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Future Rationalization of Irrigated Agriculture: Multilevel Analyses for Salyan Steppe, Azerbaijan Republic

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ABSTRACT

In this study current practices of irrigated agriculture in arid zone on the basis of multilevel approach is considered and integrated measures for its improvement are proposed. Investigations were conducted in Salyan Steppe of Azerbaijan Republic which is one of the typical arid zones of the country. The essence of this study is to analyze the peculiarities influencing irrigated agriculture and delineate necessary measures under the emerging economic and environmental conditions of land and water usage in the agriculture sector. The results of analyses indicate a number of problems in all levels of farming management. Irrigated agriculture in the country is facing a number of problems, due to deteriorated physical condition of irrigation infrastructure, currently established farming structure and farming practices. Needs for improvements of the irrigation infrastructure of a whole district is evidently demonstrated, since during conveyance, distribution and at the field level agriculture water use efficiency is low. Only one-third of water taken from the sources is used for crops in the field. The established current farming structure consisting of small plot sizes and surface irrigation practices complicate a future rationalization of the irrigation water and land usage. For the listed reasons, the concept of rehabilitation and other required measures (economic, institutional etc.) are proposed to be elaborated as integrated arrangements within a single goal-oriented program, rather than limited improvement works at a separate level of an irrigation system.

Keywords: Improvement needs, Irrigated agriculture, Multilevel approach, Salyan Steppe, Water losses.

INTRODUCTION

Irrigated agriculture is the main water consumer (71% from total consumption in 2015) in Azerbaijan due to the location of the irrigated lands in arid zones. In the past, as in other parts of the former Soviet Union, under the planned economy, when irrigation water was delivered according to the prepared annual water use plans, all associated costs for irrigation and crop farming were covered by the public funds. In realization of the targeted production plans, the district irrigation system administrations did not always provide water to the collective farms according to the actual crop water requirements, but as each of the pre-approved water delivery plans. This had led to reduced operational efficiency of the irrigation infrastructure, inappropriate use of resources, which subsequently led to loss of crop yields, degradation of soil fertility, waterlogging and soil salinity build up. By the end of 1980s, the uncoordinated actions in management of the irrigation systems at the main canal level resulted in 12-18% excessive usage of water withdrawn from the intake structures. Poor technical condition and inappropriate operation of the irrigation and drainage systems have led to

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salinization and waterlogging of soils on 687.700 ha worsening the environmental and ameliorative condition in the Kura–Araz lowland (Mamedov and Ibad-zade, 1988).

After the waiver of a planned economy and transition to the market relations the main issue was future rationalization of the irrigated agriculture under the new economic condition. In order to streamline the distribution of the irrigation water among the water users, as well as to operate and maintain the existing on–farm irrigation and drainage network, after execution of the land privatization and agrarian reforms in early 2000s, Water Users Associations (WUA), turning on into the Water Users Unions (WUUs) after 2004 were created and developed. Today, the operation of irrigation and drainage networks has become more complicated due to small size of plots, growing of multiple crops with differences in water requirements, expected returns from the crops and others. In addition, the phenomena of continuous climate change, establishment of free market mechanisms and institutional reforms, demand for optimal utilization of available water and land resources. For this reason, the effective functioning of irrigation systems requires concerted actions along the entire chain of irrigation works from field level to the source of irrigation water with consideration of the site-specific peculiarities of each system (Rzayev, 2007).

