UNIVERSITY OF CENTRAL ASIA
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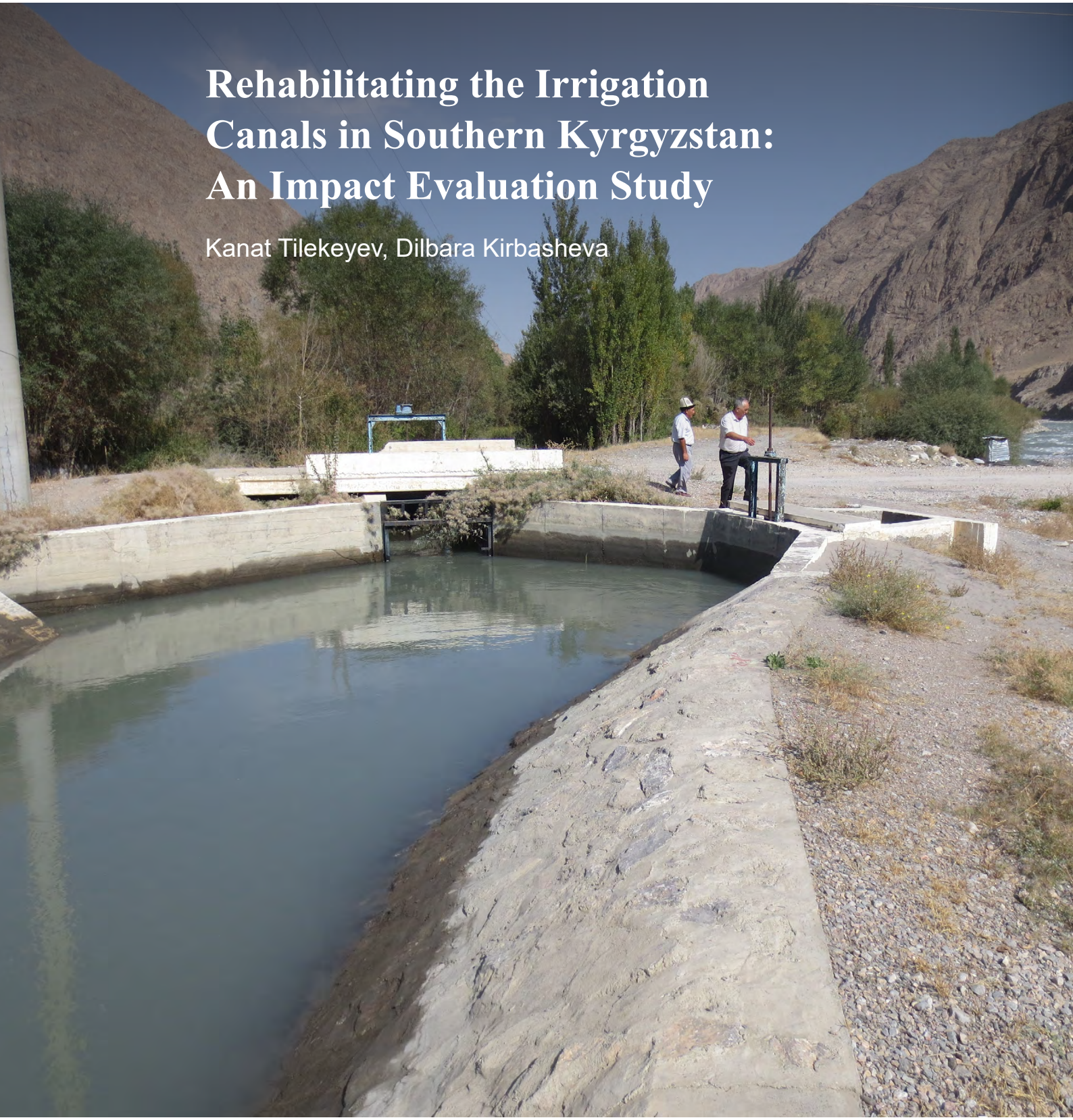
Rehabilitating the Irrigation Canals in Southern Kyrgyzstan: An Impact Evaluation Study

Kanat Tilekeyev, Dilbara Kirbasheva



Working Paper #69, 2022

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Abstract: Irrigation canals rehabilitation is one of the widespread interventions used to revive agricultural development in the number of developing countries. Impact of that intervention often become questionable in the literature. The study provides an analysis of the randomized control trial method based on a comparison of two groups of owners of land plots in pilot and control areas. Two waves of the panel survey collect household-level microeconomic data from the crop production farmers – owners of the land plots in Southern Kyrgyzstan in 2016 (prior to the irrigation canals rehabilitation) and in 2019 (after the rehabilitation intervention occurred). Sample size reaches 740 farmers in 2016, and 676 farmers in 2019. Difference-in-differences (DD) method demonstrate a positive relationship between irrigation canals rehabilitation and crop production volumes in monetary and natural terms in the target area's zones compared to those without irrigation canals rehabilitation. The statistical significance of the model measured in monetary form demonstrates a higher level of statistical error. At the same time the result was more desirable for the uniform indicator measuring crop production in-kind.

Keywords: Kyrgyzstan, agriculture, impact evaluation, irrigation, crop production, institutional development

JEL classification: D02, D04, C52, Q12, Q11, Q15

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Kanat Tilekeyev is a Senior Research Fellow at the IPPA UCA since 2012. He is mainly involved in research projects of the World Bank, USAID, FAO and other donor and research organizations in the spheres of impact evaluation, socio-economic analysis, trade, SMEs/supply chains, agriculture, climate change, and poverty analysis. He obtained his Ph.D. in Economics from the University of Giessen, Germany in 2012. Previously, he worked in the private sector and development projects in areas of fiscal reform, rural development, transport and transit issues, business consulting and the food industry.

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On the cover: General view of the head water intake structure of the Ak-Tatyr canal.

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List of Acronyms

AA	Aiyl Aimak (administrative-territorial unit in Kyrgyzstan consisting of one or more villages)
AKF KG	Aga Khan Foundation in Kyrgyz Republic
BMI	Biomass indicator
CPI	Crop Production Index
DFID	Department for International Development
DiD	Difference-in-Differences method
GDP	Gross Domestic Product
MSDSP KG	Mountain Societies Development Support Program in Kyrgyzstan
WUAs	Water Users Associations

List of Currencies

USD	US Dollars
GBP	British pound sterling
KGS	Kyrgyz Som (Kyrgyz national currency)

1. Introduction

The report presents the results of an impact evaluation exercise that aims to explore the linkage between irrigation canals rehabilitation and crop production levels of farmers located in the target zone of the intervention. The target intervention zone covers three irrigation canals rehabilitation in South Kyrgyzstan – two canals in Batken oblast and one canal in Osh oblast. The project was funded by the Department for International Development (DFID) and the Aga Khan Foundation in Kyrgyz Republic (AKF KG). The research component of the project entailed an impact evaluation of irrigation canals rehabilitation, which was implemented by the Institute of Public Policy and Administration of the University of Central Asia.

Irrigation canals are one of the key elements of agricultural activity in Southern Kyrgyzstan due to the dependence on the irrigation water supply in a dry climate with a limited precipitation during vegetation period. Thus, any problem with the irrigation canals due to the deterioration of physical capacity can lead to the immediate decline of water throughput and consequently a low crop production level. Investments in physical infrastructure have been very low in Kyrgyzstan's agricultural sector during the last few decades. Underfinancing of agricultural infrastructure in combination with a weak knowledge base of smallholder farmers and undeveloped institutional issues have caused low productivity of Kyrgyzstan's agriculture sector[1].

Study analyze the linkage between investments in irrigation networks and higher crop output on the level of household-based smallholder farmers in the project's target areas. The impact evaluation design includes besides the sample of farmers located in the zone near the irrigation canals rehabilitation a control group of households where rehabilitation infrastructure intervention was not proposed. Two waves of panel household-level data were collected in 2016 (prior to the project) and in 2019 (after the rehabilitation). The report presents information about the project including the intervention location and budget. The study context supports an overview of the characteristics of the target area and groups. The impact evaluation design describes the methodology of the study. The survey results offer a comparative analysis of the sample and subsamples in the baseline and endline years and provide details of the evaluation methodology as well as the modelling results. The results of the collected data estimations provide evidence that intervention demonstrates a positive effect on the crop production volumes in monetary and non-monetary terms compared to farmers who did not receive canal rehabilitation infrastructure.

2. Intervention, Theory of Change and Research Hypothesis

2.1. Proposed and realized intervention design

The intervention component goal was to reduce conflicts related to the use and management of natural resources such as irrigation water and pastures in Kyrgyzstan and Tajikistan. Therefore, proposed intervention focused on cross-border and other areas and aims to increase and or improve the following aspects of water supply management:

1. The physical availability of irrigation infrastructure, access to drinking water and pasture resource management for selected communities;
2. The institutional and financial capacity of local, formal and shadow civil society organizations and local government institutions to jointly manage irrigation and pasture infrastructure;

1 Mogilevskii, R. et al., 2017. «The outcomes of 25 years of agricultural reforms in Kyrgyzstan,» IAMO Discussion Papers 253882, Institute of Agricultural Development in Transition Economies (IAMO).

3. The capacity of communities in Kyrgyzstan and Tajikistan to make efficient use of their natural resources;
4. The knowledge of youth on the importance of managing water and pasture resources sustainably, as well as on the tools and approaches to mitigate and de-escalate conflicts.

Current paper concentrates only on the first two components of the program covered by the rehabilitation of irrigation infrastructures in the selected areas of Kyrgyzstan within the intervention implementation. During the four-year of work, 32 infrastructures in Kyrgyzstan were rehabilitated and built, 11 of which for drinking water systems. The total investment amount for the rehabilitation of 32 infrastructures in Kyrgyzstan was 2 203 121 GBP (British pound sterling). This amount made up 64% of the project's budget with the remaining 36% made up by contributions from different sources including the government budget and local farmers' input.

Table 1. Rehabilitation investment project input and contribution structure in 2016-2020

	Project contribution	Partners contribution	Total, GDP
2016–2017	452 494	406 063	858 557
2017–2018	452 494	166 287	618 781
2018–2019	259 356	118 352	377 708
2019–2020	240 719	107 355	348 075
Total (£):	1 405 064[2]	798 057[3]	2 203 121

Source: Data provided by MSDSP KG

Expected results from infrastructure investments include:

- **Reducing water loss** by 25-35% of the total water received from the government water supply agency.
- **Saving water use:** Water Users Associations (WUAs) will follow new water management tools aiming to receive less water by 25-35% (to reduce irrigation waters usage), and it consequently will reduce the time of use of water inflow by 25-30%.
- The cost of maintaining the canals was reduced by 70-60%, the amount of which saved can contribute towards other interventions.
- Reducing **tensions between water users** due to improved water supply and management.
- Improving the yield of cultivated crops after rehabilitation.
- Improving water usage for irrigation purposes - through better metering and distribution of water.

The intervention development objective was to identify areas that require rehabilitation intervention where necessary. A research approach to those infrastructure interventions was limited due to the focus on irrigation rehabilitation only. Implementation of the irrigation interventions and their subsequent evaluation will help answer the following research issues:

- The intervention (irrigation canals rehabilitation) positive impact on the rural crop farmers' performance measured in monetary and non-monetary terms;
- Factors support or contradict irrigation canals improvements (negative and positive determinants) in rural communities in South Kyrgyzstan.

