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ADOPTION OF MODERN PRODUCTION PRACTICES AND AGRO-TECHNICAL ACTIVITIES IN SPECIFIC SUB-SECTORS OF ARGICULTURE OF GEORGIA

AUTHORS:

NINO JAVAKHADZE – Main Researcher
TINATIN PAPASHVILI – Assistant Researcher
GIORGI TKESHELIADZE - Modelling specialist

Abstract

In order to achieve country's inclusive economic development, promotion of agriculture is one of the key objectives for the Government of Georgia. Lack of application of modern production practices and low productivity represent the main challenges for local agricultural sector. Applying modern production practices will increase competitiveness, self-sustainability and value added in the sector. Accordingly, it is important to evaluate economic effects of application of modern production practices as well as the scale of the impact of sector's production growth on total output and employment.

The present paper examines the impact of different agricultural practices on crop yield as well as evaluates wider economic effects of application of modern production practices in various sub-sectors of agriculture. Paper evaluates how modern production practices and use of agricultural technologies affect country's Gross Domestic Product (GDP) and employment.

Keywords: crop yield, agriculture productivity, economic impact, agriculture output, Georgia

Introduction

The report was developed within the project "Adoption of modern production practices and agro-technical activities in specific sub-sectors of agriculture in Georgia" implemented with the support of 50x2030 initiative to close the Agricultural Data Gap. The primary goal of this project is to contribute to the analysis, interpretation and application of data to decisions in agricultural sub-sector support policy, namely production of different crops, fruits, vegetables and plant growing in general. Paper identifies relevant efficiency constraints, related to limited use of modern production practices and agro-technical activities in this area. Paper also focuses on main challenges within the crop production capacity in local context and delivers relevant policy considerations.

The improvement of agriculture sector competitiveness represents an important factor to support inclusive economic growth. The agriculture sector provides 8.4% of GDP and 7.4% of gross output in Georgia, however the contribution of agriculture employment is much higher and accounts for 20%. Together with primary agriculture, manufacturing of foods and beverages accounts for 9.6% of gross output.

On sub-sectoral perspective, significant portion of agriculture output relies on annual and permanent crop production. The share of plant growing accounts for more than 45% of agriculture sector value added, dominated by growing of cereals. The major part of agricultural holdings is oriented at plant growing. Distribution of agricultural households according to the orientation is the following: 59.3% of households are focused on crop production, and 34.7% of households are oriented at both livestock and crop production, the remaining 6% of households are focused only on the production of livestock products. The annual crops account for around 65% of total sown area and traditional cereals - maize and wheat - constitute more than 60% of sown area of annual crops. The size of sown areas of highly productive plant products is very low. For example, berries account for less than 1% of sown area of permanent crops. Planting areas of high value-added and high-multiplier vegetable crops are also low.

Despite the fact that crop production is one of the most popular agricultural activities for Georgian farmers, and it has taken one of the biggest portions in agriculture in the country, the low level of productivity, lack of mechanization and good production practices and high share of subsistence and semi-subsistence farming are the main challenges that dampen the competitiveness and cause low utilization levels in this field. That also materialized during recent years, namely 2014-2019, increasing share of agricultural land was left unused.

Despite this, during the recent years, thanks to the agriculture sector state support programs, agriculture sector competitiveness has steadily increased, however lack of good production practices and low commercialization still represent a challenge, as even in commercialized farming good production practices are restricted by lack of basic infrastructure like irrigation systems, or lack of knowledge and insufficient access to finance for using fertilizers, pesticides or basic production technologies. More than 50% of agricultural land has not been irrigated and less than 1% of farmers implements land improvement activities. Low levels of commercial capital flows in the sector, as well as historically underdeveloped commercialization appetite formed agriculture sector that is dominated by subsistence and semi-subsistence farming, more precisely 69% of plant growing farms produce primarily for own consumption (sell less than 10% of production), only 17% of farms produce mainly for sale (selling more than 50% of production). The self-sufficiency ratio (SSR), which measures the percentage of domestically produced food products in consumption varies among products. The least self-sufficient food product is wheat. Despite increase in self-sufficiency of wheat from 2006 to 2020, the level is still low, amounting to 15%. The self-sufficiency ratios show that increasing production of fruits support export, while increasing competitiveness in other agriculture activities promote import substitution. The trade deficit for vegetables amounts to 100 thousand tons and 490 thousand tons for wheat.