This issue is also valid in regional and international context where irrigated agriculture is dominated, especially in the arid zones very often associating with limiting resources and frequent soil salinization. Therefore, the water use under such condition implies the improvement of the irrigation water delivery systems in order to achieve appropriate service performance (Pereira *et al*, 2002). One of the policy instruments for improvement of irrigation systems' performance is IMT (Irrigation Management Transfer) at the tertiary or secondary canal levels (Global Water Partnership, 2003). This must be incorporated with other measures such as application of innovative irrigation practices for better optimized system O and M (Operation and Maintenance) (Levidow *et al.*, 2014). The prognoses of the climate changes, especially in the regions with traditional irrigated agriculture, are expected to be more damaging due to shortage and uneven distribution of water (World Bank, 2010a). In the arid zones water scarcity may create problems between water users at different levels because of diversification of the water use structure by country development (Bijani and Hayati, 2015). Under this situation, relevant development scenarios, investments, and monitoring measures in irrigated agriculture should be arranged (Organization for Economic Cooperation and Development, 2007; Sylvén *et al.*, 2009). Irrigation efficiency is incommensurable for definition of the economic efficiency only, but it should be concerned about its environmental impacts as well (International Food Policy Research Institute, 2001; World Bank, 2003). Modernization of an irrigated area must start with a diagnosis of its current situation. Irrigation districts (in our case this is WUU level) are the basic unit for collective water management in a watershed, and therefore constitute the first level where such studies should be performed (Lecina *et al.,* 2005). In evaluation of the agriculture water usage in the Almudévar Irrigation District (Spain), characteristics such as soil properties, climate peculiarities, cropping pattern and water requirements, water delivery network structure, management policies and irrigation water charges were identified as factors influencing the performance of the irrigation system. Based on these studies, the actual performance quality was evaluated and modernization options were analyzed using technical and economic performance criteria (Faci *et al.,* 2000). In Ukraine for modernization / improvement of large-scale irrigation systems management information /decision support systems were applied by using ecological and economic criteria for choosing irrigated areas and crop pattern, required water application and distribution at on-farm and district level (Zhoftonog, 2004). The concept of performance evaluation of farm irrigation systems in Turkey included irrigation efficiency, irrigation uniformity, adequacy of irrigation and irrigation effectiveness. The economic assessment is executed with a set of comparative performance indicators, based on the water-yield relationships (Kanber *et al.,* 2005). The evaluation of the uniformity of irrigation application depends on many factors that are related to the method of irrigation, topography, soil characteristics and irrigation system's flow rate (Irmak *et al.,* 2011). In Burkina Faso decision-support tools are used to improve performance of WUA managed irrigation systems (Wellens *et al.,* 2013). The framework for IMT in Iran was elaborated by evaluating the agriculture water usage in combination with the ongoing IMT efforts and a comparative analysis of experiences from different countries as well as WUA development (Ul Hassan *et al.,* 2007, Omid *et al.,* 2011). In California, an assessment of the potential to improve agricultural water use efficiency at field level was conducted by comparing a baseline scenario to 4 other alternative scenarios: modest changes in cropping pattern, smart irrigation scheduling, advanced irrigation management and efficient irrigation technology (Cooley *et al.,* 2008). In the EU (European Union), irrigated agriculture is facing changes due to the reforms of the Common Agriculture Policy (EU, 2003) and the coming into force of the Water Framework Directive (EU, 2000). A methodology based on multicriteria analyses of water and agriculture policy scenarios has been elaborated to evaluate the perceived outcome of different scenarios from different stakeholders' point of view in selected irrigation systems in Italy (Bartolini *et al.,* 2010). This implies consideration of technical, economic, social, institutional, and environmental issues in line with participation of all stakeholders in the decision-making process (Naderi Mahdei *et al.,* 2015). In some cases, integrated water resource management and effective planning at the river basin level is proposed as a tool for improving the water consumption in irrigation (IHPA, 2013, Ahmedzadeh *et al.,* 2016). While in some studies concerted efforts were mostly made for irrigation improvements at field level [USA (California), Spain, Turkey], in other cases (EU, Iran, Italy) targeted institutional and policy changes were introduced to effect performance improvements at different levels of irrigation systems.

In each case we can observe that irrigated agriculture analyzes for future improvements covering various factors and levels in accordance with the defined priorities, strategies and stage of socio-economic development in different countries.

Under the current study, the irrigated agriculture is analyzed by multilevel approach to validate proposals on the integrated measures for its future rationalization in Azerbaijan.

MATERIALS AND METHODS

Study Area and the Irrigation Systems

The investigations were carried out in Salyan Steppe of Azerbaijan Republic, which locates 28 meters below sea level with semi-desert landscape and is characterized by the complex climatic conditions. The steppe is situated in the Kura-Araz lowland and is surrounded by the Caspian Sea from the East, Kura River from the North, Gizilaghaj Gulf from the South, and covers an area of 149,000 ha (Figure 1). The landscape is mostly plains. The overall very small slope exists in the South–Western part of the plain. Most of the area is composed of hypsometric lowland, and the groundwater is close to the earth surface, therefore, part of the soil has been exposed to different degrees of salinization, which complicates the agricultural land development. River valleys and irrigation canals in the area led to the disintegration of