2 of which 309 480 GBP of additional financing

3 157 145 GBP allocated from government budget

Originally, the intervention planned to cover five irrigation canals (Ak-Tatyr, 1-2 Maya, Alysh, Nurgaziev and the Kulundu pumping station), but later due to several reasons only three irrigation canals were rehabilitated: Ak-Tatyr, 1-2 Maya, Alysh (Figure 1). The canals are located in two oblasts – Batken and Osh. In Batken oblast, there are two canals - Ak-Tatyr and Alysh. Meanwhile, 1-2 Maya canal is located in Osh oblast.

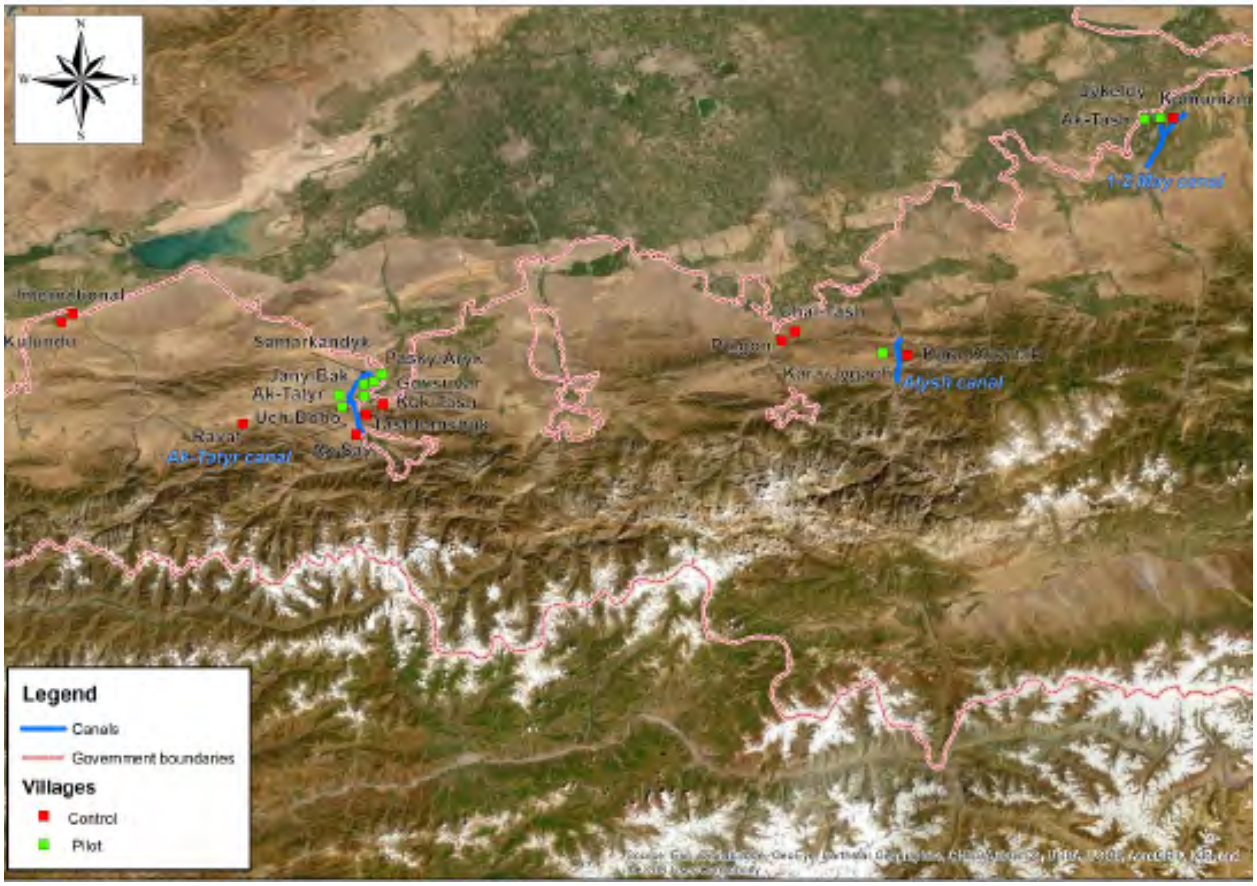
Rehabilitation work on the Nurgaziev canal was canceled due to a refusal received from the district water authority. The refusal was issued because for the work to take place it would have been necessary to dismantle the bridge on the Osh-Batken highway. As such, it was not possible to obtain permission to dismantle the bridge; in addition, there were no funds in the budget for the necessary dismantling.

The rehabilitation of the Kulundu pumping station was canceled for several reasons:

1) The service life of pumping equipment is no more than 3-4 years. Therefore, further maintenance of the pumping station would be difficult.

2) Updating the equipment would not solve the problem of water supply, as the internal irrigation canals were destroyed due to poor maintenance. Neither the external funding nor the local aiyl okmotu had the finance to rehabilitate the internal irrigation system of this pumping station.

Figure 1. Map of the Rehabilitated Canals Areas



Ak-Tatyr canal

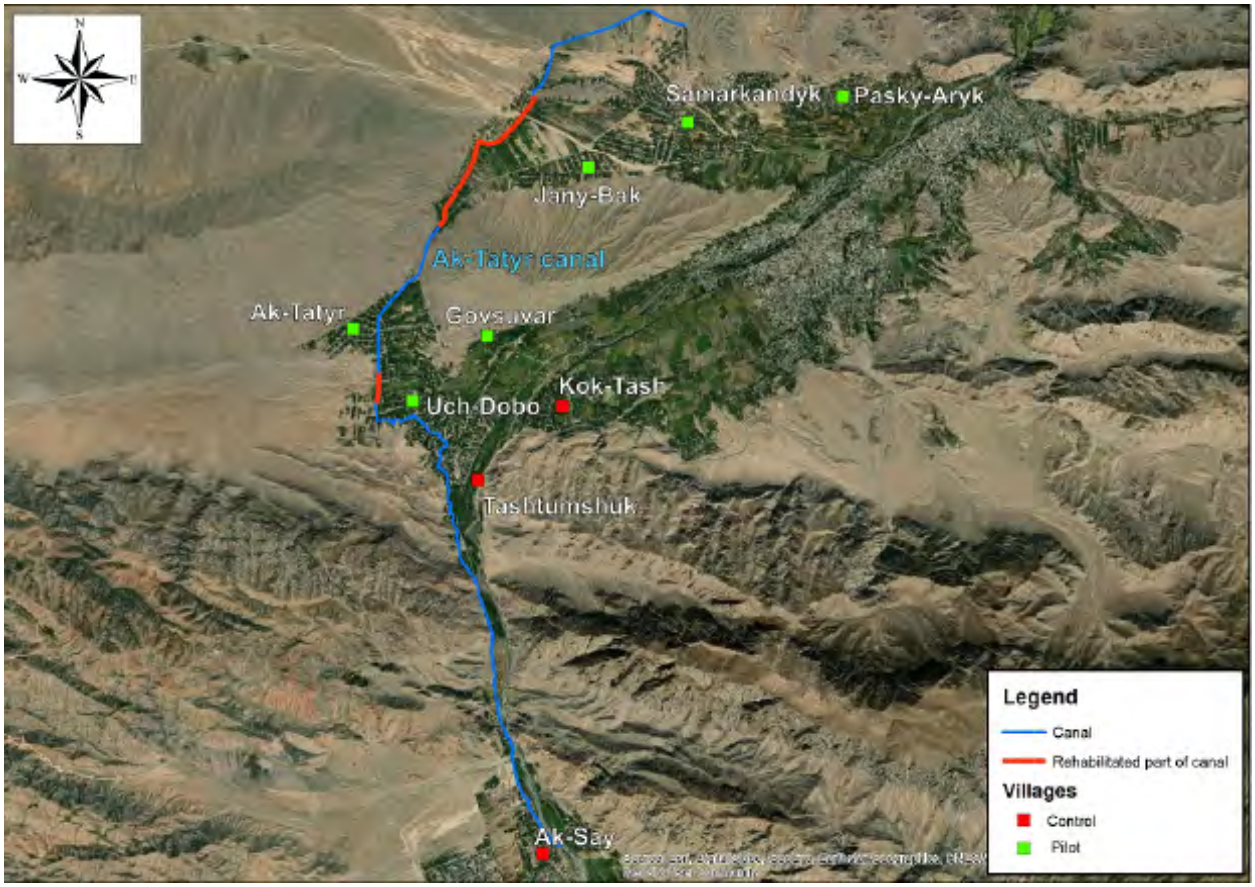
The Ak-Tatyr canal was commissioned in 1970. The area of the canal irrigation was originally 472 ha. After the construction of the canal, the irrigated area later increased by more than 1500 ha (1376 ha on the territory of Kyrgyzstan, while there is no exact information about canal coverage on the territory of Tajikistan). The canal belongs to the Batken district water department. The projected carrying capacity of the canal is 900 liters of water per second. The canal flows from the Isfara River. The canal starts on the Kyrgyz territory, then passes through on to the territory of the Republic of Tajikistan and then flows back to the Kyrgyz side to the village of Samarkandek.

Rehabilitation of the Ak-Tatyr canal was carried out in 2016-2017, and included the following works:

- Mechanized cleaning of over 8 km of the canal which contributed to an increase in the volume of irrigation water flow from 0.9–1.0 m 3/sec to 1.2–1.35 m3 /sec, i.e. 20–35% continuously over the past two years (2018–2019);
- Concreting the part of the canal that helps to reduce water loss for the filtration and siltation of the canal;
- Partial replacement of the most destroyed sections of the canal network on the intra-farm canals of Zhaylma and Ak-Tatyr-1 (125 irrigation system trays).

The total cost of canal rehabilitation amounted to 102 735 GBP[4], of which the intervention contributed 31% of funds. The rehabilitation was carried out jointly along with the Batken district water department, Samarkandek Aiyl Aimak[5] (AA), Ak-Tatyr AA, and Ak-Sai AA.

