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The Role of Irrigation Development and Its Impact on Various Indicators of Agricultural Sector Competitiveness

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CENTER FOR ECONOMIC POLICY ANALYSIS - CEPA
Ketevan Chapidze
Nino Javakhadze
Tinatin Papashvili

CEPA.GEORGIA@GMAIL.COM

Abstract

Modern agriculture practices cannot be considered without proper irrigation systems and infrastructure. Besides balancing production fluctuation, Irrigation contributes to increased crop production and productivity in the agriculture sector. As well, irrigated agriculture plays a fundamental role in ensuring food security and self-sufficiency of agricultural products. In recent years, as a result of state investment and rehabilitation of irrigation infrastructure in Georgia, the area of irrigated lands has increased significantly. Besides, the Government of Georgia plans to rehabilitate and modernize existing irrigation infrastructure and bold investments are envisaged for coming years. This paper seeks to analyze the economic effects of additional irrigation investments in Georgia, namely impact on core economic variables such as GDP, employment, and agriculture sector output. The quantitative evidence derived through the macroeconomic model is based on the survey of agricultural holdings – AGRIS. For the purpose of this paper combination of program evaluation and macroeconomic modelling were used to evaluate the quantitative impact of irrigation. The analysis showed that the use of irrigation technology exerted positive and significant impact on crop yield and increased production in the agriculture sector, indicating that irrigation significantly contributes to the increasing productivity and can play an important role to reduce imports of agricultural products and increase self-sufficiency and food security of the country.

Keywords: Agriculture; Irrigation, Crop yield; Economic effects, Input Output Modeling; Propensity Score Matching.

I. Introduction

From the 1990s onward, agricultural sector has changed dramatically and the land used for agriculture has decreased by about 50%[1]. As well, the share of agriculture in GDP has fallen significantly over the past decades, from 22% of GDP in 2000 to 8.4% of GDP in 2020 and it is anticipated that the share of the agricultural sector will fall gradually to around 7% by 2025 as the manufacturing and service sectors continue to expand at a more rapid rate. Despite its reduced

[1] World Bank, 2018, "A systemic country diagnostic".

share in the national economy, the agricultural sector is expected to grow by about 4% per annum[2] and remains a very important sector. Regarding with to the social aspects and employment, 19% of the total employment is engaged in agriculture activities and the rural population represents more than 40% of the total population. However, the dependence on the agriculture sector, as the biggest employment-generating sector is likely to continue into the medium-term future, and it is one of the greatest challenges to improve its productivity, increase farmers' incomes and reduce rural poverty. Subsistence and semi-subsistence farming represents the major part of agriculture value-added, thus representing the main impediment factor for increasing competitiveness.

In line with increasing investments in irrigation and support to agriculture sector, agriculture competitiveness has significantly improved in recent years. Despite the unfavorable climate conditions and increasing vulnerability, value added of agriculture sector in real terms in 2020 increased by 19.5% compared to 2012. The improving trends in agriculture was attributed by increasing crop yields, more precisely compared to 2012 overall crop yield for wheat increased by 29.4%, for Maize by 29.2%, for potato by 32%, for bean by 25.2% and for barley by 18.8%[3]. Regardless, the significant improvements, the productivity level in the agriculture sector significantly underperforms the productivity in all other sectors and crop yield is significantly lower compared to regional or peer countries.

In 2014, after signing the Deep and Comprehensive Free Trade Agreement (DCFTA) Georgia took an obligation to ensure agriculture and rural development in compliance with the EU policy and best practices and to harmonize the Georgian legislation with the European Legislation[4], which in turn creates greater opportunity to get benefits from investing in agricultural production by creating perspectives for exporting Georgian products to the EU market. Important investments were made to increase the productivity of agricultural production under the framework of state support programs, namely during 2014-2021 more than 800 Mln. GEL was allocated for different agriculture development state support programs.

The agriculture sector and food processing have significant untapped potential to support inclusive economic growth, increase export capacity, and support productivity enhancement. In recent years

2 Agriculture and Rural Development Strategy of Georgia 2021 – 2027

3 Relevant time series data is not available for permanent crops.

4 Agriculture and Rural Development Strategy of Georgia 2021 – 2027

Georgia introduced several support programs in the agricultural sector-oriented on the improvement of access to finance, providing insurance schemes, and quality improvement of food products, however, significant challenges still remain that are directly linked to the lack of technological upgrade, modern production, and entrepreneurship practices and low productivity.

The effects of climate change such as increasingly volatile weather and more extreme events – like droughts, floods, limited availability of water and etc. affect agriculture productivity and emphasize the importance of using modern agriculture practices. Especially, in the context of global warming, the role of irrigation is growing day by day and modern agriculture cannot be considered without proper irrigation systems. The development of productivity enhancement practices, especially irrigation has the potential to enable and strengthen local agriculture, supply chain infrastructure, enhance productivity, and support self-sufficiency and food security of the country.

The purpose and subject of the research fully comply with the important policy directions of the Agriculture and Rural Development Strategy of Georgia - 2021-2027, which envisages the priorities of the Government of Georgia, also the directions for sectorial and multi-sectoral development, which are linked to the agriculture and rural development. Including increasing access to infrastructure and services; improve irrigation and drainage systems, and disseminate climate-smart and environmentally adapted agricultural practices. The presented research is intended to support evidence-based policy implementation, identify the challenges from the economic perspective and promote the continued use of efficient agricultural policy. In order to promote evidence-based policy implementation, on one hand, the research analyzes the irrigation development issues in the context of agricultural competitiveness, and on the other hand, evaluates its' impact on the overall economic activity (taking into consideration interlinkages among economic sectors) and linkages.

Despite the fact that rehabilitation and modernization of irrigation systems in Georgia, is one of the declared priorities of Government of Georgia, there are no research papers that would analyze and assess the economic effects of additional irrigation investments in Georgia. Moreover, there is no evidence of other scientific or applied research that study irrigation issues in Georgia. Therefore, presented research paper will support awareness raising on benefits of irrigation system rehabilitation and modernization. Besides, research will assist relevant stakeholders to purse more evidence based policy-making practices, as results derived from quantitative analysis, present benefits of irrigation systems development in tangible way (concrete impact on agricultural output, employment and ect.) and make it easier to communicate to scientific as well to wider audience. The paper evaluates irrigation issues in micro and macro context thus will support proper policy insights.

Presented research is based on Agricultural Integrated Survey (AGRIS) data, that provides information for 143,323 agricultural holdings and for 387,963 parcels throughout regions of Georgia.

The paper comprises micro and macro analysis, since at the first stage it evaluates the impact of irrigation on the crop yield for different annual and permanent crops based on one of the common and widely adopted program evaluation techniques – Propensity Score Matching. Afterward, the paper analyzes the economic effects of irrigation, including expected effects on the output of the Agriculture sector and as well on Gross Domestic Product.

The analysis showed that the use of irrigation technology exerted a positive and significant impact on crop yield and increased production in the agriculture sector, indicating that irrigation significantly contributes to increased productivity and can play an important role to reduce imports of agricultural products and increase self-sufficiency and food security of the country.

Paper is organized in following manner: Abstract; Introduction in section I; Conceptual Framework – Section II; Data and Context – section III; Methodology - section IV; Results – section V, Conclusion – section VI.

II. Conceptual framework

Irrigation impacts livelihoods through several channels including through increased intensification leading to increased food production, increased use of complementary inputs, production of market-oriented crops in addition to food crops and through a reduction in risks as farmers diversify their crop portfolio (Garbero and Songsermsawas, 2018).