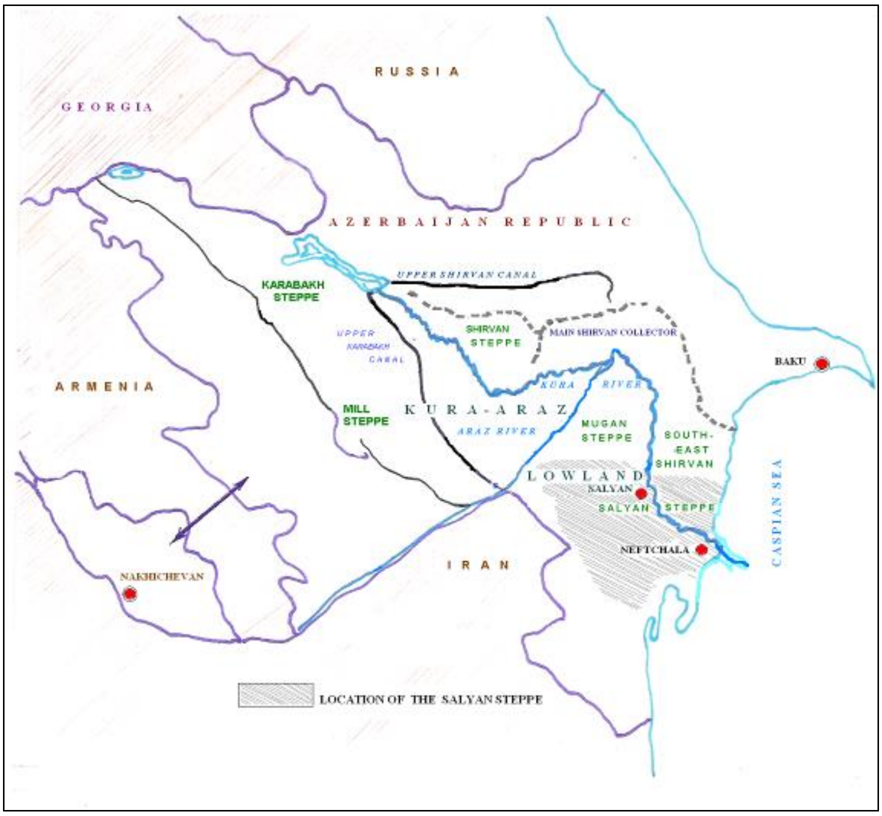


Figure 1. Location of the Salyan Steppe, Azerbaijan.

the local relief (Alimov, 2001). The area has dry summer temperate type semi-desert steppe climate. The average monthly temperature of the warmest months (July-August) is 26.2-26.4ºC, and the coldest month's average temperature (January-February) is 1.0-3.0ºC. Most of the area consists of alluvial soils. In some areas, the soil profile is completely clay, which evidently proves their development on the de-alluvial and alluvial talus of the Kura River and other small rivers. Because the majority of the soil forming rocks are rich with salts and carbonates, calcareous soils developed with different levels of salinization (Abduyev, 2003).

Salyan Steppe encompasses Salyan and Neftchala irrigation districts. The irrigation systems in both the districts were developed haphazardly during the Soviet time in order to rapidly enlarge the area of irrigated lands to comply with the obligatory state plans to increase food production, with insufficient consideration to the ecology and environmental implications of such development. The irrigation systems consist of totally 109 number pumping stations installed along the Kura and Akkusha rivers and mostly earthen irrigation and drainage canals. In Salyan district the length of the main canals is 32.4 km, secondary– 221.3 km and on-farm canals- 940 km. The total length of the collector-drainage network is 50.5 km.

Irrigation services in Salyan district are provided by *Salyan District Irrigation System Administration* (SDISA) and in Neftchala district by *Neftchala District Irrigation System Administration* (NDISA). Water supply is provided as per service contracts concluded with each WUU at the beginning of each season.

The drainage system also consists of open-channels, approximately trapezoidal in shape, collecting drainage water from fields. The water removed from the fields finally joins the main collectors, in most cases with use of a pumping system. A service organization called *Ashagi Mugan Ameliorative System Administration* (AMASA) provides services for the removal of groundwater from the fields and discharges it into the Caspian Sea.

All these organizations are public and are attached to the *Amelioration and Irrigation Open Joint Stock Company* (AIOJSC).

Currently the main cultivated crops in this area are alfalfa, winter wheat, cotton and a variety of vegetables and fruits. Surface irrigation–furrow, border and flood irrigation – is the widely currently used irrigation method, continuing from the soviet time.

