, there are no incentives (reduction of state quota for cotton and wheat, tax returns) for farmers in cases of investing resources for rehabilitation of irrigation infrastructures.

Cropping structure

The state quota for cotton and wheat is based on the bonitet scoring system in Uzbekistan as previously discussed. The main bottlenecked aspect is that the bonitet score was carried out in late 2000s and outdated. Most probably the current scores are higher because in most instances the ameliorative soil conditions have deteriorated to date and farmers cannot meet their targeted state quota which in turn is putting them into the high risk of losing their lands. For example, in a given land plot, previously prescribed bonitet score is used for estimation of cotton and wheat yields. Local authorities are reluctant to the reduction of area sown under cotton and wheat, although farmer can meet the targeted yield on smaller area with new fertilizer application or other innovative techniques. The local authorities fear that the decrease of cotton and wheat sown areas can be viewed from higher management hierarchy as non compliance to the common rules. In fact, there is a perception that by reducing the overall area prescribed for sowing cotton and wheat would result a lower crop harvest.

Consulting/Extension service

After the fundamental transformation processes in Uzbekistan, the farmers are left without strong extension/consulting services either private or quasi-governmental. Many farmers are willing to pay for consultancies on new irrigation methods and technologies, cost-effective amelioration techniques, water conservation, legal aspects, marketing. However, there is no legislation for government or private extension and consultancies services in Uzbekistan. Thus the farmers are striving to overcome their current problems with old fashioned common known irrigation and agronomic techniques.

5.2. Challenges for Water Users Associations

A WUA is a self-managing group of farmers working together to operate and maintain their irrigation and drainage network (only inter-farm or on-farm level) to ensure fair and equitable water distribution and increase crop yields (Kazbekov et al., 2009). The WUA was established to replace the shirkat for on-farm irrigation infrastructure (canal and small water diversion facilities with gates) operation, maintenance and water distribution. According to the official statistics the total number of WUA is 1711 in Uzbekistan (MAWR of Uzbekistan, 2009). WUAs already serve around 3.6 million ha of land and 111,000 km of irrigation canals in Uzbekistan.

Most of these WUAs were established in the 2003–2006 period and now play an important role in the allocation and distribution of irrigation water, the collection of irrigation service fees and the maintenance of the irrigation infrastructure (Abdullaev et al., 2008). However due to the poor technical and financial capacities of farmer members of these institutions (WUA) and WUA itself is very limited institution for proper operation and maintenance of irrigation infrastructures.

Territorial vs Hydrographic

The current WUA is established on the former kolkhoz territory, i.e., most of the WUA are organized on administrative territorial principle not the hydrographic. A farmer signs an annual contract for irrigation water delivery with WUA in form of its annual membership fee. The geographic location of farmer's field parcel can force him/her to sign several contracts with different WUAs either because of administrative boundaries or several irrigation canals pass through that farmer's land plot. There are also positive aspects of such geographic location such as guaranteed water supply but overall the farmer overpays his dues in comparison with the rest within the concerned area. The most complication arises for farmers located at the tail-end of irrigation system, especially in dry years.

Financial incapacity

Thus the WUA barely can support its limited personnel with monthly salaries from collecting membership fees from individual farmers. In addition, the most professional and trained specialists once worked at collective farms has left for other areas of employment such as business and trade. The current WUA does not have in terms of quantity and quality experts for consulting local farmers on irrigation regimes, cropping structure, appropriate water and agronomic practices and business planning.

WUA's budgetary resources are based on the individual farmers' membership fees. At the moment, each farmer signs an annual contract on irrigation water delivery with the WUA. However, the farmers cannot pay on timely manner their respective membership fees to WUA because many of them can receive their earned money for cotton and wheat (state quota ordered crops) only from the previous harvest year. The state quota system on cotton and wheat has been designed in such way that farmers on its obligation for meeting targeted harvest should produce and sell at government fixed prices. On the other hand, the government subsidizes the inputs (fertilizers, water) for farmers. The farmers can use the rest of low-cost fertilizers for producing other cash crops, fodder for husbandry practice and partially compensate their income earnings. The state quota system is put under critics by many scholars and experts for being inefficient system for agricultural production.