Since the improvement of agriculture productivity by adopting modern production practices can yield great economic benefits, evaluation of expected outcomes has great importance for policy purposes.

The present paper intends to evaluate broad economic effects of good production practices in plant growing. Firstly, it focusses on the extent to which increased prevalence of modern agro-technical activities and practices can increase crop yield and afterwards how much it affects the output of agriculture sector and GDP.

The paper aims to show the economic benefits of various production practices in Georgian agriculture sector, with high share of subsistence and semi-subsistence farming, where the use of other modern production practices is limited. Consequently, in order to show the economic benefits of different policies that support the use of modern production practices, the micro and macro model estimates can provide good insights. The results of macro model simulations provide quantitative evidence and show broad economic benefits of prevalence of different production practices in plant growing. The results also show the multipliers of sub-sectors of plant growing and wide effects of policies that support modern production practices in specific sub-sector of plant growing. Based on identified relationships and results that have policy relevance, paper also provides policy considerations and relevant recommendations for policy makers.

The paper includes micro and macro analysis. Micro analysis comprises the effects of modern production practices on production yield for different plant products based on multiple regression analysis and derives number of production scenarios to evaluate possible outcomes and impact on agriculture value added and employment in the sector. Paper mainly uses the AGRIS data that contains the information on the characteristics of agricultural holding. The data is collected in 11 regions of Georgia and sample covers 143 323 agricultural holdings and information is provided at the plot level. The project will support Ministry of Environmental Protection and Agriculture of Georgia (MEPA) as well as other policy stakeholders, to ensure the effectiveness of state policy in the development and promotion of plant growing sub-sectors in the agricultural sector, that's on the one hand considered when the state financial support programs for the development of crop production in the agricultural sector are efficient, and when high yields in the medium and long term are achieved, on the other. At the same time, we believe that the correct analysis and assessment of the plant growing sub-sectors by the policy makers will increase the interest of the commercial sector

in this area, which in turn will contribute to the growth of private investment in the agricultural sector and the adoption of modern agricultural technologies. In addition, in order to ensure the proper socio-economic situation and promote inclusive economic growth in the country, it is also important to properly assess the impact of the development of the plant growing sub-sector on such important economic parameters as output of the agricultural sector in general, productive employment in the sector and investment multipliers. Observing those multipliers gives proper understanding for policy makers regarding the sources of positive impact of intervention - whether additional investments create sufficient capacity to improve export, or it is due to increased consumption, etc. To sum up, it is extremely important for policy makers to properly assess agricultural sector policy priorities based on the country's economic development needs.

Both data analysis and interviews held during the project, show that the rate of use of modern production practices and agro-technical activities in different crops, fruits and vegetables is very low, which is one of the main reasons for the relatively low yields compared to peers. At the same time, it is important that the relevant knowledge and qualifications on effective production practices and use of agro-technical activities in production are also very low, as well as access to these means of increasing productivity is very limited, based on limited access to financial resources. In addition, significant problem is the lack of irrigation infrastructure, or in many cases inadequate irrigation levels. Land fragmentation, unregistered land use that limits those assets to be economically viable from financial institutions' perspective, insufficient or limited population of high value added and export-oriented plant products are other important systemic challenges. For the most part, all of those challenges are closely related to historical context of the country's agricultural sector.

Context

One of the important systemic determinants that limits the adoption of good production practices is land fragmentation. The share of farmers who own less than 1 hectare amounts to 72% and at the same time these holdings are very fragmented. The land fragmentation and non-developed land market negatively affects the adoption of modern production practices, since small scale holding mainly produces for own consumption, it has limited access to credit and does not apply capital expenditures, or does not care about high quality seeds.