Methodology and Data

Irrigation network is a multilevel structure, which means that the entire system represents a family of interacting sub-systems. In our case, under the "system" or "sub-system" it is meant the execution of the conversion process of input data (conveyance, distribution and application of required quantity of water at the right time) into output data (achieved crop yield). The success of the system as a whole and at each level depends on the behavior of all elements of the system. The concept of interactions implies that any intervention at an upper level affects at lower levels and vice-versa (Mesarovich *et al.*, 1970). The success of the overall system depends not only on the actions undertaken at any given level (for example timely delivery of irrigation water), but also on the corresponding response of a system component at a different (upper and lower) level. The cumulative efficiency of the system functioning is taking shape from the results, which are expressed by the state of water use throughout the system, the level of obtained crop yields, soil salinity dynamics, as well as the profitability of farming (Rzayev, 2014).

Irrigated agriculture in this study was analyzed with consideration of the above hypotheses on the basis of multilevel approach - for each technological level of irrigation water delivery separately, that is, at the level of: (i) Main canals; (ii) Water distribution network within WUUs (on–farm irrigation system consisting of secondary, tertiary and quaternary canals), and (iii) Irrigated field - applied farming practices. Studies were conducted during 2010-2014. Data was processed by using Microsoft Excel software.

Although the efficiency of earth canals is generally known, selective control measurements of flow discharges were conducted in 4 on–farm canals by using standard hydrometric propeller meter ГР-21M (Figure 2). The efficiency of each canal has been defined as a simple ratio of average net outflow to the average gross inflow, measured at the end and starting points of canals, respectively. The results of measurements were used to calculate the canals’ conveyance efficiencies (Table 1).

The losses of irrigation water at field level (surface irrigation) are accepted equal to the portion of the infiltrated water beyond the Field Capacity (FC) after completion of the irrigation under even distribution of water (without consideration of evaporation from surface and runoffs out of the field after irrigation), which was ≈20% beyond *FC* in cotton and winter wheat fields.

Data on the water abstracted from the sources at district level and the losses during conveyance in main canals is taken from statistic yearbook (SSCAR, 2015). Considering losses during distribution and irrigation, water usage starting from the source up to the field level was calculated (Table 2). Factors influencing the farmers’ cropping pattern were analyzed under the established farming structure and as a supplementary tool investigations were strengthened by direct interview with 110 active farmers, demonstrating interest to share their experiences. In addition, the meetings with the WUUs confirmed the farmer’s responses and the summarized

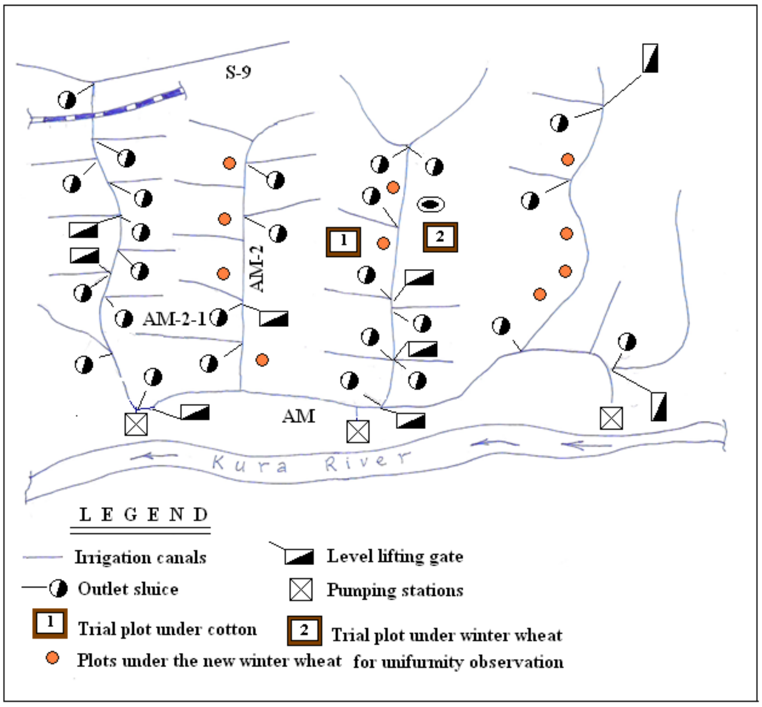


Figure 2. Schematic lay out of the on–farm irrigation canals and test fields, Kurqaraqshli, 2013.

Table 1. Off–farm and on–farm canal's indicators and efficiency (Kurqaraqashli, 2013).