Figure 2. Map of the Ak-Tatyr canal



4 Exchange rate 1 GBP=90.58 KGS in 2019

5 Aiyl Aimak- administrative-territorial units consisting of one or more villages.

Figure 3. View of the concrete covered part of the Ak-Tatyr canal – the intra-farm part of the canal (left photo) and view of the tray section of the Jaiylma canal (right photo)

Source: field study photo

The 1-2 Maya canal

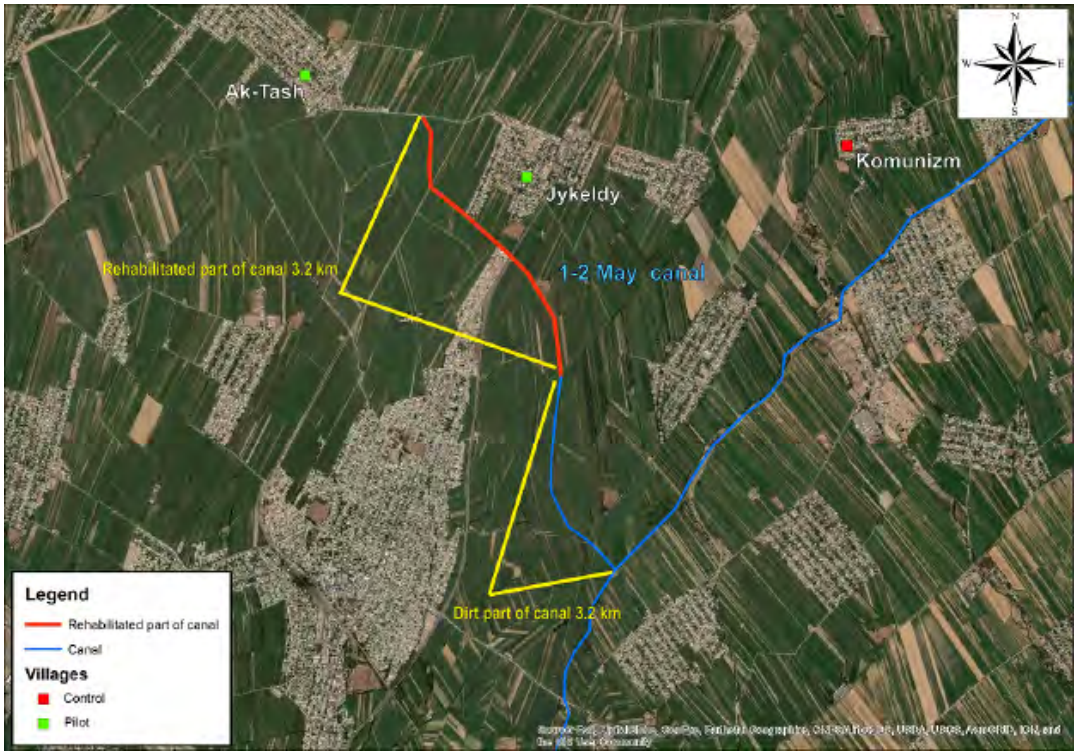
The intra-farm canal 1-2 Maya takes its water from the intra-farm Vuam canal, which is on the right side of the Ak-Buura River in Osh oblast. The canal was built in 1939. Currently, it is used to water 809 ha of land of "Kum-Aryk Bel" WUA. The length of the canal is 5.5 km, and it has a low irrigation capacity (flow rate of 0.6–0.8 m3/sec). Currently, the intra-farm 1-2 Maya canal is on the balance of and is used by the "Kum-Aryk Bel" WUA.

The 1-2 Maya canal in Ak-Tash Aiyl Aimak, Kara-Suu aiyl okmotu, was rehabilitated for a total of 103 178 GBP (of which 74% was financed by the project and the remaining funds provided by residents and from the local budget of Ak- Tash AA). As part of the project, reinforced concrete trays were installed at 3100 m and the water supply to 809 hectares of land was improved for more than 9300 residents.

Figure 4. View of the rehabilitated part of the 1-2 Maya canal by reinforced concrete trays

Source: field study photo

Figure 5. Map of the 1-2 Maya canal



Alysh canal

The inter-farm canal Alysh was built in 1916. It is situated on the left side of the Isfairam River in Batken oblast. It was built to water 231 ha of irrigated land of the villages Kara-Jygach and Alysh. The length of the canal is 17 km. Its maximum capacity is 3 m3/sec. The canal takes its water from the Isfairam River. The canal is on the balance of Kadamjay rayon water farm management and is financed by the government.

The total cost of rehabilitation of the intra-farm Alysh canal is 10 132 GBP - 50% from the project, and another half was provided by the rayon water farm management and local WUA.

In 1997, there was a severe debris flood on the Isfairam River and due to flushing from the river, the canal wall was under threat of destruction. With the support of the project, the emergency section of the canal at a length of 60 meters was strengthened and the threat of water supply interruption was prevented.

Figure 6. View of the Alysh canal before rehabilitation (left photo) and after rehabilitation (right photo)

Source: field study photo

Figure 7. Map of the Alysh canal

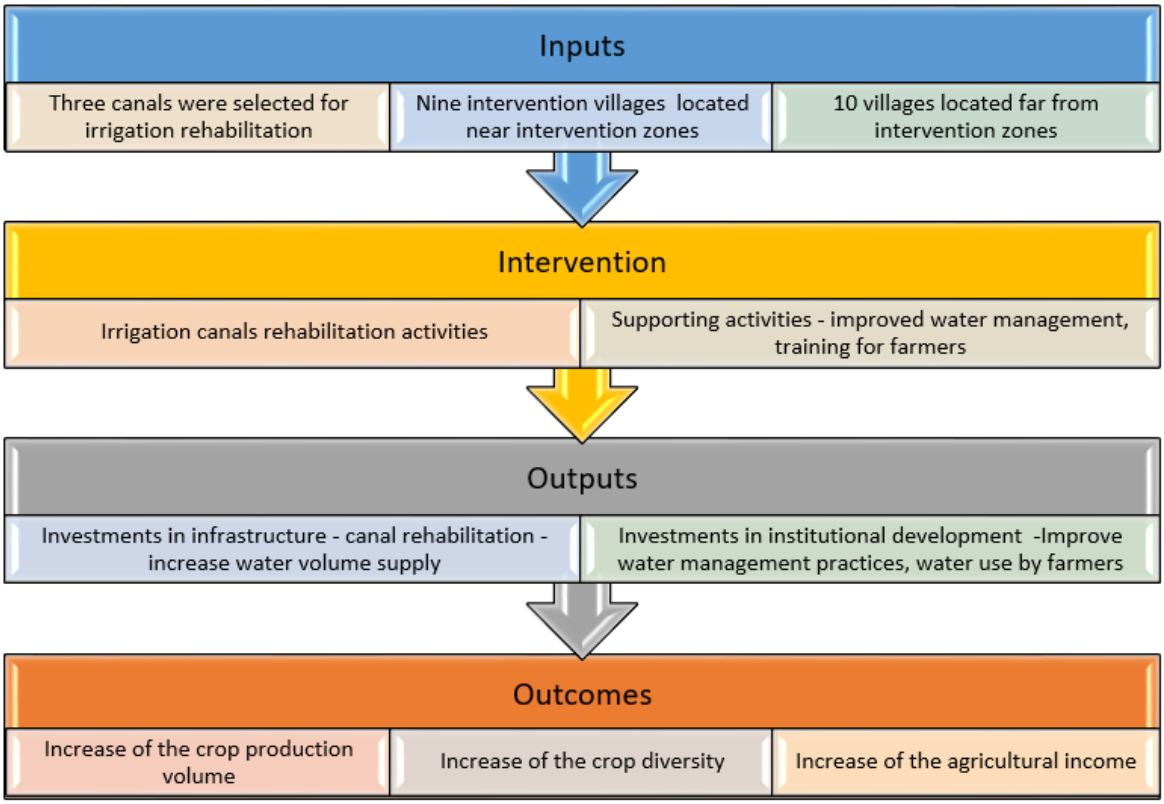
2.2. Theory of Change

The intervention applies the universal approach to the theory of change for agricultural development areas. Improvement in irrigation infrastructure should also bring improvement in the water supply to the farmers and lead to an increase in production volumes of crop cultivation or to a change of the crop structure to those more vulnerable to the water supply. According to the theory of change, the main components of the project intervention are:

1. Nine interventions and 11 control communities are purposively selected for the project and impact evaluation;
2. Within the rural community, land plots were randomly selected to be representative from the view of the landowners;
3. The project implements irrigation canals rehabilitation investments in three canals covering nine intervention villages.

The mechanism linking the intervention inputs with the outputs, and the outcomes of the irrigation system improvement are presented in Figure 8. There are two major outputs of the realized canal rehabilitation. First, during the project intervention, water supply must be improved by water supply organizations (WUAs) through repair of problematic part of the irrigation canals. This type of intervention improves the material part of the irrigation infrastructure. However, there were also activities done focusing on 'soft' skills - improvement of water use by farmers, improvement of fee collection from farmers, and improvement of water management within WUAs. Implementation of all the activities may bring about an improvement of the water supply and management on the farmer level and lead to an increase in the water supply - a scarce resource in the natural conditions of South Kyrgyzstan. It also might lead to the improvement of the crop structure – and increase the cultivation of water-consuming commercial crops. Thus, the final crop product obtained from land plots by farmers in the intervention's areas need to be increased.

Figure 8. Theory of change of the irrigation canals rehabilitation intervention



3. Study context

3.1. Study site and Target group

The study site is located in the mainly rural, southern part of the Kyrgyz Republic bordering with Tajikistan, Uzbekistan, and China. The study area includes Batken, Leilek, and Kadamjai rayons of Batken oblast and Kara-Suu rayon of Osh oblast. Batken oblast borders with Tajikistan, Uzbekistan and Osh oblast of the Kyrgyz Republic. Osh oblast borders with Uzbekistan, Tajikistan, China, and Batken, Jalal-Abad, Naryn oblasts of the Kyrgyz Republic. In 2018, the population of Batken oblast was 525 100, which shows a 4% growth compared to 2016 (503 500). The population of Osh oblast in 2018 amounted to 1 341 900, which indicates a 4% growth compared to 2016.

The research area includes farmers living in Samarkandek, Jany-Bak, Pasky-Aryk, Uch-Dobo, Ak-Tatyr, Govsuvar, Kara-Jygash, Ak-Tash, and Jylkeldi AAs, who use the irrigation canals (Ak-Tatyr, Nurgaziev, Pervoe Maya, Alysh canals and Kulundu pumping station). It includes as canals selected for rehabilitation and control zone where rehabilitation wasn't done.

The territory of Batken oblast is 1,700,000 hectares, including 64,600 hectares of agricultural arable land that makes up 6.2% of all arable land in the country[6]. The territory of Osh oblast is 2,900,000 hectares, including 179,300 hectares of agricultural arable land that makes up 17.2% of all arable land in the country.[7] Due to the unsatisfactory technical conditions of the irrigation canals water transportation losses exceed 40% of water[8]. Meanwhile, due to the aging irrigation infrastructure constructed

6 National Statistical Committee of the Kyrgyz Republic. (2018). Land held by peasant (farmer) households. Retrieved March 11, 2020, from http://stat.kg/ru/statistics/selskoe-hozyajstvo/

7 ibid

8 Kabar. (2017). Irrigation: Kyrgyzstan enters a new round of development. Retrieved January 28, 2020, from http://kabar.kg/news/irrigatciia-pravitel-stvo-kr-vykhodit-na-novyi-vitok-razvitiia/

mainly during the Soviet period, farmers who mainly engage in crop production experience certain difficulties in increasing the productivity of their agricultural land.

In 2018, Batken oblast was among the oblasts in the Kyrgyz Republic with the highest poverty rates where 33.8% of people had an income level below the poverty line. In Osh oblast, the share of people living below the poverty line was 14.8%, which is lower than the country average. In 2018, 22.4% of all Kyrgyz citizens (more than 1.4 million) had an income level below the poverty line. Compared to 2016, the poverty level in both regions has decreased: in Batken, from 37 to 33.8 %; and in Osh, from 22 to 14.8 %. In 2018, remittances made 11.7% of income in the study regions. The percentage of income from labor migration in total income consists of 31.5 % in Batken oblast and 22.2 % in Osh oblast[9]. In 2018, in terms of the total revenue of residents of Batken oblast, the share of income from labor migration amounted to 31.5 %, which is higher than the share of income from household farming - 11.8 %. Contrary to the case of Osh oblast, in 2018 in Batken oblast, 22.2 % of income came from household farming and 9.6 % from working outside the country. Compared with 2016, in 2018 in both oblasts, there was an increase in the share of income from labor migration and a decrease in the share of income from household farming. In Osh oblast, the share of income from labor migration increased from 11.2 % in 2016 to 22.2 % in 2018; the same situation can be found in Batken oblast – from 20.6 to 31.5 %. The share of income from household farming decreased in Batken oblast from 12.9 % in 2016 to 11.8 % in 2018 and from 13.5 to 9.6 % accordingly in Osh oblast.