As international experience suggests, together with increased productivity, there is another issue about increasing the use of inputs. Data analyses (IAAE, 2012) show that the irrigation impact on input use is positive as well. The input use is significantly higher in irrigated areas compared to the rain-fed areas. Smallholder farmers mainly focus on rain-fed cultivation. Low irrigation development is one of the factors that undermine the productive capacity of the agricultural sector (GoM, 2017). All input increases are additional costs. The input used, especially fertilizers and agrochemicals, are doubled in case of introducing an irrigation system. It can be caused by the fact that the same land plot is cultivated several times throughout the year and it is intuitive that several times cultivation needs more inputs, but even in this case of seasonal base input use change is highly significant. As evidence suggests, the regression of the number of cropping season on the plot characteristics suggests that establishing an irrigation system raises the number of cropping by 0.37, 0.25 and 0.34, respectively mixed, private and public irrigation system. This means that in case of the mixed irrigation system the number of cropping will increase by 0.37. The overall effect is an increase by 17%-25% (IAAE, 2012).

In addition to increasing the level of production, irrigation can also be used as a stabilizing factor for agricultural output. The main risk in the variability of the outcome through different years is systemic risks, which means the loss of output because of weather conditions, rainfall scarcity, and diseases. The risk can somehow be insured. It can be avoided for example, by crop protection programs, output insurance programs, or introducing functional irrigation systems. The first two options can be considered as variable expenses. But irrigation system is considered as a capital expense and relevant infrastructure and machines are needed to set up irrigation systems. Except, benefits from the investment in irrigation systems will be felt during years. Due to the fact that an irrigation system allows for stabilized higher production for farmers, they have higher income, consumption, and employment.

The impact of irrigation on crop yield at disaggregated level and broad economic benefits of adopting irrigation was not studied in Georgia. Consequently, the paper is limited to compare research findings and evaluations to other countries specific studies.

The irrigation issues and its role in agriculture competitiveness represented the subject of various researches conducted in Moldova, Nigeria, Tanzania, Ethiopia, Bangladesh, Pakistan, India and other countries. According to the Dowgert (Dowgert, M., 2002), irrigated crop yields are 2.3 times higher than those from rain-fed ground. Crop yields everywhere in the developing world are consistently higher in irrigated areas than in rain-fed areas (Rosegrant and Perez 1997; Ringler et al. 2000; Hussain and Hanjra 2004; Lipton et al. 2005). Ogunniyi Adebayo, Omonona Bolarin1, Abioye Oyewale and Olagunju Kehinde (2018), based on Propensity Score Matching showed that causal effect of irrigation technology use on crop yield is between 1954.66 kg/ha and 2354.66 kg/ha in Nigeria. In Moldova irrigation is considered a valuable measure to mitigate drought risk, increasing yield by 25–50% in normal years, while avoiding losses in drought years[5]. Maurice Osewe, Aijun Liu and Tim Njagi (2020) in their study found positive and significant effects of farmer-led irrigation on the smallholder farmers' per capita net crop income. Based on the results of Propensity Score Matching, they concluded that adopting farmer-led irrigation could increase the smallholder farmers' per capita net income in the range of 76,772–91,152 Tanzanian shillings[6]. In india, Songqing Jin, Winston Yu, Hans G.P. Jansen and Rie Muraoka (2012,"The impact of Irrigation on Agricultural Productivity: Evidence from India") found that firstly, irrigation is positively correlated with agricultural productivity as both annual gross revenue per acre of land and annual net revenue per acre of land are lowest for rain-fed plots in almost all states, besides crop productivity, land use intensity and land prices, input use intensity is also highest of plots that have access to both private and public irrigation [7]. The researchers showed that private irrigation, public irrigation and both private and public irrigation increase annual gross (or net) revenue per acre of land by 39%, 39% and 52%, respectively (in comparison to rain-fed plots).

The mentioned research focuses on those issues that have not been studied in Georgia, combining average impact of irrigation on crop yield for different crops and evaluation of broad economic effects, coming from irrigation investments. The research answers following research questions:

- What is the impact of irrigation development on crop yield for different annual and permanent crops?
- What is the impact of irrigation development on agricultural sector output?

[5] World Bank, 2014, "Climate Smart Agriculture in Moldova"

[6] Maurice Osewe, Aijun Liu and Tim Njagi, 2020, "Farmer-Led Irrigation and Its Impacts on Smallholder Farmers' Crop Income: Evidence from Southern Tanzania ".

[7] Songqing Jin, Winston Yu, Hans G.P. Jansen, Rie Muraoka, 2012, "The impact of Irrigation on Agricultural Productivity: Evidence from India".

- What is the Impact of irrigation on macro level, namely Gross Domestic Product and employment?
- What are policy considerations regarding irrigation development in Georgia, based on the analysis of abovementioned hypothesis?

III. Context and Data

The rehabilitation-modernization project of melioration infrastructure has been implemented since 2011. As a result, since 2012 to date, the area of irrigated land doubled and amounted to 127,000 hectares, and 38,000 hectares of land is dried.[8]

The fragmentation and average small size of land represents the important challenge of the agriculture sector that also negatively affects irrigation development. Parcels with less than 0.5 ha dominate the agricultural holdings and the share of such parcels in the case of annual crops amounts to more than 70%. The share of parcels below 1 hectare amounts to 87%.

Table 1: Structure of the cultivated land

Parcel size for annual crops	Proportion of parcels
$parcel \leq 0.5\ ha$	74.7%
$0.5ha < parcel \leq 1\ ha$	12.3%
$1\ ha < parcel \leq 5\ ha$	8.5%
$5\ ha < parcel \leq 10\ ha$	1.4%
$10\ ha < parcel \leq 50\ ha$	2.2%
$50\ ha < parcel \leq 100\ ha$	0.6%
$parcel \geq 100\ ha$	0.4%
Parcel size of permanent crops	
$parcel \leq 0.5\ ha$	80.3%
$0.5\ ha < parcel \leq 1\ ha$	12.8%
$1\ ha < parcel \leq 5\ ha$	6%
$5\ ha < parcel \leq 10\ ha$	0.5%
$parcel \geq 10\ ha$	0.5%
Irrigated lands	
Regularly	27%
Partially	21%
Non water supplied	52%

[8] Agriculture and Rural Development Strategy of Georgia 2021 – 2027

In the case of permanent crops average size of land parcel amounts to 0.6 ha and more than 80% of land parcels are 0.5 or below 0.5 ha.

The Agriculture and Rural Development Strategy of Georgia - 2021-2027 sets several targets for increasing access to infrastructure and services; the development of irrigation and drainage systems and the development of climate change adaptation practices is one of the major strategic directions of the strategy.

According to the ”Irrigation Strategy for Georgia 2017 – 2025” Rehabilitation investment is expected to increase the irrigable area to 200,000 hectares by 2025 and investments in irrigation infrastructure is expected to exceed 778 mln GEL. Most of the increase will result from the rehabilitation of existing gravity irrigation schemes, supplemented by private development of pumped surface water and groundwater. The considerable unexploited potential of groundwater will be studied and measures devised to enhance private groundwater development for irrigation, particularly in conjunction with drip irrigation technology, which is expected to expand to cover as much as 10% of irrigated area by 2025. Initially, it was expected that most of the systems purchased will be the less expensive Chinese ones. However, with time, and as experience is gained, purchases are expected to shift to higher quality systems from Turkey and Israel.[9]

Georgia has vast groundwater and surface water resources. Around 69% of water withdrawals are used by the agricultural sector for irrigation purposes, 21% is used by industry and only 10% is used for domestic use. A remarkable point here is that consumption and withdrawal are very different from each other. For example, agriculture consumes 50% of the withdrawn water, 90% of domestic withdrawn water is returned to the rivers and groundwater basins and industries use only 5% of their withdrawals. The agriculture sector is the biggest consumer of water resources and it is critically important to ensure efficient use of water resources by the sector.

In terms of irrigated land statistics, exact data on the volume of irrigated areas throughout Georgia is not available, meaning that there is no information on irrigated land plots with groundwater,

[9] ”Irrigation Strategy for Georgia 2017 – 2025”

from river basins or other channels of irrigation. Statistics are available only for areas irrigated by the "Georgian Amelioration" company through the amelioration infrastructure.

As a result of the inventory conducted by "Georgian Amelioration" company, the total area of irrigable lands constitutes 322.0 thousand hectares, out of which "guaranteed" irrigable land plots amount to 155.5 thousand hectares, out of which the area of regularly irrigated lands amount to 87.5 thousand hectares, while partially or/and temporally irrigated area is 68 thousand hectares. Non-irrigated (Irrigation not in working condition) land plots amount to 166.5 thousand hectares.