Due to the lack of modern production practices and agro-technical activities, crop yield in Georgia is very low compared to peers and European and Central Asian countries, where the contribution of agriculture sector in GDP is similar to Georgia. In line with increasing vulnerability to climate change, prevalence of modern production practices and agro-technical activities plays an extremely important role to support productivity. Georgia has significant room for improving agriculture sector competitiveness by increase of crop yields. The average productivity in Georgia underperforms peer countries in every sub-sector of agriculture. Productivity increase in agriculture sector will support increase of value added and decrease of import share as well as development of manufacturing of food products and beverages. Increasing crop yield in agriculture sector will promote export facilitation, more value added in the country and reduce import dependency. The lack of modernization of agriculture sector is one of the root causes for the persistence of high poverty levels in the country. The poverty rate in rural population is significantly higher compared to urban population and in 2019 amounted to 23.7% (urban poverty rate 16.4%). Agriculture sector accounts for only 4% of the banking sector loan portfolio and its share in fixed capital investments is below 2%. Mentioned figures clearly indicate the significant room and necessity of the improvement of agriculture sector competitiveness.

Historical Context

Since 1921, when Soviet Russia invaded Georgia and Bolshevik rules came into force, farming sector landscape changed drastically. Years of Collectivization and Kolkhoz era practically erased private farmers and farming practices in general. All agriculturally valuable land plots became "public property" and consequently yields of crops dropped significantly, this had dramatic outcomes, causing years of hunger. Worth to underline that Collectivization period in Georgia was not so repressive as for instance in Ukraine (Holodomor), but it has had deep impact on plant growing sub-sectors, cattle farming and agricultural activity in general.

Several years of Independence (1st Republic of Georgia 1918-1921) gave significant impact, land reforms and financial stability converted into basic crop production rise. For instance, wheat and maize grew from 1080 pounds in 1918 to 60 542 pounds in 1919; Wine - 6 948 pounds in 1918 to 309 340 pounds in 1919, etc.

As mentioned above, all achievements during the short period of Independence were cannibalized after Soviet occupation.

Soviet Era for Georgian agricultural sector might be characterized by two words - "Rise & Dump". There were some sectors developed based on Soviet Union "strategic needs", for instance, tea and citruses, consequently this area was developed showing significant rise in general levels of production, but other fields of sector like milking farms, wheat and meat production were "less important" due to "Centralized Planning" of the Soviet economy.

First decade after achieving independence in 1990s, so-called "land reform" was initiated that aimed to redistribute previously state-owned assets to citizens of sovereign country, based on legitimate level of rightfulness. Under this headline, policy makers have distributed little above 1 hectare land plots to citizens in rural areas for persuasion of subsistence farming. Due to lack of funds and knowledge these reforms during 1992-1998 failed and caused structural challenges as well as legal complications (land plots were not registered accurately and no electronic cadaster existed), boundaries between land plots were mismatched, etc.

In 2015 the share of land plots from 5 to 50 hectares in Georgia amounted to 1.5%, while the same figure in the EU was 36%, in US - 60% and in Germany - 56%. The share of land plots below 1 hectare amounted 98% in Georgia, 56% in EU and 0.2% in US[1].

Fragmentation of farming land plots is one of the main problems for sustainable growth of planting. As all studies show, land plots should be increased 6-folds to achieve more or less acceptable productivity levels.

However, in the conditions of mass production of the Soviet period, there was no production of specific, high value added or export driven plants, because of absence of commercial-oriented means, which hindered the possibility of commercialization of the sector in the following years. The practice of mass production has made it impossible to meet quality standards and consequently the crop or fruit production sector has been unprepared to position itself on a competitive market.

It should be noted that despite the problems, after the collapse of the Soviet Union, Georgia inherited significant irrigation infrastructure and certain scientific base in the field of crops, although this proved to be insufficient in the following years.

[1] EUROPEAN COMMISSION, 2015

During the two decades after gaining independence, country has experienced even more stagnation in this sector. There was no streamlined policy on how agriculture should be organized to be transformed into productive sector of economy. Only those few portions of farmers achieved success that managed to buy land plots from others and started more significant farming activity. Without access to finance and government support these activities were fragmented and could not have an impact on food security and import substitution.

Only after 2013 and especially because Georgia signed Association Agreement (AA) with the European Union (EU), Georgia adopted law on farm lands and law on cooperation. Until 2014, there were no government support programs for farmers. During the same years, Government of Georgia (GoG) approved Rural Area Land Plot Registration Strategy and issued a Road Map to clarify all problematic issues in this field. Those were first steps from policy perspective towards strategy-based development of agriculture in the country.