Under Uzbekistan present conditions, the main detrimental factor of this system is not the monetary value of purchased price of cotton and wheat by government. But rather the complicated control of fiscal and financial system, i.e., substantial delays of getting money from banks. In addition, the farmers cannot use their earned funds for barter arrangements.

Increase number of farmers

With the de-collectivization of former soviet collective farms and the emergence of new private forms of farming systems there has been a rapid increase of the number of farms specialized in different cropping structures along a single irrigation canal. Thus each cropping system requires different irrigation application regimes. Many farmers favor to use only simple flooding irrigation methods instead of costly drip irrigation and other alternatives. Thus, WUA can hardly cope with the large number of farmers.

Technical aspects

The most difficult aspect is technical deterioration of existing irrigation infrastructures and improper allocation of funds for operation and maintenance works. There are widely non-existing or heavily deteriorated water measuring structures in place and thus it is extremely inconvenient for monitoring the right amounts of water. In fact, only nominal water measuring mechanisms are widely carried out for payments option of irrigation delivery service fees.

5.3. Perspectives

Farmers

The most practical and viable recommendations for individual farmers should be the regulation of legal arrangements defining the concrete and transparent mechanisms for re-allocation procedure of land tenure rights from local government authorities. The most important is that the farmer should have a right to sell his/her land lease for another potential farmer in order to compensate his/her invested assets. Then farmers would be on the safe side and motivated to invest their own technical and financial resources for amelioration of lands and for rehabilitation and maintenance of irrigation infrastructures.

The second paramount aspect is the concrete definition of responsibilities and rights of farmers and government for the amelioration of lands and rehabilitation of irrigation infrastructures in land lease contracts signed between the farmer and the government. In most cases, there is no clear definition of such rights or whole responsibility shifted to farmers. As a result, farmers are at high legal risks under court rulings. The clear and concrete definition of such responsibilities and rights would stimulate farmers to improve the amelioration conditions of their lands and actively participate with technical and material contributions for rehabilitation of irrigation infrastructures.

The third aspect is the incentive mechanisms for farmers' contributions in such activities. For example, the decrease of state quota for cotton and wheat either in quantity or options for farmers to sow the two crops on less parcels while meeting the state quota.

The fourth aspect, the current bonitet scores should be carried out for all lands and updated accordingly by responsible government authorities. In addition, each farmer can hire licensed private consulting company for independent bonitet scoring. There is a dilemma the bonitet score can only be carried out by specialized state organization, thus such licensing should be shifted to private sector and necessary amendments into the regulations should be envisaged. Proper and updated bonitet score would be beneficial both for farmers and government in order to meet state quota on cotton and wheat.

The fifth aspect is provision of farmers with a more flexible system for cultivating different cash crop varieties on their plots. If the government would allow the decreasing of the size of lands sown under cotton and wheat while meeting the state quotas, the remaining lands could be used effectively for cultivation of cash crops. As a result, the income generation would be promising and farmers could contribute for amelioration works and rehabilitation of irrigation infrastructures. There was a promising sign from the government of Uzbekistan in 2008, who has issued the degree that the total size of area sown under cotton should be reduced by 75 000 ha and these lands can be used for cultivation of different crops (Shadibaev, 2009).

Water Users Associations

The first aspect is development of mechanisms for financial sustainability of WUA. The only source of income for WUA is the annual membership fees from its farmer members. Instead for diversifying the income sources in kind contributions should be introduced as in Kyrgyzstan and Tajikistan (Sehring, 2009). In kinds contributions can be either natural produce or manpower for cleaning irrigation infrastructures. For example, the farmer who installs on his/her own expense the water measuring device can have some privileges, i.e., first irrigation water delivery.

The next aspect is consultancy/extension service for farmers. As Muhamedjanov et al (2008) proposes that consultancy/extension services should be established under the umbrella of the of Basin Irrigation Systems Authority (BISA) which were established for replacing previous provincial water management organizations in Uzbekistan. The main disadvantage of such consultancy/extension service is emergence of another inefficient and bureaucratic machine. Instead the consultancy/extension should be in solely form of private companies at the WUA level. The reasons are that WUA is directly working with individual farmers and such private companies with WUA partnership will have substantial impacts as cost-effectiveness and targeted consultancy service provision. Another important aspect as early mentioned is that there is no legal framework for such consultancies. For extension service the prominent academic universities and research institutions with WUA and private consultancy companies can have synergetic partnerships for training and know-how technology transfer.