Canal name	Canal type	Canal characteristics (m)				Average discharge ($m^3 s^{-1}$)		Conveyance efficiency
		Length (m)	Bottom width (m)	Depth, m	Cross section (m^2)	Start	End	
AM	On–farm, earth	6200	1.3	1.6	4.2	1.95	1.19	0.61
AM-2	On–farm. earth	2800	1.2	1.4	3.0	0.38	0.22	0.57
AM 2-1	On–farm. earth	1500	1.0	1.2	3.0	0.30	0.18	0.60
S9	On–farm, earth	3800	1.0	1.4	2.3	0.60	0.35	0.58

results were considered relevant for all the WUUs in the area (Table 3). The characteristics of WUUs are presented in Table 4.

Irrigation and drain water quality analyses are made by samples taken from the investigated areas and refers to water quality in Kura River (Zeynalova and Iskenderov, 2009, Rzayev, 2015).

The data on the state of on-farm canal and collector drainage system and irrigation methods refer to visual assessments during field trips.

The ecological and ameliorative condition of land and groundwater is assessed based on data from public Hydro-Geological Ameliorative Service Expedition (HGASE), monitoring the land and groundwater salinity on regular basis (HGASE, 2015).

The data on the annual sown area with the main irrigated crops is collected from statistic yearbooks, which is used for drawing Figures 3 and 4.

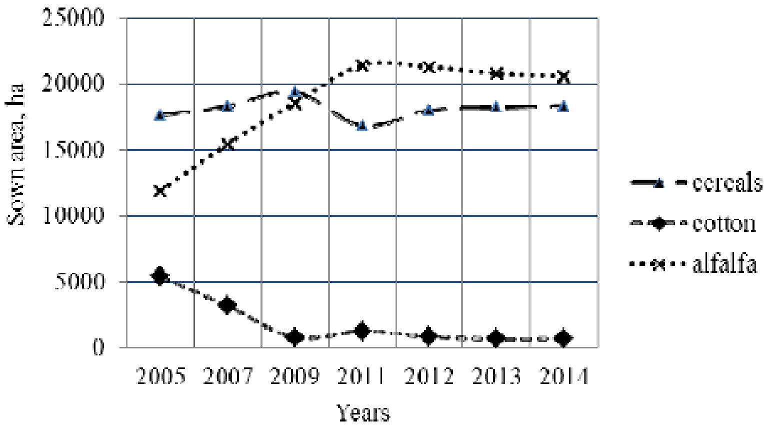
The basic data on the sizes of plots of the WUUs is collected from Kurqaraqashli

Table 3. Factors influencing farmers' cropping pattern in Salyan Steppe (2012).

Factors	Ability of plot to receive irrigation water	Availability of technical and financial means	Demand for crop in local market	Required production cost to obtain planned crop yield	Total number of interviewed farmers	
Kurqaraqashli, Salyan District	12	20	18	20	70	Persons
	17	29	25	29	100	%
Ashagi Surra, Neftchala District	8	12	10	10	40	Persons
	20	30	25	25	100	%

Table 4. Some characteristics of WUAs in Kurqaraqashli municipality.

WUA	Irrigated area (ha)		Length of canals (км)	Average size of plots (ha)	Number of families receiving plots
Kurqaraqashli	1620		44	1.6	772
Kur-Araz	830		25.2	1.7	378
Soil-water properties	Depth of layer (cm)	Field capacity (% by weight)	Volumetric weight, (g cm^{-3})	Density, (g cm^{-3})	Porosity (%)
	0-60	27.9	1.25	2.76	54.7
	0-100	28.9	1.30	2.77	53.1



Data source: State Statistic Committee of Azerbaijan (SSCA, 2015), own composed.

Figure 3. Dynamics of the sown area of the main irrigated crops in Salyan steppe.

municipality and used for processing and drawing Figure 7.

RESULTS AND DISCUSSION

SDISA provides irrigation water supply services to 45.193 ha of an irrigated land in *Salyan District*, and for 14.100 ha in *Neftchala District*. The 65 pumping stations located along Kura and Akkusha rivers, and a network of earthen canals provide water to 15 WUUs in the district (SDISA, 2014). River water quality belonging to the sodium sulphate group with mineralization of 654-725 mg l^{-1}, is classified as second category water for irrigation (Zeynalova and Iskenderov, 2009). The mineralization of water samples taken from canals is 698-792 mg l^{-1} and for the drain waters – 6,804-6,921 mg l^{-1} (Rzayev, 2015). Water losses occur during the water intake, conveyance and distribution between the service areas of WUUs through the on-farm irrigation network, and during irrigation on the fields. These losses generate excess load for the drainage network, the condition which, is also poor due to silt deposition, weed growth and lack of proper maintenance. Sudden power cuts remain one of the main problems to keep the pre-arranged irrigation schedules and leads to additional losses of the pumped irrigation water to infiltration, to make necessary additional cleaning works for removal of the deposited silt accumulated in the canal beds. In 2014, the total abstracted water was 296.6×10^6 m^3 from which 183.3×10^6 m^3 used for irrigation (SSCAR, 2015). The water losses during conveyance through the main canals are estimated to be about 112.5×10^6 m^3 increasing from 25 to 38% during 2005-2014 (Table 2). Thus, the water used for irrigation on the field level during this period is averagely 29-33% from the total intake.