3.2. The Country's Political, Social and Economic Context

The political situation in the Kyrgyz Republic is dynamically changing. Since gaining independence in 1991, the president of the country has changed four times as well as the country's government. The open opposition of people played a big role in overthrowing the president and the government twice[10]: first during the Tulip Revolution in 2005 and then in the Rose Revolution in 2010. There was strong presidential control over resources under the first president in Kyrgyzstan, who appointed regional administration and province governors. Regional heads in turn appointed low-ranked public officials. After the Tulip Revolution, local governments could restore the former top-down order by gaining more power over local-level decisions. In 2010, Kyrgyzstan adopted a new constitution, which resulted in the transformation of the political regime from a presidential to a semi-parliamentary system. The new system of government allowed the elected part of the government to execute greater control over the distribution of public resources and public procurement decisions[11].

The economy of the Kyrgyz Republic is based on the mining of gold, the development of the trade sector, agriculture, and remittances from labor migrants. During 2013-2018, the country's gross domestic product (GDP) was around $7 billion with an average GDP per capita of $1,278. In 2016, remittances contributed 34.5% of the Kyrgyz Republic's GDP[12]. Around 20% of the population is working in Russia because wages are higher there than in the Kyrgyz Republic[13]. Most of the labor migrants are young people leaving the southern regions of the country due to high poverty and a lack of job opportunities. Over the past decade, the unemployment rate in the country was around 8.5%, and among those employed 40% report working excessive hours and 26% about earning a low salary.

9 National Statistical Committee of the Kyrgyz Republic. (2018). Poverty Level in the Kyrgyz Republic. Retrieved January 25, 2020, from http://www.stat.kg/en/publications/uroven-bednosti-v-kyrgyzskoj-respublike/

10 During the paper preparation period third revolution occurs, which is not presented here due to the fact that this event is outside the time frame of our research.

11 Engvall, J. (2018). From Monopoly to Competition: Constitutions and Rent Seeking in Kyrgyzstan. Problems of Post-Communism, 65(4), 271-283.

12 OECD. (2018). Social Protection System Review of Kyrgyzstan. Retrieved January 30, 2020 from https://www.oecd.org/countries/kyrgyzstan/Social_Protection_System_Review_Kyrgyzstan.pdf

13 National Statistical Committee of the Kyrgyz Republic. (2017). Women and Men in the Kyrgyz Republic, 2012–2016. Bishkek.

A great portion of private activities in the Kyrgyz Republic is shadow. In 2014, shadow employment accounted for 71.8% of the country's total employment. In the case of the agricultural sector, 67% of self-employed are women and 53.8% men[14].

In the rural south of the Kyrgyz Republic, agriculture is the main source of living and earning an income. The development of agriculture is complicated further by the country's landscape: 90% of the territory of the Kyrgyz Republic is mountainous. During 2000–2016, the share of agriculture in the economic growth of the country declined from 36.6% to 14.4%[15]. The share of people employed in the agricultural sector decreased almost two times from 53.1% in 2000 to 29.3% in 2015. The decline of the agricultural sector accompanied by the decreasing poverty in rural areas of the country. Most of poor people (74%) live in rural areas of the Kyrgyz Republic, 60% of whom populate the southern regions of the country. The southern regions of the country face particular pressure arising from unequal access to water and the poor conditions of irrigation infrastructure. In the absence of proper water management and irrigation infrastructure in the south, the loss of water resources could account for the long-term agricultural losses.

Local governments started to play a key role in local and regional development from the beginning of the century. The Constitution of Kyrgyzstan recognizes local self-governance and the principle of autonomy (Section VIII). Local governments of the Kyrgyz Republic have an executive (ayil okmotu) and a legislative body (ayil kenesh)[16]. In 2001, all localities adopted the principles of local self-government. Local governments were responsible for managing the access of people to locally available public services, including the provision of drinking water. However, local governments lack the capacity and resources to execute adequate water management.

Unresolved border disputes and the lack of transboundary cooperation between the Kyrgyz Republic, Tajikistan, and Uzbekistan resulted in social tensions that became a key obstacle for the development of the country's border regions. In 2018, the Government of the Kyrgyz Republic adopted the national development program that highlighted the importance of regional development allowing guaranteed access to public services for the local population. It should be noted that border conflicts hamper the development of southern regions of the country in particular. Such social tensions are mainly between Kyrgyz and Tajik residents over access to and the use of natural resources, including access to water for irrigation and pasture for grazing livestock. Water conflicts appear annually during the irrigation period (April to June). The Kyrgyz Republic and Tajikistan share about 40 canals, which start in one country and flow to another. Farmers living downstream, and who experience a shortage of water, complain about the extensive use of water by farmers living upstream of the water source[17]. The water infrastructure on the Kyrgyz-Tajik border is aging and does not work at full capacity, resulting in considerable water losses. The governments of the Kyrgyz Republic and Tajikistan do not have strong economic grounds to invest in the rehabilitation of the transboundary water systems[18].

The "National Development Strategy of the Kyrgyz Republic for 2018-2040" plan the following activities in the target zones:

14 National Statistical Committee of the Kyrgyz Republic. (2017). Women and Men in the Kyrgyz Republic, 2012–2016. Bishkek.

15 ADB. (2018). The Kyrgyz Republic, 2018–2022 —Supporting Sustainable Growth, Inclusion, and Regional Cooperation. Retrieved January 30, 2020 from https://www.adb.org/sites/default/files/institutional-document/455921/cps-kgz-2018-2022.pdf

16 World Observatory on Subnational Government Finance and Investment. (2019). Kyrgyzstan. Retrieved January 25, 2020 from http://www.sng-wofi.org/country-profiles/Fiche%20KYRGYZSTAN.pdf

17 Kurmanalieva, G. (2018). Kyrgyzstan and Tajikistan: Endless Border Conflicts. L'Europe en Formation, (1), 121-130.

18 Toktomushev, K. (2017). Promoting Social Cohesion and Conflict Mitigation: Understanding Conflict in the Cross-Border Areas of Kyrgyzstan and Tajikistan. University of Central Asia, IPPA, Working Paper, (40). Retrieved January 25, 2020 from https://www.ucentralasia.org/Content/Downloads/UCA-IPPA-WP-40_PromotionCrossBorderSocialCohesion_Eng.pdf

Batken oblast

Most public investments should be directed to the rehabilitation and construction of the irrigation systems. Also, special cash injections should be made in the construction and modernization of transport and energy infrastructure. It is important to continue the work on the delimitation and demarcation of borders with neighboring Tajikistan and Uzbekistan. The following is planned:

- To additionally put into operation 5,300 hectares of newly irrigated land.
- To construct and rehabilitate drinking clean water supply systems in 107 villages.
- To construct and rehabilitate the drinking water supply and sewerage systems in the cities of Batken, Kyzyl-Kiya, Isfana, Sulukta.

Osh oblast

The city of Osh may potentially become the regional center of the Ferghana Valley. This will require attracting investment in the construction and modernization of large facilities, including the city's ring road, Osh airport, and regional educational and health centers. Osh oblast is part of an important international transit route, therefore, funds must be sought for the modernization and rehabilitation of transport infrastructure. The following is planned:

- Additional commissioning of 2,150 hectares of newly irrigated land.
- Launch of construction of the China-Kyrgyzstan-Uzbekistan railway.
- Modernization of Osh airport.
- Construction and rehabilitation of drinking water supply systems in 121 villages.
- Construction and rehabilitation of drinking water supply and sewerage systems in the cities of Osh, Kara-Suu, Uzgen, Nookat.

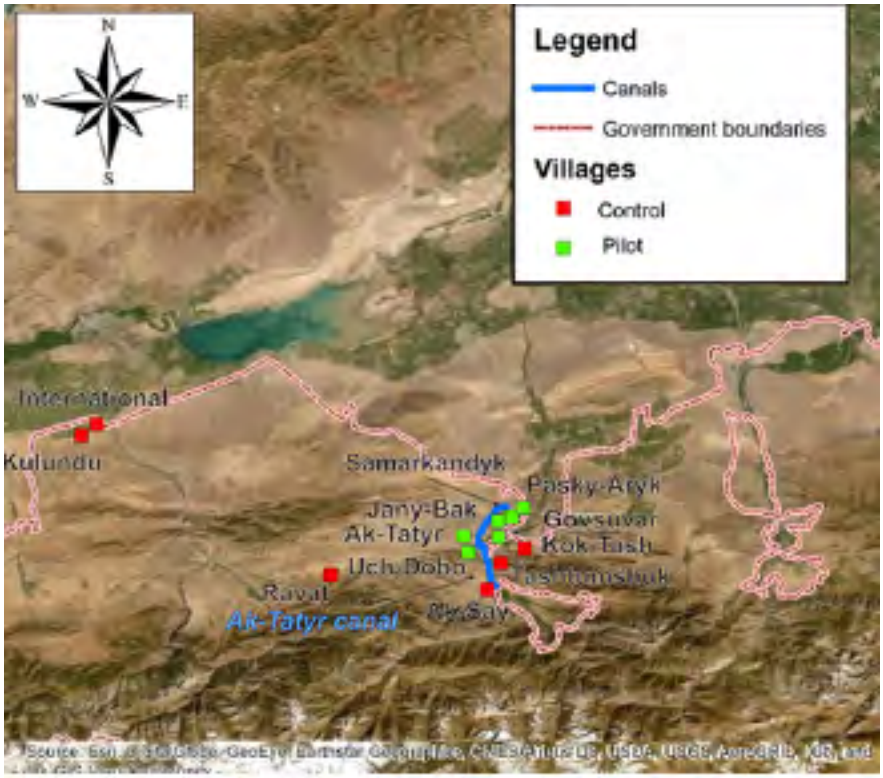
4. Evaluation: Design, Methods, and Implementation

4.1. Study Identification Strategy

The research methodology applies a randomized control trial method based on a comparison of two groups of owners of land plots in pilot and control areas. The research rests on the hypothesis that the owners of land plots in the pilot zone are more likely to demonstrate an increase in crop income after the intervention compared to those receiving no intervention. The evaluation design is based on a difference-in-differences (DD) method. Two types of groups are observed in the study: pilot and control for two time periods (before and after the canal rehabilitation is implemented).

Research team conducted a baseline survey in October 2016 – March 2017. Overall, 740 primary land plots were included in the baseline survey, with 370 in the pilot and 370 in the control villages. The list of canals was provided by the Mountain Societies Development Support Program in Kyrgyzstan (MSDSP KG) in October-November 2016.

Figure 9. Pilot and control villages in the example of the Ak-Tatyr canal area



Initially, the list included five canals where rehabilitation was planned ("Ak-Tatyr" canal, "Kulundu" pumping station, "Nurgaziev" canal, "1-2 Maya" canal and "Alysh" canal). The areas of the canals were divided into treated and control areas due to the sample size being smaller than initially planned and the differences between the canals. Treated areas are the downward parts of the canal or areas close to the canal, while control areas are the upward parts of the canals or territories further away from the canal. But before the endline study, a technical assessment of the proposed canals showed that two canals from five were not rehabilitated: "Kulundu" pumping station and "Nurgaziev" canal. There was an option to exclude samples of uncovered canals from both groups, but it was decided to analyze households located in the zone of those two unrepaired canals as a control zone. So, the sample size of the survey was changed to 308 land plots in the pilot area and 432 land plots in the control area (land plots irrigated from the "Kulundu" pumping station and the "Nurgaziev" canal were included in the control group).