CONCLUSION

The Central Asian countries have faced new challenges for practicing sustainable irrigated agriculture and in particular in term of institutional challenges. The physical deterioration of irrigation and drainage infrastructures is technical issue that would impede the constraints on agricultural production, environmental concerns and as a result on the impact of livelihoods conditions for many million farmers. In fact poor conditions of irrigation infrastructures impact the efficient irrigation water distribution at various levels of irrigation conveyance system. The global climate change and transboundary nature of water resources would be major supplemental aspects for sustainability of irrigated agriculture production in the Central Asia.

The national and international donor programs would play a pivotal role for reversing the current situation if the intervention measures would be targeted to institutional changes such as land tenure, water rights, and incentives for rehabilitation of irrigation and drainage networks.

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LIST OF TABLES

Table1. Soil type distribution in Uzbekistan (Talipov, 1992)

Soil type	Area	% of area	Altitude

	Million ha	occupied to the total	(above sea level) m
Plain zone			
Grey-brown desert	11.5	25	150-250
Sandy	1.37	3	120-150
Takyr	1.78	4	120-180
Meadow-takyr	0.47	1	120-150
Meadow and wetland-meadow	1.85	4	80-100
Solonchak	1.27	3	80-100
Sands	12.1	28	120-150
Piedmont and mountain zone			
Light serozem	2.59	6	250-500
Typical zerozem	3.05	7	500-700
Dark serozem	1.06	2	750-1200
Brown and brownish middle-altitude	1.66	4	1200-2800
Light brownish high-altitude	0.54	1	2800-3500
Meadow-serozem	0.78	2	250-500
Meadow and wetland-meadow	0.75	2	250-500
Rock	3.0	6	-
Water surface	1.12	2	-
Total	44.89	100	

Table2. The population and per capita irrigated lands transformation in Uzbekistan for the last century (Talipov, 1992; UNDP, 2009)

Year	Total Population ('000 persons)	Per capita irrigated land (ha/person)
1940	6551	0.41
1960	8722	0.30
1970	11799	0.22
1980	16158	0.20
1990	19906	0.19
2000	24487	0.17
2007	26663	0.16

Table3. Irrigation network of Uzbekistan (Royal Haskoning, 2001; UNDP, 2007)

Hydraulic structures	Location in the system	Unit
Irrigation canal	Main	7923 km
	Inter-farm	20 437 km
	On-farm (include)	137 385 km
	Concrete lined	12 103 km
	Chute	21 668 km
	Conduit	3308 km
Pumping station	Inter-farm	1466 pieces
	On-farm	12 780 pieces
Drainage system	Inter-farm	29 939 km
	On-farm (include)	
	Open	106 321 km
	Closed	30 242 km
	Vertical drainage wells	4309 pieces
Irrigation well		5022 pieces
Water reservoir		55 pieces
Water intake		42 pieces

Table4. Land quality classification in Uzbekistan

Classes	Description	Bonitet Score
10	Best	91-100
9	Best	81-90
8	Good	71-80
7	Good	61-70
6	Average	51-60
5	Average	41-50
4	Below average	31-40
3	Below average	21-30
2	Bad	11-20
1	Bad	0-10

Table5. Typology of farming systems in Uzbekistan

Period	Type of farming system	Ownership	Command area (ha)
Prior 1900's	Nomadic	Private	various
1920-1940	Kolkhoz	State cooperative farm	10 000-20 000
1940-1980	Sovkhoz	State farm	Up to 100 000
1990-2006	Shirkat	Semi-Cooperative farm	1500 - 2000
2005-present	Fermer	Private farm	20
2000-present	Dekhkan	Individual farm	1

FIGURE CAPTIONS

Figure1. The location of Uzbekistan and Central Asia

Figure2. The soil map of Uzbekistan

Figure3. The evolution of irrigated lands in Uzbekistan for the last century

Figure4. The area sown under cotton and its yield for the last century in Uzbekistan