NDISA delivers water to 38.158 ha, covering the service areas of 21 WUUs, with 44 pumping stations (NDISA, 2014). During the period of 2005-2014, the water losses increased from 44 to 59%. In 2014, the water used for irrigation was 162.5×10^6 m^3, while the losses in the main canals were 97.5×10^6 m^3. In addition to the common difficulties in cleaning of the canal system and in delivery of water to the small plots, sudden power cuts also is an additional problem to follow irrigation schedules.

In both the districts, the main grown crops are cotton, alfalfa and winter wheat. Over the past several years, the farmers here preferred to grow alfalfa due to the relatively low production costs and high demand for the livestock sector in the local market. The interviews showed that most of the farmers prefer to grow crops with low production costs and relatively high incomes (Table 3). One-third of the farmers in choosing the cropping pattern considered *the availability of technical and financial means*. In Kurqaraqashli municipality, the area under cotton dropped to 74 ha in 2013, compared to 550 ha in 2005, in opposite the area under alfalfa increased to 1,271 from 450 ha during this period. The area under cotton declined from 5395 in 2005 to 716 ha in 2014. Only farmers with the capacity of proper farming could continue growing cotton and increase the yields gradually to 23.6 t ha^{-1} by 2014. During the same period, the area of cotton in Ashagi Surra village had reduced from 450 to 180 ha. In Neftchala district, the cotton growing area also reduced from 9030 to 557 ha, and the yield reduced from 13.9 to 13.8 t ha^{-1} (SSCAR, 2015). The reasons, as explained by the farmers are the low purchase price and high labor requirements for cotton growing (Figure 5). The analyses on the dynamics of the crop yield demonstrates no significant raise (Figure 6).

In Kurqaraqashli during the land reform, the former collective farm's land was distributed between 1,150 families (Table 4). In 2013, the total irrigated area was 2,153 ha, out of which 803 ha was wheat, 74 ha was cotton, and 1,271 ha was alfalfa. Most of the earthen canals' beds are exposed to deformation due to silt deposition and weed growth, resulting in reduced canal capacity, causing flooding of the adjacent areas and excessive seepage losses (Figures 6). The hydraulic structures, including gates, need also to be replaced and rehabilitated. The calculated flow discharge measurements in several canals (by hydrometric method) and the average canal efficiency of these canals are equal to 0.59 which is less than 0.65 fixed in SDISA operational documents (Table 1). The small size of the plots creates a number of problems during irrigation, such as increasing the density of the field ditches, difficulties in using farm machinery. Considering an average top width of 2.0 to 2.2 meters for the field canals, and an average length of 1,000 meters, the field canal covers an area of 0.22 ha or 22% of per hectare. During irrigation, farmers receive water through their own field canal, but as the nearby plot is also irrigated through its own canal, some portion of water is lost as

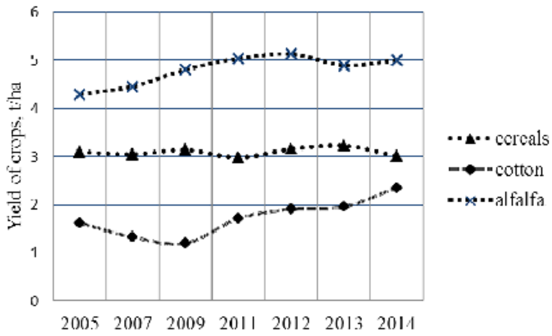
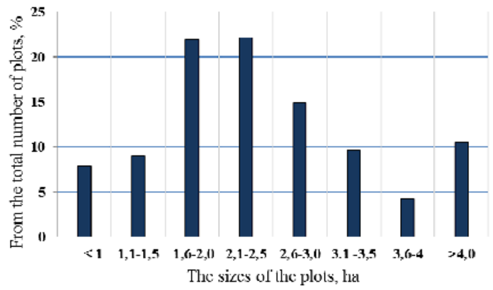


Figure 4. Dynamics of the yields of main irrigated crops in Salyan steppe.