The AGRIS data showed that a significant part of sown land with an irrigation system is not sufficiently irrigated. More precisely, 21.1 percent of cultivated land area that has irrigation system are not irrigated sufficiently. Not sufficiently irrigated land amounts to 30.5 percent in the number of those parcels, which has an irrigation system. In the case of permanent crops, not sufficiently irrigated land amounts to 25 percent of the area of those parcels that has irrigation. The most widespread types of irrigation are canal and tube well irrigation. As the evidence suggests, the best results are achieved by using the mixed structures of irrigation systems, while the least productive is the canal system. The most part (around 90%) of the irrigation system in Georgia is based on the canal system. Due to water scarcity (associated mainly with seasonal factors), farmers can only receive water when there is enough water through the canal. The mentioned circumstances explain the problem related to the non-sufficient irrigation of different crops.

A lack of modern systems and equipment for irrigation systems creates bottlenecks, leading to an uneven supply of water resources. For example, farmers located at the springhead and middle part of the canal get water continuously, while those located near the tail part receive a small amount of water and are usually, not sufficient for irrigation purposes. As well, some farmers receive more amount of water than others, while they pay the same rates. It should be noted, that in recent years, the drip watering method has been rapidly developing, and new crops that are popular in Georgia, such as blueberries and hazelnuts, which were not traditionally irrigated, are now irrigated with drip irrigation systems.

As for irrigation systems, "Georgian Amelioration" company operates 131 irrigation systems, out of which 74 are engineering type systems, 49 - semi-engineering and local s ystems and 8 systems are subject to restoration. Irrigation systems are located in 6 regions (Kakheti, Lower Kartli, Mtskheta-Mtianeti, Shida Kartli, Samtskhe-Javakheti, Imereti) and in 28 municipalities throughout Georgia. The total area of irrigation lands with irrigation systems (322.0 hectares) according to the type of irrigation is distributed as follows: 1. Gravity fed irrigation lands - 258.5 thousand hectares, where irrigation is mainly carried out by flood water irrigation (in rows, ditches, etc.). Drip irrigation has been developing intensively in recent years (statistics on drip irrigation areas are not available). 2. Mechanical irrigation lands - 63.5 thousand hectares, where water supply is carried out through pumping stations.

The rehabilitation and modernization of irrigation systems is a key to supporting a greatly expanded horticultural crop production. Since the temperatures in Georgia will continue to rise and the estimated precipitation varies greatly, irrigation systems on the one hand can reduce the damage of climate change and on the other hand, can support higher crop yield.

Two of the main indicators that are influenced by the development of the irrigation system are:

1. Increase in productivity per hectare per season and

2. Increase of the land-use intensity, meaning that the same land can be cultivated several times throughout the year.

Therefore, the impact of irrigation greatly depends on the type of irrigation system used, farm location, water availability and the characteristics of the farm itself.

Due to the fact that most of the irrigation network was designed and constructed during the Soviet era, it doesn't correspond to existing land structures/management and irrigation requirements. Transition to a market economy, followed by the privatization process, contributed to land fragmentation into small land plots, with different water requirements by farms. The inter-village irrigation network was designed and built to irrigate collective farms and large contour plots of state farms and is not adapted (highly difficult to irrigate) for small-natural farm plots, while the complete rearrangement of the infrastructure is associated with high costs and is not feasible. In addition, due to the fact that irrigation systems were mostly built in the last century, are damaged to varying degrees and unable to function in their design parameters.

Land fragmentation negatively affects the agricultural sector as a whole and creates additional bottlenecks for irrigation development. For example, the biggest portion of agricultural land parcels owned is less than 0.5 hectares, which is associated with several challenges:

- Due to inter-land irrigation network development, sowing land area loss is quite significant.
- In order to irrigate land plots, the farmer needs to obtain the consent of various plots owners on which the irrigation canal must pass.
- Due to the fact that it is not feasible to install water meters separately for small land plots, the volume of supplied water cannot be measured for small land plots.
- There are cases when the main irrigation canal is operational, however, an irrigation network isn't developed for the land plots, and in order to irrigate specific farm, the irrigation network shall cross 10-20-30 other farmers' plots, most of whom may not cultivate the land and only one farmer will have to bear quite large financial costs for building a canal.

Besides there are number of challenges that are associated with the development of irrigation systems in Georgia. For instance, it is critically important to balance water demand and water supply for agricultural crops, as during drought periods, even though irrigation canals are operational and cleaned, there are cases when the water debit is not enough. Also, in some cases, when water debit is low, most of the water may flow in one direction into canals and some farmers do not receive an adequate amount of water. In addition, watering plots are mainly carried out in an "old-fashioned way" – Most land plots use inefficient ways for watering land plots. For example, the "Flood irrigation" approach, which is one of the widespread methods for irrigation in Georgia, leads to abnormally large amounts of water consumption and high water losses.

It should be noted that the revenues of the Amelioration Company does not cover the costs, therefore the state subsidizes the revenues of the company. The company's own revenues are 6 million GEL, while operating (maintenance), salaries, equipment) costs more than 20 million GEL. In total, the company receives a subsidy of 60 million GEL (+6 million own revenues), of which about 40 million GEL is allocated for capital expenditures (development) and the rest for the system maintenance and operational costs. As empirical evidence suggests, the collected revenue is significantly lower than expected (determined by contracts) revenue.

According to the law, the Georgian National Energy and Water Supply Regulatory Commission are mandated to set Tariffs for services provided to its customers by the primary water user (Georgian Amelioration company) till 2024. By the end of the year 2021, with the involvement of the World Bank, the Ministry of Environmental Protection and Agriculture Of Georgia, Georgia Amelioration Ltd. and Georgian National Energy and Water Supply Regulatory Commission the development of tariff calculation methodology for the transition period will be completed.

In addition, a number of irrigation infrastructure rehabilitation/development projects are underway within the framework of donor support. In particular, various projects worth up to 100 million GEL are being implemented with the funding of the World Bank. Also, full rehabilitation of Zemo Samgori irrigation network is planned within the framework of EIB project and work is underway with ADB to launch Lower Samgori network rehabilitation project.

AGRIS survey

The AGRIS data provides the information for 143,323 agricultural holdings and for 387,963 parcels in all regions of Georgia. The biggest share of surveyed agricultural holdings among regions comes on Kakheti (19.8%), followed by Imereti (13.9%), Samegrelo (12.4%) and Lower Kartli (10.8%). Surveyed agricultural holdings in other regions of Georgia amount 43.1%.

The different tables of AGRIS survey provide the information on farmers, crop and parcel level about various characteristics of an agricultural holding, including: sown and cultivated area, harvested area, presence of irrigation, harvested production, if the parcel was irrigated sufficiently or not, use of fertilizers and pesticides, agricultural machinery, production costs and information on agricultural credit. Average crop yield for annual crops is calculated as the ratio of harvested production and harvested area, however in the case of permanent crops to avoid bias it is more precise to define crop production per seedling of fertility age since the data provides information on the number of all seedlings and those seedlings of fertility age.

From the data of AGRIS survey the variables that were used for constructing the control group were: sown area of the crop, use of fertilizers, access to the credit, and capital expenditures. The survey contains the information if the parcel was irrigated sufficiently or not, subsequently the comparison factor represents sufficient irrigation of parcels.

The irrigation infrastructure network is mainly spread in Eastern Georgia, while drainage systems are mainly present in Western Georgia. More than 40% of irrigated land is in Kakheti. The Kakheti, Lower Kartli and Inner Kartli outperform other regions with overall agricultural productivity.

It is important to analyze existing trends regarding crop yield and the difference between irrigated and non-irrigated land, considering the existing structure of the Georgian agricultural sector. Besides the several binding factors, including the low level of mechanization and lack of relevant knowledge and skills irrigation has the potential to significantly increase the existing level of productivity.