In the endline survey, the owners of the same land plots that were selected for the baseline study were interviewed again (Figure 10). The method of sampling chosen for the baseline survey was selecting randomly land plots on different distances from the irrigation canal (Figure 11). According to this approach, land plots selected on the map, and their owners were found in the village and interviewed. This approach provides an opportunity to represent landowners and land users in the research area. It allows to concentrate on the specific agricultural activity- crop production. Households without access to land was not represented in the study.

4.2. Sample Size

The survey sample included 740 households from Batken and Osh oblasts. In total, 19 villages of Batken and Osh oblasts were covered by the surveys. Nine villages were from treated (pilot) areas and 10 villages from control areas (Table 2). It should be noted here that all three rayons from Batken oblast were included in the survey, while only one rayon from Osh oblast was included due to the location of one of the canals there.

Figure 10. Selected land plots in the pilot zone of the Ak-Tatyr canal

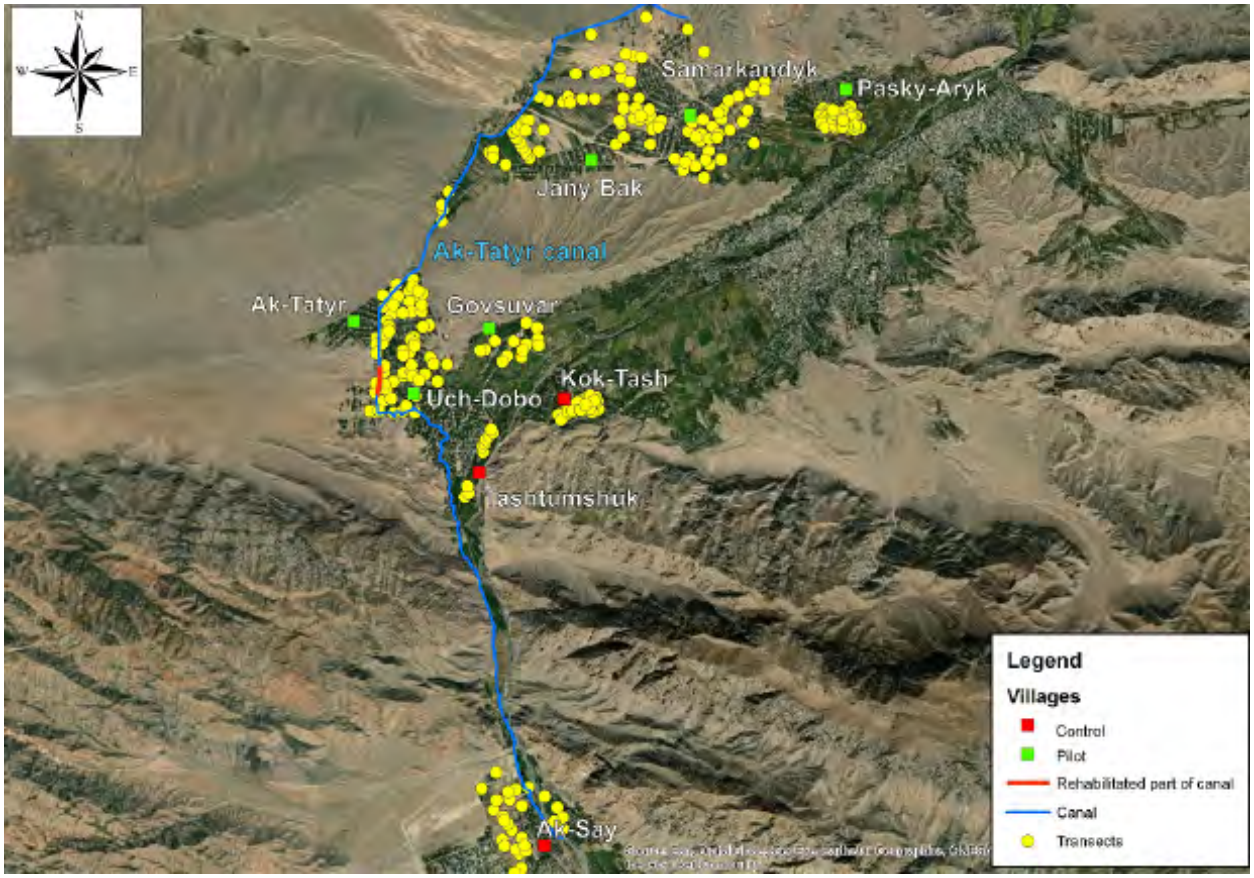


Figure 11. Selected land plots in the control zone of the Kulundu canal

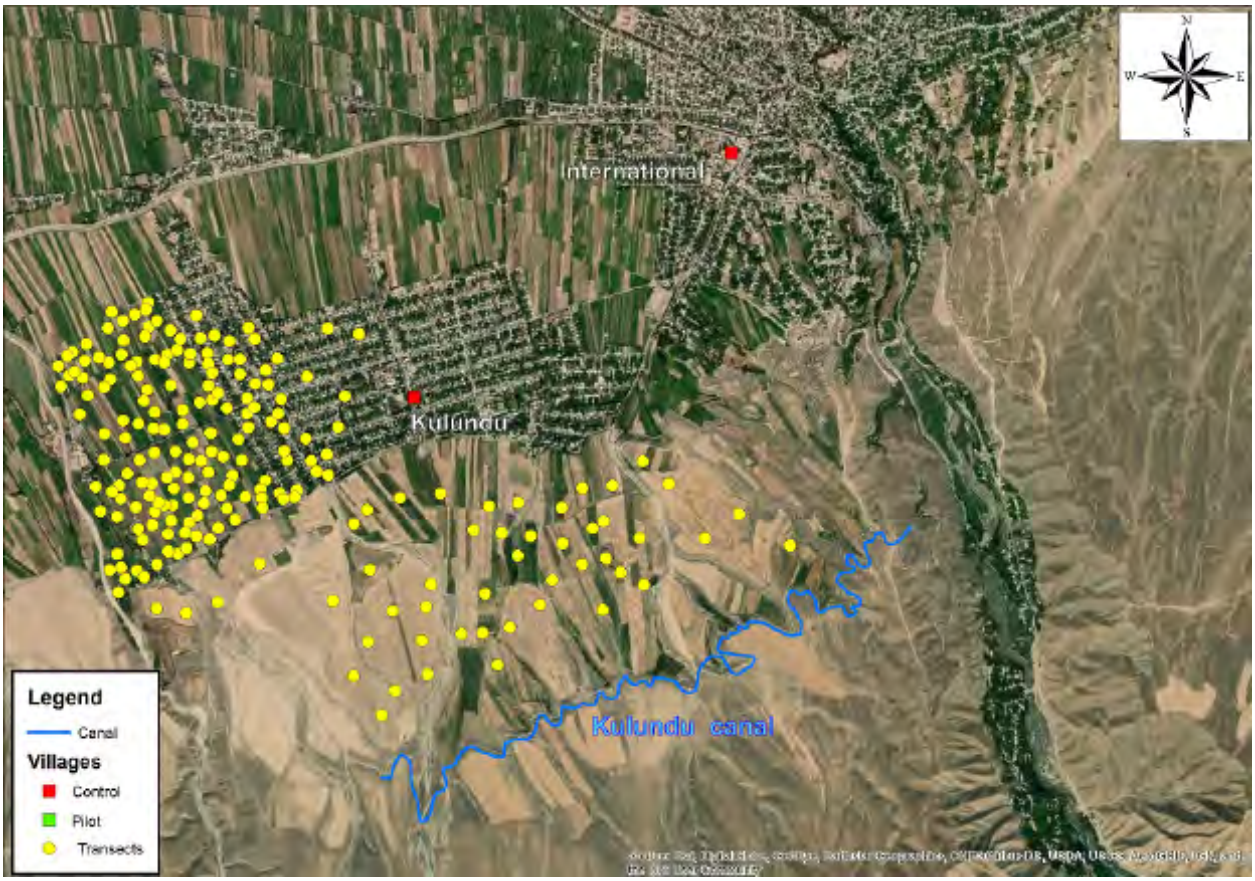


Table 2. Sample size by oblast and rural communities

Oblast	Rayon	Territory	Baseline	Endline	Loss of the sample[19]
Treated area					
Batken	Batken	Pasky-Aryk AA Samarkandek	35	34	1
Batken	Batken	Samarkandek AA Samarkandek	71	59	12
Batken	Batken	Jany-Bak AA Samarkandek	22	21	1
Batken	Batken	Uch-Dobo AA Aksai	22	20	2
Batken	Batken	Ak-Tatyr AA Ak-Tatyr	44	39	5
Batken	Batken	Govsuvar AA Ak-Tatyr	13	13	0
Batken	Kadamjai	Kara-Jygach AA Maidan	20	18	2
Osh	Kara-Suu	Ak-Tash AA Ak-Tash	40	36	4
Osh	Kara-Suu	Jylkeldi AA Ak-Tash	41	39	2
Total			308	279	29
Control area					
Batken	Batken	Tashtumshuk AA Aksai	10	10	0
Batken	Batken	Aksai AA Aksai	28	27	1
Batken	Batken	Kek-Tash AA Aksai	53	50	3
Batken	Batken	Ravat AA Ak-Tatyr	49	49	0
Batken	Kadamjai	Kara-Kyshtak AA Maidan	22	21	1
Batken	Kadamjai	Chal-Tash AA Kadamjay	25	23	2
Batken	Kadamjai	Pulgon AA Kadamjay	13	12	1
Batken	Leilek	Internazionalnoe AA Kulundu	49	47	2
Batken	Leilek	Kulundu AA Kulundu	162	142	20
Osh	Kara-Suu	Communism AA Joosh	21	16	5
Total			432	397	35

The actual sample of the endline survey was 676 households: 308 households in the pilot zone and 432 in the control zone. In total the panel lost 64 survey units. The panel survey loss rate were 8.6%.

4.3. Data Collection

The data collection was conducted by the survey company[20]. It was selected on a competitive basis among seven companies that applied for the announced closed tender in 2016. Survey company hired 14 interviewers and two field supervisors for the survey team of the endline survey. All of them were locals from Batken and Osh regions to be able to perceive local context and get more reliable information.

Two training events were held before the launch of the endline fieldwork: on 13 November 2019 in Osh, and on 15 November in Kyzyl-Kiya. The training consisted of theoretical and practical parts. In both waves, the heads of the households were interviewed as primary sources of information.

Data collection method consisted of the following: formalized personal interviews (face-to-face) with the respondents (owners of selected land plots) in their dwelling with the use of tablets. To conduct

19 Reasons of loss - not found, moved to another region / Russia, refusal to answer, etc.

20 A research company "Rebicon" successfully support the crucial data collection component of the study with an excellent team of interviewers, supervisors and data analysts.

a survey on tablets, an electronic data entry form was developed –using the Survey Solution software package, a platform developed by the Word Bank. The questionnaire was based on the Life in Kyrgyzstan survey with an additional agricultural module adopted for the survey's purposes. The questionnaire was prepared in English, Russian and Kyrgyz. In the endline survey, the questionnaire's content was identical to the questionnaire used for the baseline survey, with only a section on intervention impact assessment added. The fieldwork was carried out from November 18 to December 11, 2019.

In general, the study was conducted without significant obstacles. The most difficult problems included the inability to find suitable households and refusals to participate in the survey (due to the situation on the border with Tajikistan, and sometimes religious reasons, removal of households from the study area etc.).