Source: Municipality of Kurqaraqashli (2014), own collected data.

Figure 5. Size of the plots in Kurqaraqashli municipality (2014).

Figure 6. Turnout from the secondary canal, Salyan (2013).

infiltration. In fact one plot is irrigated from both sides, which led to over-irrigation. The field canals are weedy; their beds are deformed, as the farmers don't have enough resources to restore at the beginning of season, which causes additional water losses while conveying water along the field. Currently 61% of the plots have a size that is less than 2.5 ha (Figure 7).

According to the visual observations only up to 10% of the plots can be considered decently leveled. We observed 10 plots under new wheat during border-strip irrigation, and later the germination of the crop on monitor (Figure 3). Because of a poor uniformity of water distribution, some areas of the plots were over-irrigated, whereas other parts remained dry. The poor uniformity of water distribution along the fields negatively affected germination, as we can see the areas with weak growth as a result of over-watering or poor irrigation (Figure 8). The cost of land leveling is high, 300 AZN ha^{-1}, which is not affordable for most of the farmers.

It was observed that after completion of the border-strip irrigation in the field under winter wheat, the soil moisture was measured 17-20% beyond *FC*, only at the end of the 4^{th} day reaching *FC*, with a moisture storage volume of 3,700-3,800 m^3 ha^{-1} in the one-meter soil layer.

The farmers do not have enough capacity to fully apply deep plowing, cultivation, application of temporary surface drainage, chemical melioration and farming tools, which aggravates the situation.

Thus, irrigated agriculture analyses by multilevel approach shows that the actual cost of irrigation water delivery and distribution is AZN 9.2/1,000 m^3 (1 USD = 1.50 AZN as per June 2016). The irrigation water mineralization may cause risk of soil re-salting. Most of the canal structures for water delivery and distribution are primitive and in a poor condition. The collector drains partly lost their depth because of silt deposition and weed growth, and insufficient cleaning of the on–farm drains. The operation of pumps takes averagely half of the allocated funds. The uniformly fixed public fee throughout the country for supplied water to the WUUs is AZN 0.5/1,000 m^3. The water fee for the WUU members is AZN 1.40/1,000 m^3, which is approved by the WUU administration actually covering about 25% of the required minimum O and M costs. The changes in the cropping pattern in recent years are not appropriate for sustaining the fertility level of the soils. In Salyan steppe 17,568 ha irrigated

Figure 7. Plots under new wheat cropping, Salyan (2013).

lands have middle and high degree of salinization and 35,170 ha or 44% of the irrigated land needs to be reclaimed through soil leaching. The groundwater level of 1.5-2.0 m below soil surface is 45% of the total irrigated land (HGASE, 2015).

The results of the analyses demonstrated the following tendencies:

- Irrigation water loss increase during conveyance, distribution and usage in the field;

- No significant rising of the main agricultural crop yields;

- Inadequacy of measures to maintain the irrigation and drainage infrastructure in a good working condition;

- Difficulties in application of crop rotations, necessary farming and irrigation technologies due to the small sizes of the plots;

- Worsening of ameliorative conditions of the irrigation lands,

- Inadequate experience and capacity of WUUs in operation of the on-farm network.

The following key integrated measures for irrigation improvement are proposed:

1) ***Reduce the water losses****:* lining the bed of the main canal system with waterproof coating or if feasible to apply a closed type network, also to equip the necessary water metering, water distribution facilities for reliable water delivery; to support farmers for land leveling which can be arranged through the special subsidy policy on a periodic basis.

2) ***Improvement of the agriculture land usage*****:** optimization of the plot sizes by farm consolidation, re-planning of the on-farm road network, construction of the closed-type drainage system, for rising of the land use efficiency. The farm consolidation policy makes it necessary to develop appropriate normative legal framework and wide explanatory work among local farmers on its benefits.

3) ***Improvement of the farming practices****:* restoration of crop rotation, improvement of surface irrigation methods, updating of the irrigation norms and compliance with the irrigation and land fertilization regimes. Adoption of innovative irrigation techniques like Regulated Deficit Irrigation (RDI), SubSurface Irrigation (SSI) in combination of efficient fertilizer application. Application of drought and salinity resistant, more productive seeds and necessary agricultural machinery;

4) ***Raising knowledge of the farmers on farming practices:*** targeted training programs on economic and ecological aspects of the agricultural activity, increasing farmers' skills and capabilities in management of their lands, operation of on–farm system. This program should be supported by the scientific-research institutions, which will also promote strengthening of their capacity and improve the quality of researches based on the advanced experiences.