Annual crops

The sown area in Georgia is dominated by the following annual crops: Maize, Wheat, Barley, Potato, Vegetables, beans and melons.

Around 20% of irrigated land is temporarily uncultivated. The cultivated and irrigated land of annual crops are covered by the following crops: Maize (23%), Perennial grasses (22%) Wheat (19%), Barley (16%), Potato (7%), Bean (4%) and Tomato (3%). They constitute more than 90% of cultivated and irrigated land.

Permanent crops

The irrigated land of permanent crops is covered by the following crops: Apple (34.8%), White grape (18.6%), Hazelnut (18.4%), Red grape (8.1%), Peach (4.1%), Plum (3.7%),Persimmon (2.9%) and Walnut (2.9%). They constitute more than 90% of irrigated land.The paper applies the propensity score matching tool to check the irrigation effect on crop yield. The PSM method has been generally adopted in the impact evaluation literature and represents the common practice for such type evaluations.

Before applying propensity score matching, it is important to estimate the significance of the difference between sufficiently irrigated and not irrigated groups. The standardized difference can be used to compare the mean between treatment groups. The standardized difference compares the difference in average crop yields that are not affected by sample size. One of the most common thresholds to indicate the important difference is considered that standard difference should be more than 0.1, the standardized difference that is less than one indicates a negligible difference. The standardized difference in the case of barley, bean and herbs is less than one. The table below summarizes the average crop yield, standard deviation and number of observations for sufficiently irrigated and not irrigated plots of different crops.

Table 2: Descriptive Statistics of Irrigated and Not irrigated parcels by crops

	Irrigated			**Non Irrigated**			**Standardized difference greater than 0.1**
	Average yield	St. deviation	Number of observations	Average yield	St. deviation	Number of observations	
Permanent crops							
Apple	13.7	11.4	154	12.5	11.9	97	Yes
Hazelnut	2.7	2.5	109	1.7	1.4	415	Yes
Red Grape	2.6	2.4	119	1.6	1.3	441	Yes
White Grape	2.5	2.3	277	1.7	1.6	1408	Yes
Annual crops							
Herbs	7163.7	12030.9	1565	6493.2	11552.8	5131	No
Beans	1262.8	1248.4	369	1193.5	1472.8	1287	No
Potato	11164.5	8959.2	846	9237.6	8020.3	2974	Yes
Maize	4070.1	4377.3	474	1850.3	2062.6	2973	Yes
wheat	3054.0	1102.4	28	1808.0	830.0	322	Yes
Barley	2110.6	1078.3	39	2029.0	1134.2	356	No

Macro data

For estimating macroeconomic broad economic effects of irrigation, time-series data of national accounts on an annual basis, supply and use tables, labour market data and Agriculture sub-sectors data were applied. The source of national accounts, supply and use tables and labour data is National Statistic Office of Georgia.

IV. Methodology

General methodology and scope of the quantitative study

The analysis of the results modelled under the project, we focuse on the impact of irrigation development/expansion on core economic variables such as GDP, employment and agriculture sector output.

The macroeconomic model that estimates the impact of irrigation on GDP and agriculture output mainly uses quantitative evidence based on the survey of agricultural holdings –AGRIS. One of the most important estimates for modelling purposes represents the data of crop yields for different annual and permanent crops in irrigated and non-irrigated parcels and the distribution of irrigated land by crops. The model estimates the macroeconomic impact and channels of investments in irrigation. The figures of planned irrigation investments are based on "Irrigation Development Strategy 2025".

For the evaluation of broad economic impacts of irrigation, the research team applied the combination of program evaluation and macroeconomic modelling. The bottom-up approach was used to evaluate the quantitative impact of irrigation, as firstly based on AGRIS survey data and Propensity Score Matching technique there were calculated average treatment effect - the impact of the adoption of irrigation on crop yield, secondly, considering the distribution of irrigated land by crops, the weighted impact was estimated separately for annual and permanent crops and mentioned aggregated results was integrated into a macro model that in turn includes Input-Output tables, sectoral disaggregation of GDP and its components.

Irrigation Impact evaluation on crop yield - Propensity Score Matching technique (PSM)

Most studies use propensity score matching (PSM) to estimate the impacts of irrigation development interventions. The literature shows that the Propensity Score Matching evaluation techniques were used in several countries to estimate the impact of irrigation on crop yield and crop income (for instance, Ogunniyi Adebayo, Omonona Bolarin1, Abioye Oyewale and Olagunju Kehinde, 2018 and Maurice Osewe, Aijun Liu and Tim Njagi, 2020).

The PSM evaluates crop farmers' propensity to irrigate or not and it is commonly estimated using the Logit regression as a function of observable characteristics and then matches each crop parcel with a similar propensity score. The Propensity Score represents the probability that a farmer would adopt irrigation based on observable characteristics.

The observable characteristics that produce the probability of sufficient irrigation are the following: sown area of the crop, use of fertilizers, capital expenditures, access to the credit and regional dummies. The variable - use of the fertilizers represent the dummy variable that gets value 1 if the farm uses the fertilizer and 0 if does not. The logic is that if a farm already uses some production practice to increase crop yield, it has more willingness to adopt irrigation and support increasing crop yield more. As well more harvested area motivates incentives for adopting irrigation, due to the scale effect and higher potential benefits to generate higher revenues. Farmers that have access to the credit, in turn, have more possibility of adopting irrigation. With the same rationale, capital expenditures also support irrigation. Regional dummies were selected based on regional characteristics and availability of basic infrastructure or practice that promotes the prevalence of irrigation. Consequently, three regional dummies were selected for Kakheti, Lower Kartli and Inner Kartly, while Western Georgian regions represent the baseline for those dummies. All of the above-mentioned variables represent the significant variables for adopting irrigation in the Logit model.

The evaluations based on Propensity Score Matching in different countries together with the mentioned variables also use the rainfall information, farming experience, farmer's education and household size. The mentioned variables are not available in AGRIS survey, however taking into consideration national context, a high share of subsistence farming and significant lack of skills and capacity, based on farming experience and education, agricultural holdings in Georgia provide quite homogenous sub-groups and do not produce a significant increase of variance of Propensity Scores. The access to credit, regional dummies and farm size represent the significant factors of adopting irrigation, consequently, by including these variables, the analysis minimizes the bias in irrigation effect, since these variables are related both to assignment and to the outcome.

Matching on the stratification score leads to more accurate matches, sufficiently irrigated plots are matched to control participants who have a similar probability of adopting irrigation based on all relevant characteristics provided by AGRIS data.

The next step envisages the search for the fit counterfactual(s). The obtained propensity score is usually used to create matched samples, homogenous subgroups with similar propensity scores. After constructing propensity scores for fitting counterfactuals that match parcels depending on their propensity score paper uses the stratification matching approach to calculate the average treatment effect. The entire set of propensity scores were divided into five mutually exclusive subsets. Differences in yield between sufficiently irrigated and not irrigated parcels in each interval were calculated for different crops. The average treatment effect represents the weighted average of outcome differences per interval. In general, to calculate the overall average treatment effect, stratum-specific estimates of effect are weighted by the proportion of subjects who lie within that stratum. The stratification does not consider bad matches from the control and reduces variability.

The overall model is statistically significant at a P-value equals to of 0.00. The signs of the coefficients in the table show the direction of change in the probability of sufficient irrigation given the change in the explanatory variables. The significant variables that affect the use of irrigation technology are plot size, access to credit, capital expenditures, use of fertilizers and all regional dummies. The model showed a significant and positive relationship between plot size and the probability of adopting irrigation since farmers with higher farm sizes can get higher revenues due to the increasing crop yield. Capital expenditures are positively associated with the probability of use irrigation in holding. The use of fertilizers was found to increase the probability of irrigation use. The Positive and significant relationship was found between access to credit and adoption of irrigation technology, suggesting that the farmers with credit availability have more possibility to adopt irrigation. Access to credit represents one of the major problems in Georgia for farmers. Consequently, access to credit is one way to improve farmers' access to new technology, including the adoption of irrigation and increasing farmers' ability to purchase inputs. All regional dummies in the model exerted a significant and positive impact on adopting irrigation, suggesting that farmers in Eastern Georgian regions: Kakheti, Lower Kartli and Inner Kartli are more likely to adopt irrigation.