Besides the face-to-face interviews with households, the research team also conducted a technical assessment of the selected canals. Such an assessment of the technical conditions of the canals is needed to objectively analyze the impact analysis. The technical assessment of the canals was done by an irrigation specialist from Batken oblast, Abdikhalil Madimarov, who was also selected among the participating applicants for this position. The irrigation specialist visited each site, assessed the conditions of the canals/pumping station, and collected information from local administration and local water specialists to get information on various technical indicators and the current stage of the canals' performance.

5. Survey Results

5.1. Comparison of the Basic Characteristics of the Baseline and Endline Surveys

The baseline survey was conducted in Batken and Osh oblasts from October 2016 until March 2017 and the endline survey was done in November-December 2019. The total number of interviewed households for the baseline survey was 740, including 308 households who represented the pilot group and 432 households selected as the control group (see Section 4.2 Sample Size). The households were selected based on the main assumption that every household had at least one land plot used for agricultural activities. In 2016, the average age of the interviewed population was equal to the country average (27 years of age) (Table 3)[21]. In 2019, the average age of the pilot group increased from 27 years to 30 years and the control group from 27 years to 29 years, which demonstrates the expected natural aging of the surveyed population between 2016 and 2019.

The comparison of the baseline and endline survey results shows the change in the population gender composition. In 2016, the majority of the interviewed household heads were males, making up 84% in the Osh oblast and 91% in the Batken oblast. This can be explained by the fact that in rural families in the Kyrgyz Republic, women do not play an active decision-making role in family farming-related activities[22].

21 National Statistical Committee of the Kyrgyz Republic. (2017). Demographic Yearbook of the Kyrgyz Republic, 2012–2016. Bishkek. Retrieved 3 February 2020 from http://www.stat.kg/media/publicationarchive/e9f4dd01-137a-47fc-a90e-f2e7f8f500ff.pdf

22 UNDP. (2018) Kyrgyzstan gender equality strategy. Retrieved 3 February 2020 from https://www.undp.org/content/dam/kyrgyzstan/Publications/gender/UNDP%20in%20Kygyzstan%20Gender%20Equlaity%20Strategy%202018.pdf

Table 3. The demographic profile of the sample

	Pilot group		Control group		Batken		Osh	
	2016	2019	2016	2019	2016	2019	2016	2019
Average age, years	27	30	27	29	29	33	27	29
The share of male population	52%	49%	53%	52%	52%	51%	54%	50%
The share of female population	48%	51%	47%	48%	48%	49%	46%	50%
Male household heads	88%	83%	91%	86%	84%	85%	91%	80%
Female household heads	12%	17%	9%	14%	16%	15%	9%	20%

However, the share of female households increased among the pilot population - from 12% in 2016 to 17% in 2019, and among the control population - from 9% to 14%. This may serve as a signal that over time some women became household heads because the former male heads left their families after divorce or passed away. In 2019, compared to 2016, there was also an insignificant decrease in the share of the male population from 52% to 49% in the pilot group and from 53% to 52% in the control group. The growth of female households can hardly be linked with the participation of male heads in terms of labor migration. Compared to 2016, in 2019 in the pilot group, the number of migrant workers decreased 1.3 times and the volume of annual remittances per migrant dropped 2.5 times (Table 4).

Table 4. Labor migrants and remittances, USD per household and per migrant

	Pilot group		Control group	
	2016	2019	2016	2019
Number of labor migrants	84	67	51	66
Number of labor migrants per household	1.8	1.5	1.4	1.5
Average annual transfer, in US Dollars (USD) per migrant	1,447	1,123	1,110	1,001
Average annual transfer, in USD per household	2,375	948	1,521	773

The comparison of the baseline and endline survey results shows a decrease in the share of people with higher education and an increase of people with vocational education. The share of people with higher education declined from 9% in 2016 to 8% in 2019 in the pilot group and from 8% in 2016 to 6% in 2019 in the control group (Table 5). The diminished number of people with higher education can be explained by a countrywide tendency. The highly skilled are leaving rural areas and moving to urban areas of the country to improve their living conditions. Different from the control group, the share of people with vocational education among the pilot group increased from 4% in 2016 to 9% in 2019.

In the Kyrgyz Republic, school education includes primary level (grades 1-4), basic level (grades 5–9), and secondary level (grades 10-11). In rural areas, around 72% of children aged 7 to 17 years old do not attend school, 40% of whom are children aged 16-17 years[23]. More than 68% of children aged 16-17 years old not attending school are living in Osh oblast. In the study area, in 2016, the share of uneducated people and people with incomplete primary education was higher in Osh oblast (12%) compared to Batken oblast (11%) (Table 5). However, in 2019, the share of uneducated people and people with incomplete primary education in Batken oblast increased up to 13%, contrary to Osh oblast where it decreased to 7%. In 2016, the share of people with secondary education was lower in Osh oblast (40%) than in Batken oblast (46%), whereas, in 2019, it increased in Osh oblast up to

23 National Statistical Committee of the Kyrgyz Republic. (2018). Education and Science in the Kyrgyz Republic. Bishkek. Retrieved 3 February 2020 from http://www.stat.kg/media/publicationarchive/500720d5-e440-4bfd-9e9c-b05c210f5f92.pdf

56%, but decreased to 41% in Batken oblast. Such changes might be explained by two factors - newborn children in the surveyed households and a change in the sample from the baseline point.

Table 5. The education level of household members

	Pilot group		Control group		Batken		Osh	
	2016	2019	2016	2019	2016	2019	2016	2019
People with higher education	9%	8%	8%	6%	7%	7%	18%	6%
People with vocational education	4%	9%	4%	4%	4%	6%	7%	6%
People with secondary education	47%	43%	44%	43%	46%	41%	40%	56%
People with primary education	12%	16%	16%	20%	15%	19%	10%	15%
Uneducated people and people with incomplete primary education	12%	12%	11%	13%	11%	13%	12%	7%
Children under the school age (0-6 years of age)	16%	13%	17%	14%	17%	14%	13%	10%

The comparison of the baseline and endline survey results shows an increase in the officially employed and a decrease in the self-employed and unemployed. The share of the officially employed almost doubled (from 15% in 2016 to 28% in 2019) in the pilot group and increased 1.5 times (from 18% in 2016 to 28% in 2019) in the control group (Table 6). The share of the unemployed declined 1.3 times (from 36% in 2016 to 28% in 2019) in the pilot group, and from 37% in 2016 to 29% in 2019 in the control group. The share of the self-employed decreased from 29% in 2016 to 26% in 2019 in the pilot group, and from 22% in 2016 to 19% in 2019 in the control group. The same dynamics were revealed at the country level: the number of self-employed people decreased by 13% (from 1 million workers in 2016 to 872,300 workers in 2018)[24].

Table 6. The labor market status of household members

	Pilot group		Control group		Batken		Osh	
	2016	2019	2016	2019	2016	2019	2016	2019
Officially employed	15%	28%	18%	28%	17%	25%	14%	33%
Self-employed	29%	26%	22%	19%	17%	20%	64%	32%
Students	5%	7%	5%	6%	6%	7%	2%	3%
Unemployed	36%	28%	37%	29%	44%	31%	5%	16%
Retired	14%	17%	17%	17%	16%	17%	15%	16%

The comparison of the baseline and endline survey results shows a decrease in the number of owned cultivated fields, an increase in the average size of land plots, and the number of rented out land plots. In 2016, from all interviewed households with cultivated land for crop production, 86% of them were also owners of cultivated fields and gardens. Compared to 2016, in 2019, the number of owned cultivated fields decreased 1.2 times (see Table 7). In the case of the pilot group, the average size of the land plots increased from 0.31 in 2016 to 0.33 in 2019. The highest decrease was observed in the number of kitchen gardens that decreased in 2019 compared to 2016 by 1.1 times. At the same time, compared to 2016, in 2019, the number of rented out land plots increased 4.3 times in the case of the pilot group which is roughly two times more than in the case of the control group (2.5 times).

24 National Statistical Committee of the Kyrgyz Republic. (2018). Employment and Unemployment in 2016, 2018. Retrieved March 11, 2020, from http://stat.kg/ru/publications/zanyatost-i-bezrabotica-itogi-integrirovannogo-vyborochnogo-obsledovaniya-byudzhetov-domashnih-hozyajstv-i-rabochej-sily-v-2013g/

Table 7. The agricultural land characteristics

	2016				2019			
	Pilot group		Control group		Pilot group		Control group	
	Number of land plots	Average size, ha	Number of land plots	Average size, ha	Number of land plots	Average size, ha	Number of land plots	Average size, ha
Own cultivated field	276	0.31	359	0.3	230	0.33	305	0.3
Rented in	15	1.30	16	1.0	15	1.60	9	0.9
Kitchen garden	250	0.09	367	0.1	232	0.11	319	0.1
Fallow land	4	0.24	9	0.3	5	0.21	18	0.5
Rented out	3	0.12	20	0.2	13	0.36	51	0.2
Orchard	33	0.14	37	0.3	38	0.13	30	0.2
Hayfield	13	0.50	55	0.5	16	0.41	19	0.6

Separate attention needs to devote to the decrease of the land plots in the sample between 2006 and 2019 (See Table 8). More detailed description of it presented in Table 8. Data demonstrate that in two villages from 19 number of land plots increased. The rest of the sample demonstrates a decline in the number of land plots used. In 16 villages 144 land plots were not used. 64% of the lost land plots located in four villages - Kulundu (54), Ak-Tatyr (16) Chal-Tash (12), Pulgon (10). The biggest loss was in Kulundu village. All villages located close to the border with Tajikistan. The previous year's conflicts on the border led to the decline of the agricultural activity where demarcation line between Kyrgyzstan and Tajikistan wasn't set. It consequently led to a decline in the use of scarce agricultural land.

The comparison of the baseline and endline survey results shows an increase in the living area per person (see Table 9). Compared to the control group, in the case of the pilot group, the share of households with the main source of water supply in a courtyard increased 2.7 times (from 11% in 2016 to 30% in 2019) (Table 9). This can be linked with the implementation of the national program aiming to improve the supply of drinking water.

Compared to 2016, in 2019, contrary to the farmers from the control group, the farmers from the pilot group could benefit from selling peaches, maize, tomatoes, and cotton. If comparing the average income per household (reported by households in 2019 prices), it is clear that in the pilot group the highest income came from selling peaches (Table 10). In 2019, compared to 2016, the farmers' average income from selling peaches increased almost three times. The pilot group farmers' average income from selling maize increased by 73%. Meanwhile, the farmers' average income from selling tomatoes and cotton increased by 38% and 24% respectively. However, contrary to the farmers from the control group, the farmers from the pilot group could not benefit from selling apples and apricots. For instance, the income from selling apricots in 2019 compared to 2016 dropped by 40% respectively.

The results of the endline study showed that the total sown area for crops decreased from 337 ha to 272 ha (80.7% compared with the baseline survey): in the pilot zone, the sown area decreased from 132 hectares to 121 hectares, while in the control zone it decreased from 204 hectares to 151 ha. Also, the number of planted crops reduced from 38 to 32.