Figure5. Institutional water management hierarchy in ancient Uzbekistan

Figure6. Hashar working for the cleaning of an irrigation canal in ancient Khorezm (Irrigation of Uzbekistan, 1979)

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Figure1

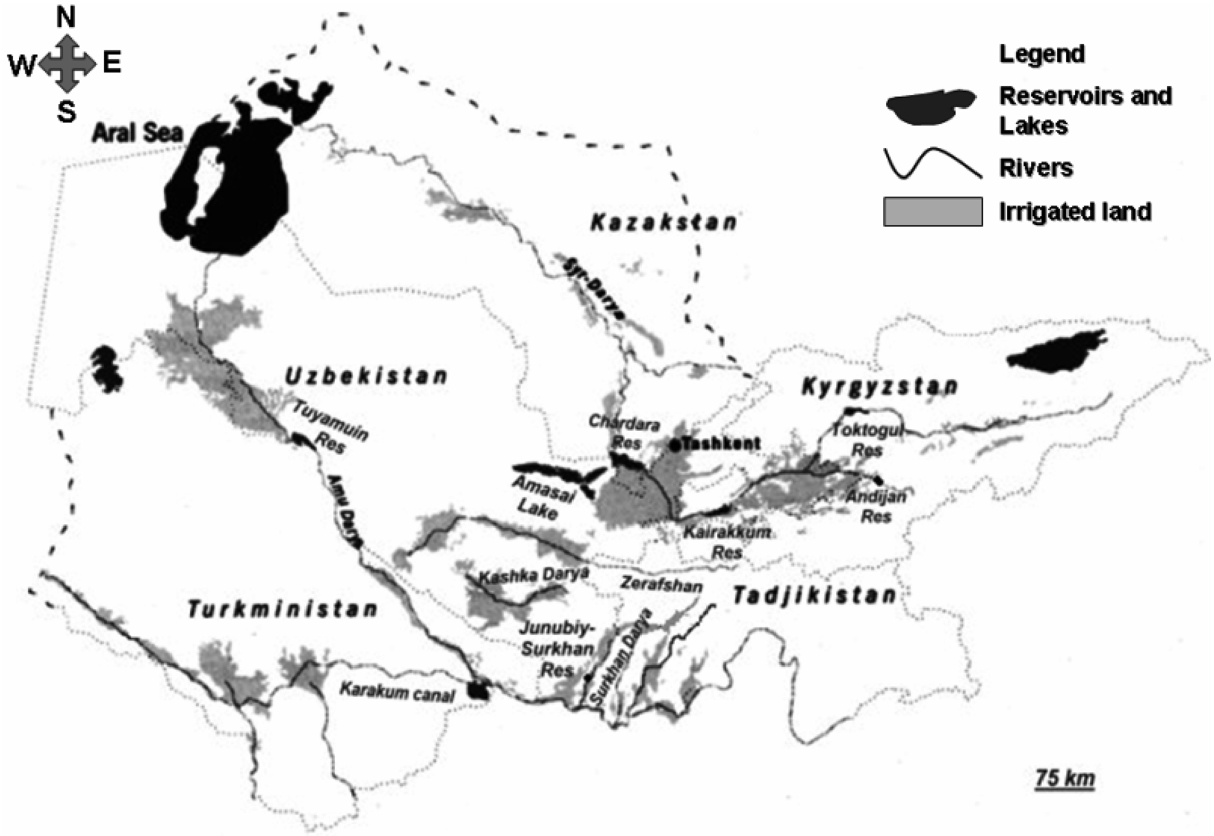
N
W
E
S
Aral Sea
Legend
Reservoirs and Lakes
Rivers
Irrigated land
Kazakstan
Syr-Darya
Uzbekistan
Kyrgyzstan
Tuyamuin Res
Amu Darya
Chardara Res
Tashkent
Toktogul Res
Amasai Lake
Andijan Res
Kairakkum Res
Kashka Darya
Zerafshan
Tadjikistan
Turkministan
Junubiy-Surkhan Res
Surkhan Darya
Karakum canal
75 km