5) ***Capacity building*:** It requires an appropriate mix of competent personnel, technologically advanced devices and facilities, legal guidelines and administrative efficient and effective processes for the sustainable management of the irrigation water resources.

Currently, the Government of Azerbaijan is implementing the WUU infrastructure rehabilitation project (World Bank, 2010b). A limited amount of off-farm infrastructure improvements is undertaken as necessary to ensure effective delivery of water to rehabilitated on-farm systems (World Bank, 2011). However, according to the results of the current study in spite of certain positive outcomes of the realized projects, these arrangements *cannot be considered as equal and sufficient for a proper solution of the current problems in the service area of a single irrigation system management administration for a long term perspective and a set of measures should be applied covering the whole system improvement.*

In order to achieve efficient irrigated agriculture within one district investments for improvement of the water conveyance, the distribution network and water usage at field level as well as measures related to the farming structure, WUA institutional development, sown structure, etc. should be elaborated and realized within a single *goal-oriented* program.

CONCLUSIONS

Through different experiences and studies of irrigated agriculture, improvements from various countries with different economic backgrounds was briefed in order to demonstrate that the variety of problems and the ways of their solution depends on the status and role of the irrigated agriculture in each country. Since the problems of the irrigated agriculture exist at all levels of irrigation management, it was substantiated that under current farming conditions multilevel approach for irrigated agriculture rationalization is more appropriate to be applied in Azerbaijan. The analyses in Salyan Steppe are conducted to define main shortages of the irrigated agriculture and use its results for future feasibility studies. The current study shows that only one-third of the water taken from the source is used by the crops and the remaining amount is lost or returning to the drainage system. Besides poor irrigation infrastructure, the additional factors negatively influencing irrigated agriculture are due to the small size of individual plots (1-2 ha), limited income and insufficient capability of farmers to use required farming techniques. The investment programs implemented in the country cover the limited measures mainly at selected on–farm irrigation systems and for this reason their contribution for overall irrigated agriculture improvement cannot be expected to be significant. Therefore, the concept of rehabilitation and other improvement measures (economic, institutional etc.) must be elaborated as integrated arrangements within a single *goal-oriented* program. Thus, the application of the integrated measures to reduce unproductive water losses, improve agriculture land usage, farming practices and raise knowledge of farmers on modern farming practices are highly recommended.

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راه اندازی عقلانی کشاورزی آبی در آینده: تجزیه و تحلیل چندسطحی برای Salyan steppe ، جمهوری آذربایجان

رضایو

چکیده

در این تحقیق، روشهای فعلی کشاورزی آبیاری در منطقه خشک بر مبنای رویکرد چندسطحی مورد توجه قرار گرفته و اقدامات یکپارچه برای بهبود آن پیشنهاد شده است. تحقیقات در سالیان استپ جمهوری آذربایجان انجام شد که یکی از مناطق خشک معمول کشور است. هدف این مطالعه بررسی و آنالیز ویژگی های تاثیر گذار بر کشاورزی آبی و تعیین اقدامات لازم مطابق شرایط اقتصادی و محیطی پیش رو در زمین و آب مورد استفاده در کشاروزی است. نتایج تجزیه و تحلیل، تعداد زیادی از مشکلات در تمام سطوح مدیریت کشاورزی را نشان می دهد. کشاورزی آبی در کشور با مشکلات زیادی به دلیل شرایط فیزیکی به وجود آمده از زیر ساخت های آبیاری، ساختار کشاورزی و شیوه های کشاورزی موجود، بوجود آمده است. نیاز برای بهبود ساختار آبیاری در تمام مناطق مشهود است زیرا در طی انتقال و توزیع در سطح زمین، میزان بهره وری و راندمان آب بسیار پایین بود. ساختار فعلی کشاورزی که شامل زمین های کوچک و اعمال آبیاری سطحی می شود، استفاده در از آب های آبیاری و استفاده از زمین را در آینده دچار مشکل می کند. به علت دلایل ذکر شده، پیشنهاد می شود که مفهوم نوسازی و سایر اقدامات ضروری (اقتصادی، نهادی و غیره)، به عنوان طبقه بندی های یک پارچه درون برنامه واحد هدفمند، به جای بهبود کار محدود در سطح جدای سیستم آبیاری، تعریف و مشخص شوند.