Table 8. Decrease of agricultural land plots by villages

Village	Baseline	Endline	Change
Samarkandek	113	119	6
Jany-Back	40	35	-5
Pasky -Aryk	70	63	-7
Uch-Dobo	43	39	-4
Ak-Tatyr	79	63	-16
Govsuvar	27	26	-1
Kara-Jygach	59	58	-1
Ak-Tash	81	82	1
Jylkeldi	82	74	-8
Kek-Tash	102	97	-5
Aksai	55	50	-5
Tashtumshuk	20	16	-4
Ravat	101	98	-3
Kulundu	290	236	-54
Internazionalnoe	96	94	-2
Kara-Kyshtak	68	62	-6
Chal-Tash	66	54	-12
Communism	32	31	-1
Pulgon	33	23	-10
Total	1457	1320	-137

Table 9. Dwelling and drinking water supply

	Pilot group		Control group	
	2016	2019	2016	2019
The living area in dwelling per person, sq. m.	18.5	19.4	20	21.2
The main source of water supply in a courtyard	11%	30%	42%	32%
The main source of water supply on the street	89%	70%	58%	68%

Table 10. The structure of the sown area by major crops in the baseline study, 2016

Crop	Pilot	Control	Batken	Osh	Total
Maize	37%	13%	12%	49%	22%
Apricots	19%	7%	17%	0%	12%
Winter wheat	8%	13%	11%	11%	11%
Burley	0%	17%	14%		10%
Sainfoin (Esparcet)	1%	15%	13%	1%	10%
Cotton	19%	0%		28%	8%
Apples	3%	8%	8%	1%	6%
Hay	3%	8%	9%		6%
Other crops	10%	18%	17%	10%	15%
Total	100%	100%	100%	100%	100%

Table 11. The structure of the sown area by major crops in the endline study, 2019

Crop	Pilot	Control	Batken	Osh	Grand Total
Clover	13%	24%	19%	19%	19%
Cotton	34%	2%		51%	16%
Maize	19%	10%	11%	19%	14%
Apples	5%	15%	14%	2%	11%
Apricots	17%	3%	13%	0%	9%
Burley	0%	12%	9%	1%	7%
Sainfoin (Esparcet)	2%	12%	10%	1%	7%
Winter wheat		8%	6%	1%	4%
Other crops	11%	15%	16%	5%	13%
Total	100%	100%	100%	100%	100%

Comparison of the results of the baseline and endline surveys demonstrate that in crop structure the share of cotton increased in the control zone while maize and winter wheat declined. The areas under apricots also declined but lands under apples increased proportionally. The crop structure in the control zone also demonstrates a decline in winter wheat, burley, sainfoin, maize, and hay. Meanwhile, areas under apples and clover in the control zone increased.

Table 12. Change in crop yields of major crops, t/ha

Crops	Pilot group		Growth rate	Control group		Growth rate
	2016	2019		2016	2019	
Maize	5.1	5.9	16%	4.1	5.6	38%
Apricots	2.2	1.4	-37%	1.6	2.3	41%
Winter wheat	3.6			2.9	2.4	-16%
Burley	3.0			2.1	1.2	-41%
Cotton	3.1	4.0	28%	3.0	1.3	-57%
Apples	12.7	7.3	-42%	3.2	2.2	-30%
Tomatoes	26.0	13.7	-47%	15.4	7.7	-50%
Cherries	3.1	2.0	-36%	1.9	1.2	-36%

Table 13. The average income received reported by households from the sales of selected agricultural products (2019 prices), USD per household

	Pilot group		Growth rate	Control group		Growth rate
	2016	2019		2016	2019	
Peaches	77	305	296%	953	516	-46%
Maize	343	595	73%	295	121	-59%
Tomatoes	131	181	38%	116	98	-16%
Cotton	2096	2610	25%	1549	896	-42%
Apples	380	378	0%	518	879	70%
Apricots	367	222	-40%	255	496	95%
Tomatoes	26.0	13.7	-47%	15.4	7.7	-50%
Cherries	3.1	2.0	-36%	1.9	1.2	-36%

Table 14. The average amount of livestock per household, heads

	Pilot group		Growth rate	Control group		Growth rate
	2016	2019		2016	2019	
Goatings<1 year	4.36	9.63	121%	8.31	9.7	17%
Lambs < 1 year	4.33	7.17	66%	5.81	7.98	37%
Bulls > 1 year	1.26	1.89	50%	1.29	1.44	12%
Chickens	11.89	17.56	48%	14.82	10.6	-28%
Heifers > 1 year	1.16	1.59	37%	1.3	1.5	15%
Goats > 1 year	13.61	15.86	17%	13.2	13.97	6%
Sheep > 1 year	8.53	9.11	7%	10.35	10.04	-3%
Cows	1.78	1.72	-3%	2.15	1.95	-9%
Calves < 1 year	1.31	1.26	-4%	1.64	1.49	-9%

The data in the Table 12 demonstrate the decline of the crop yield for apricots, apples, and tomatoes in the pilot zone. Yet, at the same time, the yield of apricots increased in the control zone, while it declined for the rest of the main crops – burley, cotton, apples, tomatoes, and cherries. Such a significant drop led to the situation that in general crop income declined for all major crop revenues in the control zone compared to the pilot group (Table 13).

Compared to 2016, in 2019, there was an increase in the average number of goatings, lambs, bulls, chicken, heifers, goats, and sheep per household in the pilot group (Table 14). If compared to the average number of animals per household, it is clear that in 2019, households in the pilot group experienced the higher growth in the number of goatings by 121% per household. Meanwhile, the average number of lambs and bulls per household increased by 66% and 50% respectively. Contrary to the control group, the average number of chickens per household in the pilot group grew by 48%. Meanwhile, the average number of heifers and goats per household increased by 37% and 17% respectively. In both control and pilot groups, farmers experienced a decrease in the average number of cows and calves per household.

Irrigation management issues

During the survey, respondents were asked about water management issues such as water payment collection persons, water distribution schedule, and water amount distribution issues. People mostly pay the WUAs for irrigation water. In this regard, the district irrigation department is in second place and aiyl okmotu third. During the baseline and endline years, the role of WUAs decreased while the role of aiyl okmotu and the district irrigation department increased. The difference between the pilot and control zones is not significant in both waves (Table 15).

During the years between 2016 and 2019 the role of the WUA increased in defining the amount of water for final users – namely, farmers. The role of aiyl okmotu and the district irrigation department for the same period also increased (Table 16). Such changes led to the decline of the role of mirabs in 2019 to zero. However, in the baseline period, mirabs play a very important role for farmers – for instance, they were in second place after WUAs in 2016.

In the baseline and endline periods, the responses on the institutional agents who resolve water disputes change considerably (Table 17). The roles of aiyl okmotu and WUAs increased for the pilot zone, while for the control zone only the role of the WUAs increased. In general, the WUAs is the most important institution in resolving water disputes. The role of aksakals (elder, respectable man in rural community) increased for both zones between waves. The role of the district irrigation department was important for the control zone and slightly increased between surveys. Other institutions were in third place by importance during the baseline survey but disappeared entirely in the endline survey.

Table 15. Institutions and agents responsible for water payment reception[25], % of households for each group

	2016		2019	
	Pilot	Control	Pilot	Control
Aiyl okmotu	8%	3%	35%	11%
Water users associations (WUAs)	95%	87%	72%	61%
District irrigation department	1%	0%	13%	25%
Aksakals[26]	0%	0%	0%	2%
Neighbors	0%	0%	0%	8%
Other	1%	8%	6%	7%
Nobody	1%	2%	0%	2%

Table 16. Responsible persons, determining the amount of water for irrigation, % of households for each group

	2016		2019	
	Pilot	Control	Pilot	Control
Aiyl okmotu	6%	4%	27%	10%
Water users associations (WUAs)	38%	57%	71%	64%
District irrigation department	0%	6%	8%	17%
Aksakals	0%	0%	0%	4%
Neighbors	1%	0%	0%	9%
Mirabs[27]	54%	32%	0%	0%
Nobody	5%	2%	0%	0%
I don't know	0%	0%	4%	4%

Table 17. Responsible persons, who resolve water supply disputes, % of households for each group

	2016		2019	
	Pilot	Control	Pilot	Control
Aiyl okmotu	27	30	44	17
Water users associations (WUAs)	37	30	51	56
District irrigation department	0	13	3	17
Aksakals	0	2	13	14
Neighbors	4	2	9	12
Other	35	26	3	1
Nobody	2	2	16	12

The last issue asked to respondents on water management issues was the role of the local institutional settings that are able to resolve canal repair problems (Table 18). During the baseline period, aiyl okmotu and WUAs play an important role in canal repair. Later in 2019, the role of WUAs increased

25 Total amount of water users in percentage is bigger than 100%, because of multiple answers.

26 Elder, respectable man in rural community.

27 A person in charge of the irrigation system and water use practices in Central Asia.

for both groups and declined for aiyl okmotu. However, for the pilot group, aiyl okmotu remains the most important institutional agent responsible for canal repairs.

Table 18. Responsible persons, who can repair canal damages, % of households for each group

	2016		2019	
	Pilot	Control	Pilot	Control
Aiyl okmotu	92	71	64	30
Water users associations (WUAs)	17	20	57	59
Water farm (regional level)	0	11	11	22
Aksakals	0	0	1	7
Neighbors	0	0	1	10
Mirabs	0	8	0	0

Intervention impact assessment

During the endline survey, data were collected on farmers' knowledge on the target activity from the sub-sample located in the pilot zone. About 35% of households in the pilot zone were aware of the intervention activities occured. Forty-two percent of households in the pilot zone indicated that they were aware of work on improving irrigation canals, many of whom had heard about the rehabilitation of the Ak-Tatyr canal (27%) and the Zhany-Yuzhnyy canal (13%). There was a small proportion of those who were aware of the rehabilitation of the canals of Alysh (0.7%) and 1-2 Maya (0.7%). About 53% of those who were aware of canal rehabilitation (23% of all households in the pilot zone) noted an improvement in water distribution and canal throughput. Thirty-two percent of households reported that the operations of WUAs improved, among which the main improvements included: purchase of equipment for repair and maintenance of irrigation networks (21%), improvement of the practice of solving water distribution issues (4%), and an increase in the number of meetings of WUAs participants to solve WUAs issues (4%).

5.2. Crop Production Index - Methodology and Results

To analyze the differences between the farmers in the two groups (control and treatment) the measurement indicator must be defined, which directly reflects the linkage with the intervention. According to the Theory of Change (Figure 8), the intervention may lead to the following expected outcomes:

- Change in crop production caused by improved irrigation;
- Change in the crop production structure;
- Change in agricultural income.

It was decided to use the indicator named Crop Production Index (CPI), which addresses the first two requirements fully and partially reflects the last one. The CPI is calculated for every household in the sample according to the following formula:

$$CPI_i = Crop1_i \times Crop1price_{2019} + \ldots + Crop41_i \times Crop41price_{2019},$$

where,

CPI_i – Crop Production Index for the by farmer *i*,

$Crop1_i$ – the production of the crop 1 produced by farmer *i*,

$Crop1price_{2019}$ – price for the crop 1 in 2019.