The results provide balanced propensity scores and large overlap of propensity scores that implies a good match of treated and control cases. For testing the good match Standardized Bias (SB) test was applied that compares whether the means of covariates differ between the treated and the matched control groups. The results show that difference of propensity scores between the treated and control groups is statistically insignificant in each stratum (SB test in each stratum is less than 0.1, I stratum 0.06, II stratum 0.09, III stratum 0.07, IV stratum =0.07, V stratum 0.08), as well SB test shows that there are statistically insignificant differences in each observational variable between treated and control groups.

Table 3: Determinants of the use of irrigation

Variable	Description	Coefficient	Probability
regional dummy - Lower Kartli***	1 if agricultural holding is located in Lower Kartli, 0 otherwise	0.883 (0.042)	0.0000
regional dummy -Inner Kartli ***	1 if agricultural holding is located in Inner Kartli, 0 otherwise	1.492 (0.040)	0.0000
regional dummy –Kakheti ***	1 if agricultural holding is located in Kakheti, 0 otherwise	0.134 (0.038)	0.0002
Area **	Area of plot in ha	0.010 (0.004)	0.0118
use of fertilizers ***	1 if fertilizer was used on the plot, 0 otherwise	0.104 (0.030)	0.0006
CREDIT ***	1 if holding has access to credit, 0 otherwise	0.426 (0.097)	0.0000
capital expenditures *	Amount of capital expenditures (thousand GEL)	0.009 (0.000)	0.1076

***Significant at 1% level, **Significant at 5% level, *Significant at 10%

Macroeconomic Model

The I-O model was considered to be suitable for estimating the economic impacts of irrigation since Input-Output models are capable of estimating indirect as well as induced impacts of a change in demand for a particular good or service and economic impacts of forward linkages can be estimated using these models.

The macro model incorporates econometric estimation of behavioral parameters (method: OLS), Evaluation of main components of output and GDP, their disaggregation on a sectoral level, subsequent sectoral linkages based on supply and use tables transmitted to the input-output tables and sectoral output linkages with employment. By building on past information and econometric estimates model allow policy analysis and broad economic impacts of irrigation development.

The two most commonly used models for assessing the broad economic impacts of environmental changes are Computable General Equilibrium (CGE) and Input-Output (IO) models. IO models, on the other hand, reflect the economic interdependencies between sectors and regions within an economy, through intermediate supply and final demand, based on linear relations.

The model data includes:

- System of National Accounts and GDP by components
- IO tables of 38 economic activities (based on SNA 2008 classification) - they are derived from Supply- and Use-Tables, provided by National Statistics Office of Georgia.
- Labor market data on sectoral level
- Prices for particular products
- External Trade- imports and exports at a sectoral level

The model data is provided on annual basis and source of the macro data is National Statistic Office of Georgia.

The Regression analysis used in the model includes the estimation and regression for the following economic variables:

- Consumption expenditures of households (as a function of GDP in previous year-Y_{t-1}, and interest rate-i_t)

- Consumption expenditures of government (as a function of GDP in previous year-Y_{t-1}, and government efficiency- gei_t)
- Gross capital formation (as a function of GDP in previous year-Y_{t-1}, and interest rate- i_t)
- Export of goods and services (as a function of World GDP WG_t, real effective exchange rate- $REER_t$ and interest rate i_t)
- Consumption expenditures of households -Deflator
- Consumption expenditures of government - Deflator
- Gross capital formation –Deflator
- Per capita wages awpc_s are used as an explanatory variable for changes in the domestic price level, import prices account for price changes of foreign goods. Average wage per capita in nominal terms awpc_s is estimated based on the productivity of the previous period. The productivity is approximated by value added per employed person, with the consumer price index included to account for changes in the price level.
- Employment across sectors is estimated based on gross output, employment of each individual activity can be adjusted using the labor intensity adjustment coefficient.

To ensure stationarity the time-series regressions include trend factor, in those regressions, where trend factor is not sufficient for stationarity, first differences are used. For testing stationarity, the augmented Dickey-Fuller test is applied. The Residual diagnostic and goodness of fit provide acceptable diagnostic results since the residuals are homoscedastic, normally distributed and do not face serial correlation problems.

After estimating macroeconomic variables, the Input-Output framework inside the model gives the possibility to disaggregate output categories across sectors. Then model calculates the final demand and total use of different economic sectors and based on the input coefficients and import shares in different sectors it estimates the GDP. In all cases, final demand in real terms and the respective price deflator are used to calculate final demand at market prices in nominal terms. Total final demand at the sectoral level is required for the calculation of gross output and the difference between final use and imports.

The value-added per sector is calculated as the difference between gross output and total intermediate consumption. Nominal GDP at the macro level at market prices is the difference between final use and imports of goods and services. Real GDP is calculated analogously. The GDP deflator is the ratio of nominal to real GDP.

Modelled results not only show the direct effects of irrigation system upgrade/rehabilitation but also demonstrate macroeconomic consequences for Georgia due to the economic interrelationships of different sectors.

Together with increasing agriculture productivity, the model also captures other channels, such as increasing capital expenditures and substitution effect between increasing investments and decreasing government consumption. The rehabilitation of existing gravity irrigation systems is done by construction works (e.g., canals, drainage, reservoirs) carried out by the local construction industry. Based on interviews and market analysis we can conclude that water-saving technologies, such as drip irrigation systems, will be imported from abroad (e.g. China, or higher quality from Turkey and Israel).

However, if the farmers will have no choice, rather than buy irrigation systems, they will pass their costs to the consumers by increasing the prices of agricultural products. If the government subsidizes the irrigation systems, it may have to reduce its investments elsewhere. In addition to the direct effects (construction works, material imports, increased agricultural production), these effects account for further second-round and induced effects, e.g., an increase in production in upstream and downstream sectors of agriculture and construction as well as for price and income effects, which in turn influence consumption expenditures.

Based on the above-mentioned methodology and quantitative evidence derived from the survey of agricultural holdings – AGRIS and Propensity Score Matching, the research evaluates the impact of irrigation system upgrade/rehabilitation on the economy and the agriculture sector.

V. Results

Results of Micro Analysis

The analysis based on Propensity Score Matching showed that the use of irrigation technology exerted a positive and significant impact on crop yield. The results of the analysis for different cops indicates that irrigation significantly contributes to the increased productivity and can play an important role to increase agriculture production and reduce import.

The table below shows the Average Treatment Effect of adopting irrigation on crop yield for different crops. It is important to express these figures in percentage terms to evaluate how much percentage increase of crop yield is associated with sufficient irrigation for different crops. As mentioned above, crop yield for annual and permanent crops was calculated differently to avoid the bias in the case of permanent crops caused by different figures of the area occupied by permanent seedlings and area occupied by seedlings with fertility age.

It is worth mentioning that figures of weighted crop yield estimated based on the mentioned analysis are consistent with the data provided by National Statistic Office.

The Average Treatment effect shows that if any crop farmers in the population used the irrigation technology the crop yield of the farmers will be increased by mentioned number in the table. As table shows, irrigation has the highest impact on crop yield in the cases of maize and the lowest impact in the case of apples. It can be explained by the fact that apple has roots deep in the ground and consequently, even without irrigation can get groundwater, while maize is not sowed at enough depth.

The difference in crop yield between irrigated and not irrigated parcels is significant in the case of Hazelnut, Red grape, White grape, Herbs, Potato, Maize and Wheat.

Considering the distribution of irrigated land, the weighted average treatment effect in the case of annual crops amounts to 48% and 28% in the case of permanent crops. The weighted average of expected yield increase for permanent crops is lower due to the small effect of irrigation on the yield of apples that occupies 35% of irrigated land of permanent crops.