Figure2

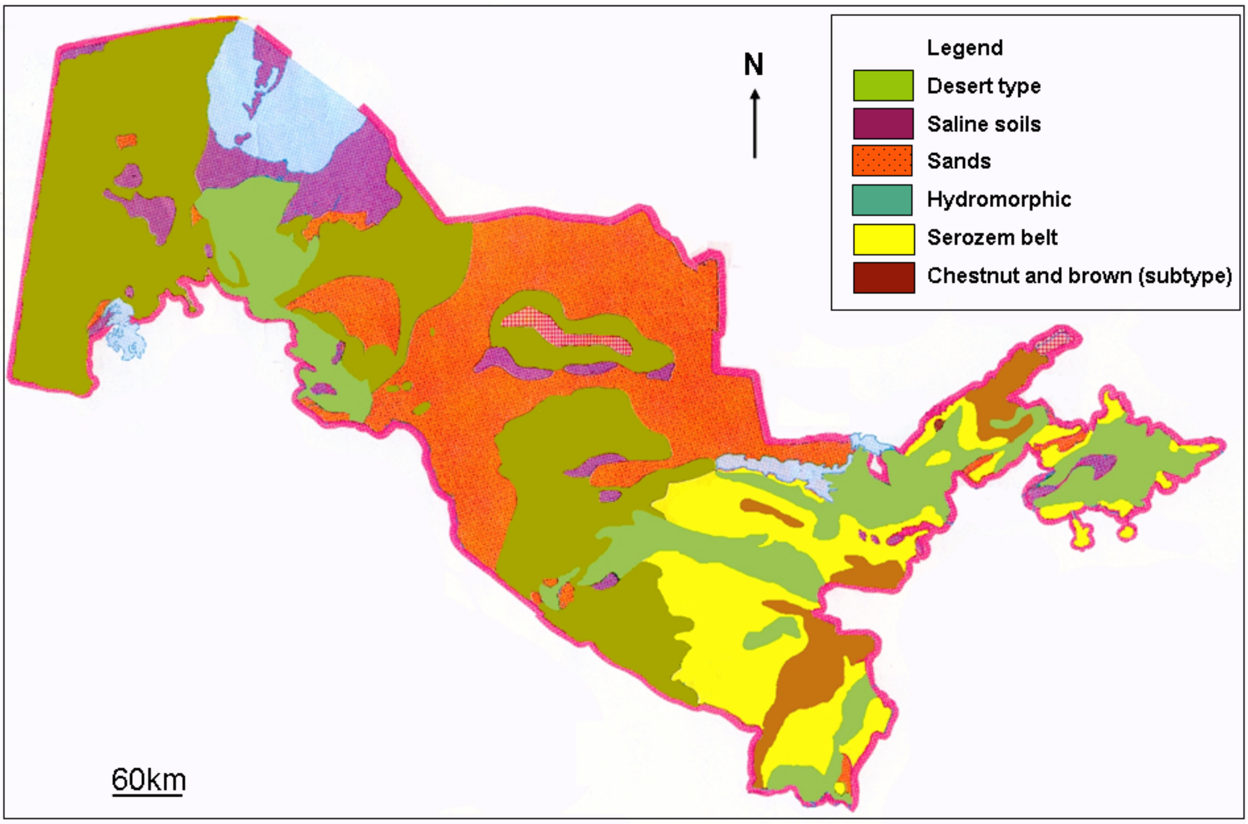

Figure3


4,5
4
3,5
3
2,5
2
1,5
1
Irrigated land (million ha)
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Years