Existing State Policy on Plant Growing Sub-Sectors

The signing of the Deep and Comprehensive Free Trade Area Agreement (DCFTA) with the EU created a real perspective of bringing Georgian products to the EU market. In the process of implementing the Association Agreement with the European Union, reforms have been carried out in a complex way in all areas.

The Ministry of Environmental Protection and Agriculture of Georgia has initiated and implemented a unified agro-project, which aims to provide cheap and affordable financial resources for processing and storage of primary agricultural production, promote insurance in the agricultural sector, establish nurseries and perennial crops, co-finance agricultural products processing and storage enterprises. The total volume of agro-credits within the unified agro-project as of 2019 (as of 30.06.2019) already exceeded 2 bln. GEL (preferential agro-credit project); also 7,473 ha of intensive orchards have been cultivated (7,526 ha have been funded / approved).

Significant results are in the field of agro-insurance, the main purpose of which is to develop the insurance market in the agro-sector, promote agricultural activities, increase the competitiveness of agricultural enterprises. In 2014-2018, 81,453 policies were issued under the agro-insurance program. A total of 71,413 hectares of land are insured. Reimbursed losses in 2014-2018 amounted to 35.3 mln. Georgian Lari (GEL).

As of 2019, 102 contracts were signed within the framework of the agricultural machinery co-financing program, which aims to increase access to agricultural machinery, with a total amount of 14.3 mln. GEL, of which the co-financing amounted to 6.7 mln. GEL.

Measures taken in the field of viticulture and winemaking are noteworthy, including the vineyard cadaster program and market diversification.

Annually, programs are implemented to protect agricultural crops through quarantine and eradication of foci from particularly dangerous pests.

The experimental-collecting orchards were enriched with 120 local, 60 introduced and 8 varieties of berries. 45 wild vine forms, 30 local and 15 introduced varieties were found and added to the study. In order to establish quality seed and planting material in the market, also in order to introduce a system of certification of seeds and planting material, a legal framework in accordance with international rules and standards was created, a system of mandatory certification of cereals (wheat, barley) and voluntary planting material was developed. A seed quality laboratory has been equipped

in accordance with modern standards and accreditation works are underway. Active collection of field crops and in-vitro gene banks have been launched.

Conceptual Framework/Theoretical Background

The present paper includes micro and macro analysis. Micro analysis comprises the effects of modern production practices on crop yield for different crops based on multiple regression analysis.

Use and level of presence of good production practices and what can be considered as such type of activities according to Georgian reality, were identified based on the AGRIS survey. More precisely based on the AGRIS survey data and regression analysis following parameters were calculated:

- How much does the use of fertilizers increase crop yield for different crops?
- How much does the use of pesticides increase crop yield for different crops?
- How much does the irrigation increase crop yield for different crops?
- How much does the use of basic technologies increase crop yield for different crops?
- In the case of several crops like vegetables, greenhouses can be considered as good production practice in comparison with growing such cops on open ground, since it ensures substantially higher yield. Based on the data, the difference in crop yield for relevant crops between greenhouses and open ground was calculated.

Macro analysis includes the economic effects of more prevalence of modern production practices in plant growing based on the outcomes derived from regression analysis.

Moreover, paper presents first tier multipliers of different sub-sectors of agriculture, namely: growing of cereals and other crops; growing of fruits, nuts, beverage and spice crops and growing of vegetables, horticultural specialties and nursery products.

The mentioned data was used as inputs in macroeconomic model to calculate the impact of different scenarios on agriculture output, GDP and employment. More precisely based on expected increase in crop yield and land distribution by crops, weighted impact was estimated separately for vegetables, traditional annual crops, fruits and other permanent crops and mentioned results were integrated in macro model to simulate the scenarios.

In addition, first tier revenue and investment multipliers were calculated based on the supply and use tables.