The highest difference in crop yields of annual crops between irrigated and not irrigated parcels was observed in the case of maize that represents 23% of irrigated land and 39% of the whole sown area of annual crops. These results are consistent with the different estimates that irrigation can double the yield of maize compared to rain fed maize.

The highest difference in crop yields of permanent crops between irrigated and not irrigated parcels was observed in the case of red grape amounting to 67.7%.

Table 4: Average impact estimates of PSM: Stratification Matching

	ATE	ATE in % terms	T statistics
Permanent crops			
Agregate effect	0.5***	31.5%	5.6
Apple	0.3	2.3%	0.8
Hazelnut	1.1***	66.1%	5.5
Red Grape	1.1***	67.7%	6.1
White Grape	0.4***	20.3%	7.0
Annual crops			
Agregate effect	1125.6***	38.2%	6.2
Barley	325.9	16.1%	0.4
Herbs	613.8**	9.5%	1.99
Beans	232.1	19.4%	0.82
Potato	2356.2***	25.5%	6.0
Maize	2166.5***	116.9%	17.9
wheat	1179.4***	65.2%	7.4

***Significant at 1% level, **Significant at 5% level, *Significant at 10%

These numbers demonstrate that irrigated agriculture will continue to play an important role as a significant contributor to the increase of food supply and self-sufficiency of agricultural products.

In order to reduce the negative nature of the extreme weather events, like droughts and heatwaves, which causes sharp deficit of irrigation water, first of all, the advantage should be given to irrigation of the permanent crops, on the one hand to avoid the neccessity of new caltivation and relevant costs and on the other hand to avoid losses due to the reduction in harvest.

As international experience shows, the impact of irrigation is different across different irrigation systems, farm locations, water availability, and the characteristics of the farm itself, however, different researches proved that the productivity of the households with all three irrigation systems was higher than in rain-fed areas. For example, evidence from India (IAAE, 2012) suggests that productivity increase for the mixed irrigation systems is 46%, while the revenue is increased by 39% for private and public irrigation systems and 52% for both mixed structures.

Several studies that used Propensity Score Matching found positive and significant effects of farmer-led irrigation on the smallholder farmers' per capita net crop income and crop yield. According to Propensity Score Matching evaluations in Tanzania found that the Average Treatment Effect on net per capita crop income in percentage terms amounts to 41%.

Results of Macroeconomic Analysis

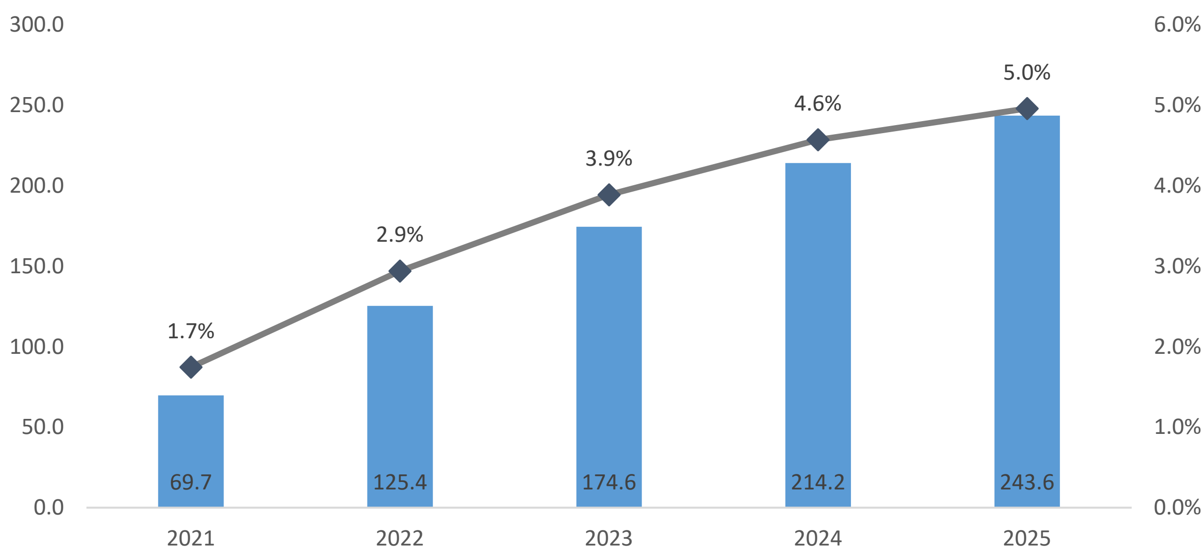
The input-output macroeconomic model evaluates the economic effects of additional irrigation investments. The figures of irrigation investments are based on the Agriculture Development Strategy, however precise distribution of additional irrigated land by crops is not known, consequently the paper considers two scenarios regarding the distribution of additional irrigated land by crops. The first scenario maintains the existing structure of irrigated land by crops. The second scenario envisages the increasing share of permanent crops, mainly hazelnuts and grapes in additional irrigated land (not an apple, since irrigation has no significant impact on apple productivity). In line with state support for orchards, berries and other permanent crops, an increase of shares of permanent crops is expected, as well it is expected that the share of Barley and Beans will decrease. Besides, the Strategy envisages the increasing share of drip irrigation facilities that also supports the mentioned argument. The climate change factor provides additional support for increasing shares of permanent crops since the damage due to climate change is definitely higher in the case of permanent crops.

The biggest economic effects are expected from increased production in the agriculture sector due to the increased irrigated farmland. The overall effect on imports derives on the one hand from additional imports due to higher investment and on the other hand from reduced imports of agricultural products. The production is increasing not only in the agricultural sector but also in those sectors delivering inputs for the agricultural sectors and those sectors using agricultural products as an input. While the annual investment in the construction of irrigation systems has a positive effect on GDP, the import of drip irrigation systems has a negative impact. The positive effects on GDP result in lagged positive effects on consumption and investment, which in turn also has a positive impact on other economic sectors and thus on the GDP. Since the government subsidizes the irrigation systems, the government's consumption expenditures are reduced elsewhere, leading to counter effects.

Scenario 1: Results

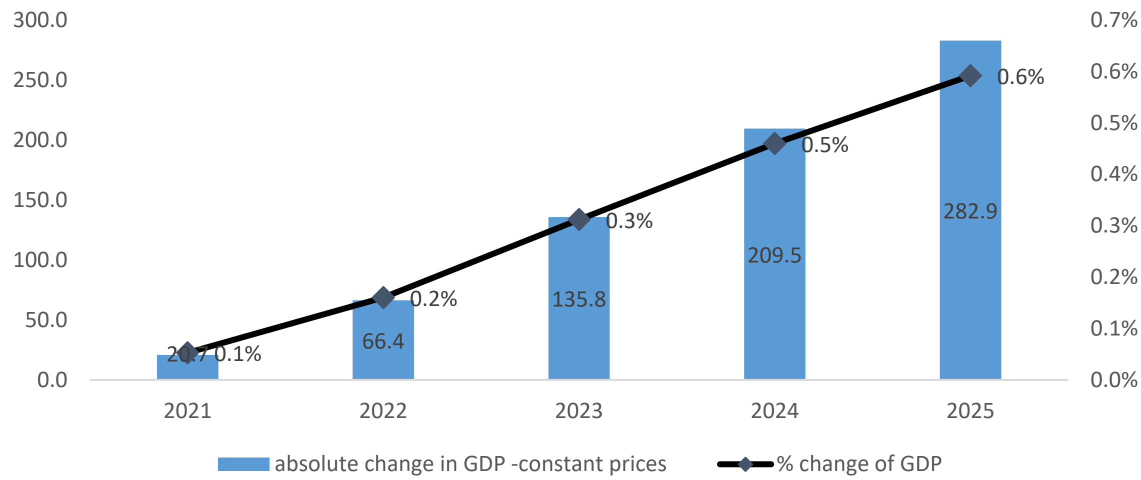
The positive impact of irrigation investments on agriculture output in fixed prices amounts to 244 mln. GEL by 2025. The model estimates the scenario of additional irrigation investments to the scenario without additional irrigation investments. The irrigation development positively affects the output of the following subsectors of agriculture: Growing cereals and other crops; fruit, nuts, beverage and spice crops; vegetables, and nursery products, thus accounting to 43% of total agriculture output. In percentage terms, the positive impact on agriculture output amounts to 5%.