Figure4

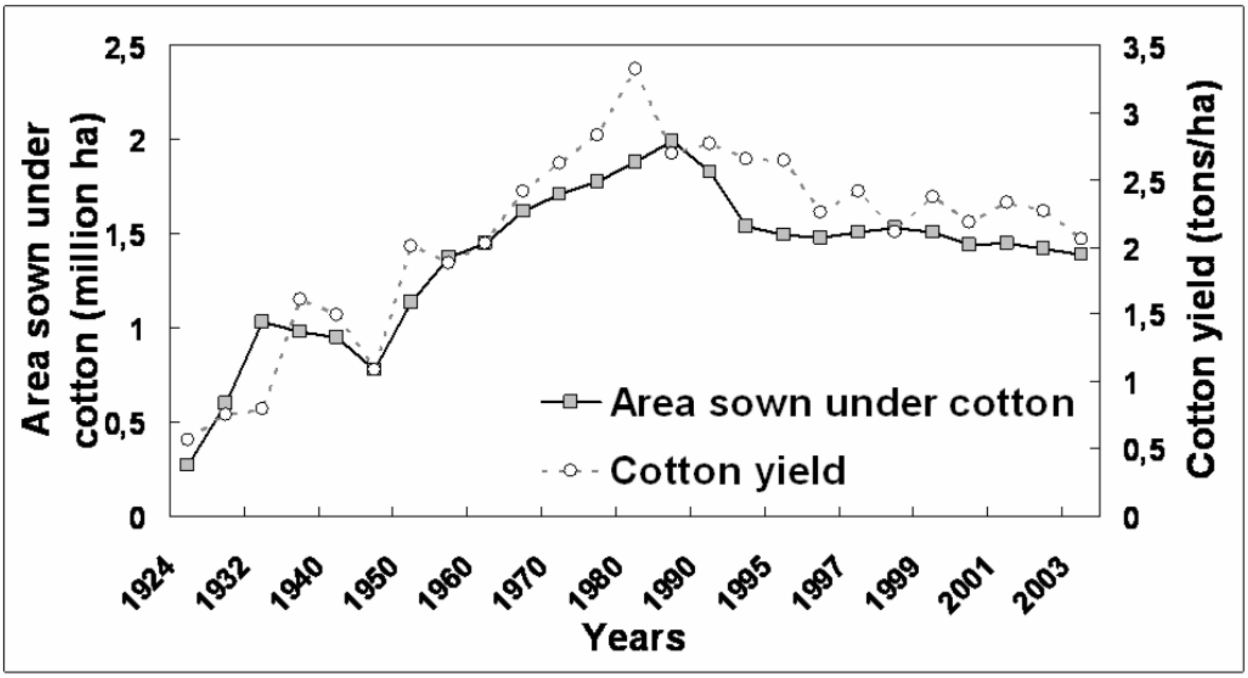
2,5
2
1,5
1
0,5
0
Area sown under cotton (million ha)
3,5
3
2,5
2
1,5
1
0,5
0
Cotton yield (tons/ha)
Area sown under cotton
Cotton yield
1924
1932
1940
1950
1960
1970
1980
1990
1995
1997
1999
2001
2003
Years