Table 19. Average Values of Crop Production Index by Villages, Groups, and Sample, KGS[28] per are

Communities/groups	Baseline (2016)	Endline (2019)	Change, %
Pilot			
Samarkandek	1022.7	620.3	-39%
Jany-Back	816.9	587.8	-28%
Pasky -Aryk	785.5	421.1	-46%
Uch-Dobo	826.3	783.0	-5%
Ak-Tatyr	831.0	408.2	-51%
Govsuvar	764.1	659.8	-14%
Kara-Jygach	1625.7	1509.5	-7%
Ak-Tash	1010.5	1384.1	37%
Jylkeldi	699.2	644.9	-8%
Total pilot	47467	46373	-2%
Control			
Kek-Tash	915.5	632.2	-31%
Aksai	617.9	307.5	-50%
Tashtumshuk	645.6	312.73	-52%
Ravat	236.6	72.1	-70%
Kulundu	722.3	509.2	-29%
Internazionalnoe	538.0	355.6	-34%
Kara-Kyshtak	1046.6	1284.0	23%
Chal-Tash	374.6	309.9	-17%
Communism	646.5	313.0	-52%
Pulgon	727.8	500.6	-31%
Total control	33974	19857	-42%
Sample Total	39543	30800	-22%

Forty one crops were produced by the farmers during the baseline and endline surveys (Annex 1). Thus, CPI is the sum of all crop products produced by every farmer in the sample. The CPI was calculated for each farmer in the sample for the baseline (2016) and endline (2019) surveys. The prices for 2019 were used for both waves to exclude the factor of changing crop prices between the baseline and endline periods. Accordingly, a dataset of target indicators was calculated for every farmer in the sample, which reflects the change in the overall crop production for every farmer in the different periods. However, this indicator is not only useful due to its ability to compare crop product volumes in a quantitative manner, but also because it allows different groups of farmers to be aggregated. Such representation allows us to assess the average range of crop production parameters in the different sub-samples settings (Table 19).

Results of the CPI calculation demonstrate that between 2016 and 2019, a significant decline was observed in the crop production volumes (22% decline). However, there is one particular difference between the pilot and control zones: in the control part of the sample, the decrease was much greater compared to the pilot zone - 42% vs 2% respectively. The analysis of the results by village demonstrates high volatility, but the difference between the control and pilot zones is obvious.

28 KGS – Kyrgyz Som (Kyrgyz national currency)

5.3. Difference-in-Difference Analysis

The difference-in-difference (DiD) method allows the treatment effect to be estimated with the use of longitudinal data from treatment and control groups to obtain an appropriate counterfactual relationship between the intervention and target desirable indicator to estimate a causal effect. The DiD method was estimated according to the following specification:

$$CPI = \beta_0 + \beta_1 * Wave + \beta_2 * Pilot_{Control} + \beta_3 * (Wave * Pilot_{Control}) + \varepsilon,$$

where,

CPI – Crop Production Index,

Wave – dummy variable for the different periods (Baseline – 0, Endline –1),

$\boldsymbol{Pilot_{Control}}$ – dummy variable for indicating households from pilot areas (Pilot area – 1, Control area – 0),

$\boldsymbol{(Wave * Pilot_{Control})}$ – composite dummy variable indicating when ***wave = pilot_control* = 1.**

If the household did not grow any crops or did not receive a harvest from the crop production during the baseline and/or endline period, its CPI was equal to 0.

The DiD approach allows biases to be excluded in the post-intervention period comparisons between the treatment and control group that could be the result of constant differences between the comparable groups. It also removes biases from comparisons over time in the treatment group that could be the result of trends due to causes other than the ultimate outcome indicator. The results of the model specification are presented in Table 20.

Table 20. Difference-in-difference analysis results in monetary terms (2019 prices)

Outcome Indicator	DiD coefficient	SE	t-statistics	Sample
Crop Production Index – 2019 prices	13 023.4	7 803.2	1.67	1352[29]

The results of the estimation provide us with the following findings: the location in the zone of the irrigation canals rehabilitation brings a positive effect on the crop production volume: 13 thousand KGS more in comparison with the control zone. However, the t-statistics equal 1.67, which makes our results statistically significant at the 90% significance level only. Results of the estimation are also supported by the results of the CPI mean values (Table 19). According to the DiD approach estimations and CPI variation, volumes in the intervention areas declines: the crop production volumes measured in 2019 prices produced in the pilot zone declined on 2%, while in the control zone the decline reached 42%, i.e. the effect of the intervention was expressed at a lower decline rate compared with the non-intervention area.

In addition to the main model estimation, considering the influence of the prices in the model, an alternative approach was applied. It was decided to count all crop products in one unified indicator - biomass indicator (BMI), which is simply the weight of the all crops measured in kilograms. The BMI is calculated for every household in the sample for the baseline and endline periods according to the following formula:

$$BMI_i = Crop1_i + \ldots + Crop41_i,$$

where,

BMI_i – Biomass indicator for the farmer i,

$Crop1_i$ – the production of the crop 1 produced by farmer i in kilograms,

29 N = 1352 observations, which comes from 676 households participating in both waves of the panel survey – baseline and endline.

The same 41 crops were produced by the farmers during the baseline and endline surveys. The BMI was calculated for each farmer in the sample for the baseline (2016) and endline (2019) surveys. The same DiD model was applied but replacing CPI with BMI. The results of the model are presented in Table 21.

Table 21. Difference-in-difference analysis results in natural volume (Biomass index)

Outcome Indicator	DiD coefficient	SE	t-statistics	Sample
Biomass index	1059.3	439.5	2.41	1352

The results of the estimation are positive and allow the following finding to be formulated: farmers residing in the location of the zone of the irrigation canals rehabilitation demonstrate a crop production volume on 1 059 kilograms / farmer higher in comparison with the control zone farmer. The value of the t-statistics (2.41) is also positive and demonstrates higher statistical significance (95%), compared to model measuring results in monetary forms. Thus, this estimation additionally supports the findings of the main model results.

The same interpretation of the results and improved statistical significance of the estimations provide us with enough evidence to state that the study's hypothesis was confirmed, namely that farmers in the pilot zone demonstrate an increase in crop income or crop product (in our case less of a decline) after the intervention compared to those receiving no intervention.

6. Key Findings and Lessons Learned from the Study

The study's empirical findings support a positive relationship between irrigation canals rehabilitation and crop production volumes in monetary and natural terms in the target area's zones compared to those without irrigation canals rehabilitation. The results indicate that the target intervention program has a positive effect on:

- Crop production volumes measured in monetary terms;
- Overall volumes of crop yield measured in physical volumes.

The statistical significance of the model measured in monetary form demonstrates a higher level of statistical error. At the same time the result was more desirable for the uniform indicator measuring crop production in-kind. In real terms, the crop product per farmer measured in monetary form in the pilot zone slightly declined (on 2% on average), while in the control area it demonstrated a sharp decrease (on 42% on average). Thus, the statement that investments in irrigation infrastructure bring a positive effect compared with no investment practices is valid within the achieved level of statistical accuracy.

Between 2016 and 2019, the agricultural performance indicators of the observed farmers demonstrate the following contradictory dynamics:

- The yield for major crops declined (the decline was stronger in the control zone compared to the pilot zone);
- The livestock amount increased for most of the animals in both groups;
- The price dynamics for major cultivated crops were volatile, which makes planning crop structure complicated.
- One of the very important features of the zone is the hardships in agricultural activities due to conflicts in the border zone with Tajikistan. Farmers decrease use agricultural lands in

significant volumes – almost on 10% of land plots (Table 8) and on 20% of own land plots (Table 7). Security instability deteriorates the possibility to develop agricultural activity in the irrigation canals rehabilitation zone.

The livelihood of rural residents becomes less dependent on agricultural activities – the share of officially employed people increased in both groups, while the share of unemployed people as well as self-employed persons (mainly in agriculture) decreased. At the same time, labor migration decreased in the pilot zone and increased in the control zone with the corresponding change in remittances.

The results of the analysis were affected by the changes occurred within the proposed intervention cycle. It reframed the sample composition:

- The original sample included four canals in Batken oblast and one canal in Osh oblast in 2016. By 2019, the sample had changed significantly due to the exclusion of two canals from the rehabilitation program. This makes our sample skewed towards the control group. In the original settings, two thirds of the sample were devoted to the pilot zone.
- Another issue is the significant difference between the sample collected from Batken and Osh oblasts. In the pilot zone this provided 27% of the subsample, while in the control group it reached only 4%. The original setting provided a more balanced composition. Such changes led to an increase in statistical error due to the imbalanced sample structure. It also affected the possibility to analyze different subsamples based on regional features.

For future irrigation rehabilitation interventions, the research and implementation team may devote more attention to the selection of the intervention areas and sampling as this may improve the results of the impact assessment exercise.

In addition, during the 2016-2019 period, the role of water management institutions transformed in both zones and more important roles were taken on by local authorities and WUAs. In the pilot zone, a significant share of people were aware of the intervention activities. More than half of the respondents were aware of the canal rehabilitation and reports on the improvement in irrigation water supply. The irrigation canals rehabilitation improves access to irrigation for many households in the pilot zone, which consequently led to better crop production volumes compared to the control zone. Finally, the decline of crop production was not significant for crop farmers in the pilot zone, while farmers in the control zone demonstrated a significant decline in crop production.

Collected dataset provides an excellent opportunity to continue the analytical work for studying agricultural activity in the combination with the other socio-economic aspects of rural livelihood and mixed methods for the future studies by researchers.

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Annexes

Annex 1

Prices used for crop index calculation, KGS per kilogram

# crop	Crop name	Base-line	End-line	Prices from open sources, average for 2016	Prices from open sources, average for 2019	Prices selected for calculations in 2016 prices	Prices selected for calculations in 2019 prices
1	Winter wheat	11.8			15.7*	11.8	15.7
2	Spring wheat	12.0	12.0			12.0	12.0
3	Burley	12.4	13.0			12.4	13.0
4	Maize	13.5	7.0			13.5	7.0
5	Sunflower			not found	not found	only 1 observation, excluded from analysis	only 1 observation, excluded from analysis
6	Cotton	40.2	40.1			40.2	40.1
7	Potato	20.0	19.0			20.0	19.0
8	Tobacco			not found	not found	no observations	no observations
9	Beans	36.7	13.0			36.7	13.0
10	Rice			76.8**	78.3**	61.5	62.6
11	Sainfoin (Esparcet)	2.8	4.8			2.8	4.8
12	Alfaalfa (Lucerne)	6.8	6.0			6.8	6.0
13	Tomatoes	27.4	23.3			27.4	23.3
14	Onion	8.5	20.6			8.5	20.6
15	Carrot			13.7*	19.1*	13.7	19.1
16	Sugar beat			12.5*	19.2*	12.5	19.2
17	Cabbage	7.5	7.0			7.5	7.0
18	Apple	24.7	26.4			24.7	26.4
19	Pear	24.0	40.0			24.0	40.0
20	Cherry	111.4	138.2			111.4	138.2
21	Grape		60.0	78.51**		62.8	60.0
22	Peach	27.5	18.3			27.5	18.3
23	Plum	21.0	100.0			21.0	100.0
24	Apricots	99.9	66.7			99.9	66.7
25	Raspberries	80.0	52.5			80.0	52.5
26	Strawberry	65.0	55.0			65.0	55.0
27	Currant			16.8*	49.5*	16.8	49.5
28	Garlic	180.0			73.4**	180.0	58.7
29	Sweet pepper	15.0			not found	15.0	15
30	Pea			49.8**	40.1**	39.8	32.08

32	Quince			25.3*	28.6*	25.3	28.6
33	Eggplants			23.22**	24.7**	18.6	19.76
34	Pomegranate	90.0			43.4*	90.0	43.4
35	Herbs			139.8**	114.0**	111.8	91.2
36	Clover		15.4			15.4	15.4
37	Cucumbers			64.2*	33.5*	64.2	33.5
38	Nuts	70.0			145**	70.0	116
39	Grass	100.0	50.0			100.0	50
40	Mulberry			16.8*	49.5*	16.8	49.5
41	Persimmon	26.3			48.1*	26.3	48.1

Sources:

*average producer prices for sold agricultural products in Batken, NSC KR 2019

**Average consumer prices for selected products in Batken, NSC KR 2019