Figure 1: Impact of additional irrigation investments on Agriculture output compared to scenario without additional irrigation investments



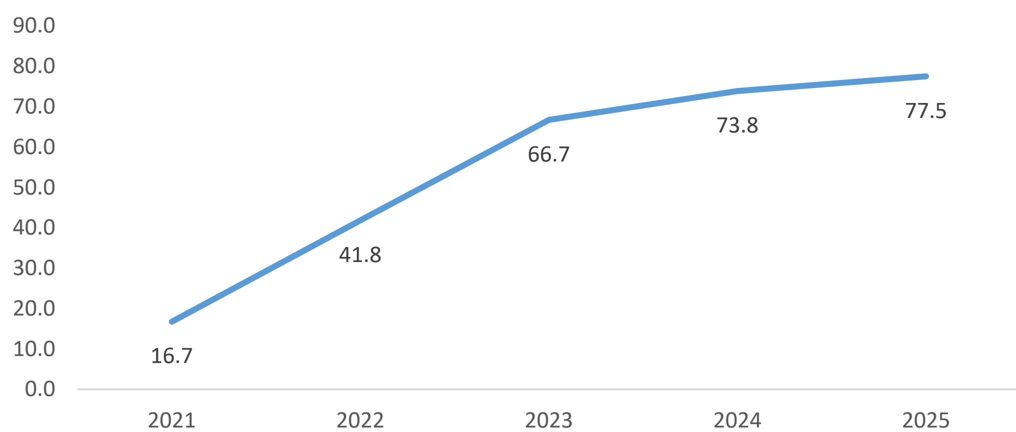
Combining the different effects of irrigation investment, a positive impact on GDP amounts to 283 mln. GEL by 2025. Initially, due to the counter effects of decreasing government consumption on consumption is negative, afterward, positive impact in line with additional demand on the inputs of different economic sectors gradually increases. The overall positive impact on GDP is 0.6%.

Figure 2: Comparing of irrigation scenario to scenario without additional irrigation investments - impact on GDP



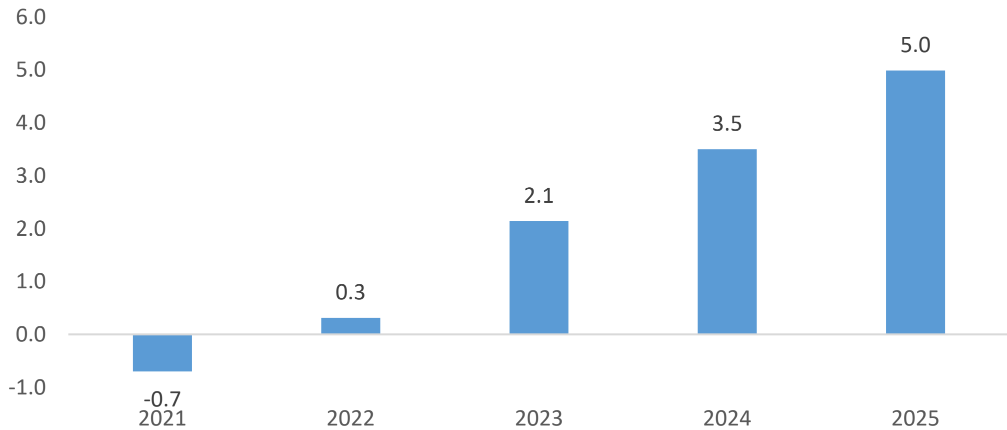
The important positive impact comes from decreasing import of agricultural products and improving trade balance.

Figure 3: Impact of additional irrigation investments on trade balance (mln. GEL)



The impact of irrigation on employment is quite limited due to the positive effects mainly coming from increasing productivity and excessive labour in subsistence and semi-subsistence farming nowadays thus limiting employment generation. In some cases, productivity increase leads to a decrease in employment. Initially, production increase in agriculture sector and subsequent employment do not outweigh employment reduction coming from decreasing government consumption (due to the additional irrigation investments).

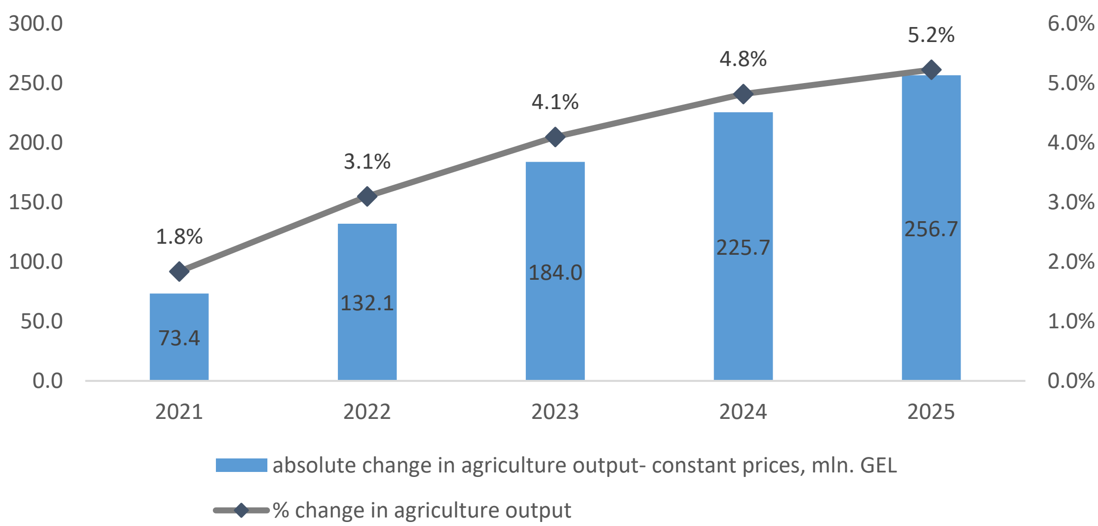
Figure 4: Impact of additional irrigation investments on employment (thousand)



Scenario 2: Results

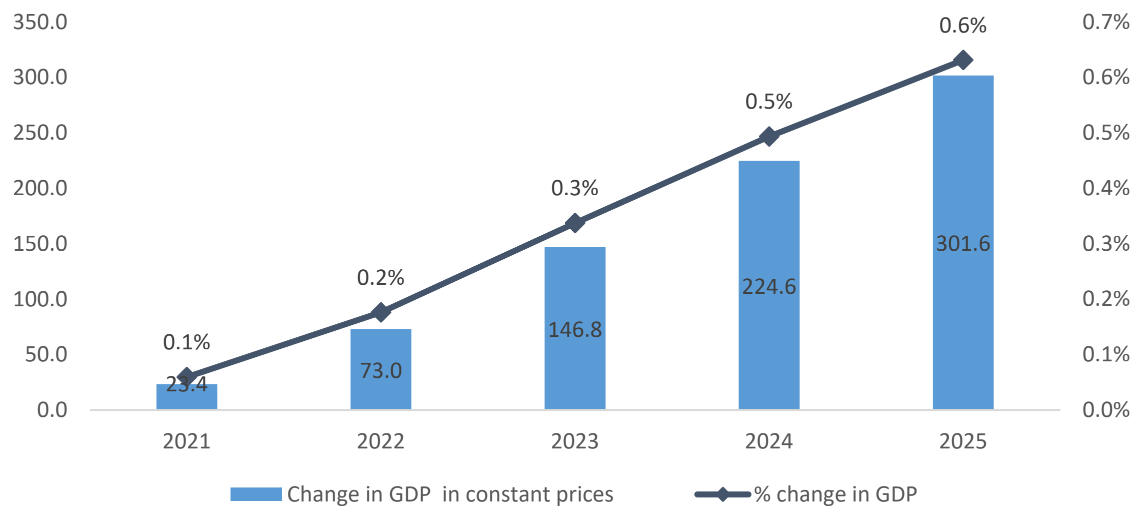
The mentioned scenario envisages a slight increase of shares of Hazelnut, grape, wheat and maize only in additional irrigated land. Consequently, the positive impact on agriculture output is higher by 14 mln.GEL compared to the previous scenario.