Figure5

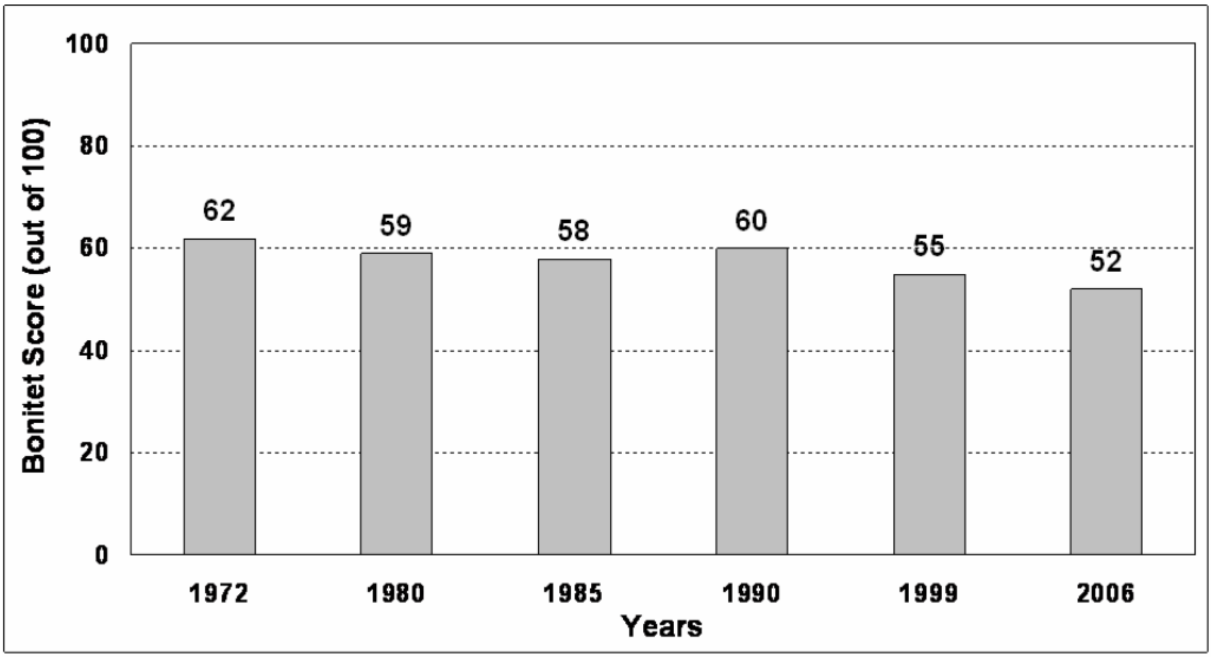

Figure6

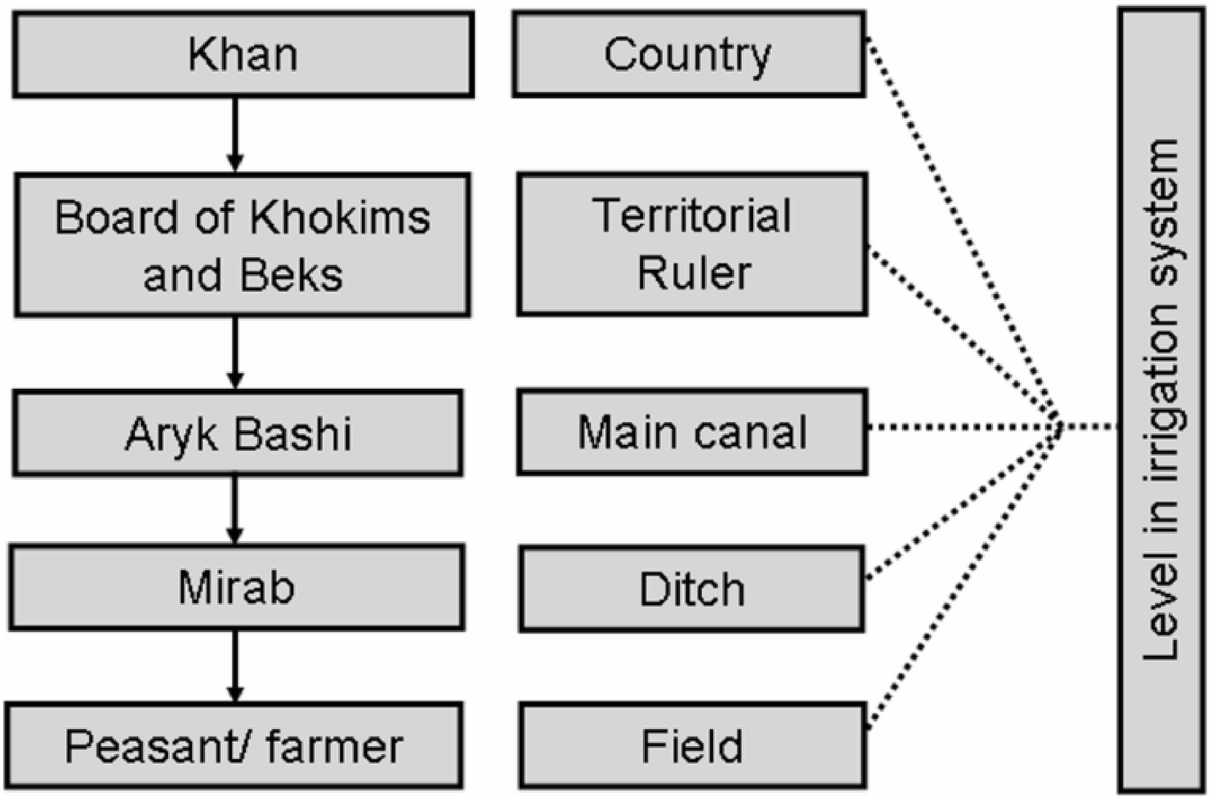

Figure7