Figure 1: Impact of additional irrigation investments on Agriculture output compared to scenario without additional irrigation investments



The positive impact on GDP amounts to 302 mln. GEL by 2025 and trade balance will improve by 82 mln. GEL. Compared to the first scenario additional value added equals to 45 mln. GEL.

Figure 2: Impact of additional irrigation investments on GDP output compared to scenario without additional irrigation investments



It is worth to mention that results in both scenarios depend on the existing impact of irrigation on crop yield, however in line with more prevalence of drip irrigation, as well modern production technologies and agro-technical activities, irrigation investments will lead to higher outcomes.

VI. Conclusions

Research Findings

This study focused mainly on providing an answer to the question of how much impact the use of irrigation has on crop yield and are wide economic benefits of additional irrigation investments in Georgia. The paper showed that irrigation investments generate significant economic benefits and greatly support agricultural competitiveness. The results are based on the effects of irrigation on crop yield in the existing environment in agriculture, while in the case of more efficient irrigation technologies and in line with the development of modern agro-technical activities, irrigation investments will produce higher economic benefits. The irrigation technology use is not a substitute for other productivity-enhancing factors rather a complementary factor. The irrigation effects provided in the paper can increase in the future since state support programs promote the adoption of drip irrigation facilities that provide 90% efficiency compared to the 60% efficiency of surface irrigation thus recently representing the most widespread irrigation facility in Georgia. Changes in the distribution of irrigated land in favor of permanent crops excluding apples will also support higher economic effects.

The study has substantiated that irrigation in the study area significantly improves the crop yield, supports agriculture competitiveness, reduces import dependency and promotes economic growth. The role of irrigation is steadily increasing due to the climate change vulnerability.

In order to reduce the negative impact of extreme weather events, like droughts and heatwaves, which causes sharp deficit of irrigation water, first of all, the advantage should be given to irrigation of the permanent crops, as in the case of declining and/or abstaining plants, in addition to the need to be expelled and newly cultivated, farmers can not afford to harvest which leads to the additional losses.

The limitations of the research

The research focuses on important issues for evidence based policy implementation that have not studied in Georgian reality yet and consequently, research has several limitations. The limited sample size and data availability for niche high value added crops with high export potential that occupies relatively small share of cultivated land in Georgia represents the one of the shortcomings of the research. In overall paper provides estimations for the crops that accounts majority of cultivated land.

The analysis discussed in the paper fully relies on actual figures and variables based on the existing widespread irrigation facilities in Georgia, however different types of irrigation can yield different impact on crop yield considering different efficiency levels of different types of irrigation facilities. Subsequently, positive economic effects of irrigation can increase over time, in accordance with more prevalence of more efficient irrigation facilities, like drip irrigation. For instance, drip irrigation brings multiple benefits to adaptation and productivity: increases soil fertility; reduces heat stress and decreases post-harvest loss. In the case of increasing data coverage and providing more detailed data by types of irrigation, there is room for further research to evaluate the economic effects of different irrigation schemes. Besides, useful research can be done regarding the role of irrigation in the context of climate change adaptation in agriculture, since those issues are not explored sufficiently in Georgia.

Policy implications

Setting up an irrigation system is associated with high capital costs, leading farmers to weigh up options whether or not to install irrigation systems. On most occasions, their decision depends on the characteristics of the land, the weather in the area, and the capital costs of the irrigation system. Government can support eliminating high capital costs for farmers by subsidizing capital expenditures of setting up irrigation systems and promote the development of individual, modern irrigation schemes. As discussed below, existing irrigation systems is associated with high maintenance costs, as well as efficiency shortcomings. Reduction of maintenance costs is linked to the consolidation of lands, therefore policies that support land market development and consolidation of fragmented plots represent the important factor for increasing efficiency of irrigation systems and overall agricultural competitiveness. To this end, Government may consider shifting its irrigation rehabilitation and modernization policies towards more market based approach, meaning that irrigation network construction should be based on commercial principles. For example, instead of rehabilitating old and amortized irrigation infrastructure, it might be more feasible to arrange boring wells or small water reservoirs for commercially viable agricultural holdings.

It should be underlined that, several state support programs, under the Rural Development Agency of the Ministry of Agriculture and Environment protection of Georgia, already support development of modern irrigation systems in Georgia. For example, according to the recent changes in state support program "Plant the Future", in order to benefit from the program it is necessary to have an irrigation canal or a boring well, and in case of absence of irrigation network, it is possible to finance the arrangement of a boring well with program component. As prerequisite for the operation of any irrigation systems is water debit. Besides, it is important to promote/introduce other types of modern irrigation systems, including drip irrigation systems. Instalment and operation of modern irrigation systems is associated with significant costs and requires proper maintenance. There is still a lack of knowledge and experience in Georgia in terms of maintenance of modern irrigation systems. For instance, it is quite common to damage irrigation systems during mowing the lawn or harvesting activities. Renovating such irrigation systems can be associated with significant additional costs.

In order to increase efficacy of agricultural state support programs, on one hand it is important to increase access to finance for farmers and on the other hand support in adaptation of modern technologies. Combining grant component along with and a technical assistance (knowledge/technical expertise growth) component should also be considered within state support programs design. As of now, the importance of the technical assistance component is not properly acknowledged within the state support programs from farmers as well from implementing agency's' side. Therefore, it is essential to include technical assistance component as a prerequisite for benefiting from the grant or other forms of state support program.

Besides, other challenges associated with irrigation and discussed in Data and Context section needs to be tackled in order to ensure efficient, uninterrupted provision of melioration services and minimize the dependence of agricultural production on climate conditions. In this regard, existing amelioration infrastructure needs to be rehabilitated and modernized, including springhead structures, main irrigation canals, hydro-technical structures, etc. It is necessary to create additional reservoirs to ensure adequate water debit during all seasons of the year, as well, upgrading rural irrigation networks and increasing the drip irrigation areas is critically important. Besides, it is important to improve the quality of amelioration services and expand the coverage of land plots. In order to achieve the abovementioned objective, existing non-functioning reservoirs should be restored and commence construction of new reservoirs.

It is important to introduce modern irrigation technologies and define market-based tariffs for irrigation in order to use water rationally and increase the effectiveness of irrigation. The current tariff in Georgia is not adequate, fair and does not ensure the rational use of water resources. Tariff for 1 hectare of irrigated land in Eastern Georgia amount to - 75 GEL per year, and in Western Georgia - 45 GEL per year. In some cases, farmers located at the springhead of the canal use water recourses without paying irrigation fees. In order to create incentives for efficient use of irrigation water resources and send the correct signals to market players, the introduction of market price principles for water resource usage can be considered. Market-based price provides an incentive for consumers to adjust their behavior and use water resources more rationally, leading to an increased number of well-irrigated land plots. According to international practices, several irrigation fee models exist. “Volume meter” fee, implies payment based on consumed water amount, can be considered as a most efficient model but is associated with additional investments for adopting technologies to measure the volume of consumed water for each farm. Another tariff is “Binomial”, which means that there is a fixed amount for each irrigated land plot plus a variable part of the fee, based on a number of irrigation procedures and time for irrigating the land. In Georgia, almost all of the irrigation systems are public and the fee for irrigation is flat per hectare per year, despite the amount of water used. Because of this, the existing tariff structure cannot encourage farmers to use water efficiently and represents a challenge not only in terms of developing efficient irrigation systems but also in terms of rational use of water resources. In addition, farmers not using water at any given time during the year, don’t pay fees for maintenance of the irrigation system. Besides, the problem of management of the irrigation system also arises with regard to revenue collection. The land consolidation and more prevelance of individual and efficient irrigation systems will partially adress above mentioned issues, reduce irrigation costs and foster the development of agricultural commercial practices.

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