Based on the literature review, the wide range of technological improvements in agriculture like genetic improvement of varieties, fertilizer technology, adaptive microbial technology, pesticides, farm machinery, irrigation technology have supported enhancing crop productivity. It has been reported that 1 kg of nutrient fertilizer produces 8 kg of grain. In addition, fertilizers are contributing to up to 50% of the crop harvest product.[2] The doubled increase of food production worldwide was partially attributed to a 6.9-fold increase in nitrogen fertilization and a 3.5-fold increase in phosphorous fertilization in the 1990s.

Increases in productivity are supported by several factors including use of fertilizer, better varieties, more resilient crops, irrigation and use of machinery. Pesticides have been an integral part of the

[2] Umina P, Baker G, Edwards O. Russian Wheat Aphid: Tactics for Future Control. Grains Research and Development Corporation; 2017. 40 p.

process by reducing losses from the weeds, diseases and insect pests that can reduce the harvested production. The use of harvested machinery supports the reduction of losses in harvest and production left in field.

In Georgia most of agricultural activities are not commercial and farmers rarely use different practices, such as fertilizers, irrigation, pesticides and machinery. The irrigation reduces the negative impact of climate change and heatwaves on crop productivity, while pesticides support the resistance of crops to diseases and help to sustain harvest.

The economic effects of adopting modern production practices and its impact on agriculture competitiveness has not been studied in Georgia. Consequently, there is no availability of any previous estimations regarding modern production practices in Georgia. The relevant studies conducted in Nigeria, Tanzania, Ethiopia and Ukraine showed that good crop management and application of modern productions, like application of harvesting technologies, fertilizer application, control of pests and diseases, irrigation, storage are the prerequisites for increasing crop yield and successful crop production. For instance, Marten Graubner and Igor Ostapchuk, based on the regression analysis showed that the additional application of fertilizer (in terms of higher input costs) of 1 thousand Ukrainian Hryvnias (UAH) per hectare would cause an increase in yield of wheat by about 1 to 1.2 tons per hectare[3]. According to the Dowgert, irrigated crop yields are 2.3 times higher than those from rain-fed ground. Ogunniyi Adebayo1, Omonona Bolarin1, Abioye Oyewale and Olagunju Kehinde, 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[4].

The paper aims to evaluate the correlation between crop yield of different crops and application of modern production practices and analyze wide economic effects of increasing crop yield due to modern production practices. It mainly focuses on those issues that have not been studied in Georgia yet.

Data

The AGRIS data contains the information on the characteristics of agricultural holding. The data is collected in 11 regions of Georgia and sample covers 143 323 agricultural holdings and information is provided at the plot level.

The main sections of the survey data contains the information on general characteristics of the holding: area of holding and number of plots; presence of irrigation facilities; land use type; geographical location; sown crops on the plot and their harvested area, production and irrigation level (sufficient irrigation, not sufficient or no-irrigation); information on greenhouses; crop production in the holding and its use; use of fertilizers and pesticides; agriculture machinery and use of machinery; presence of storage facility, production costs including costs of the crops, capital expenditures; agriculture credit and main characteristics of the credit.

The sample data is available for 387,963 plots that comprise sown area of annual crops, permanent crops, scattered trees and greenhouses. The sample covers 23% of total sown area of annual crops and 7% of sown area of permanent crops.

[3] Marten Graubner, and Igor Ostapchuk, 2018
[4] Ogunniyi Adebayo, Omonona Bolarin, Abioye Oyewale and Olagunju Kehinde, 2018.

The sown area of annual crops is mainly covered by maize, wheat, barley and potato. The land under permanent crops is mainly covered by orchards and vineyards.

Figure 1: Distribution of sown area of annual crops

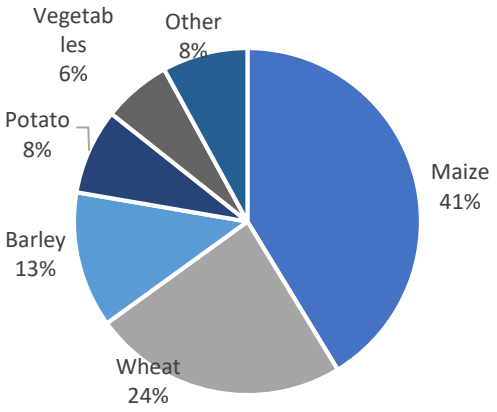
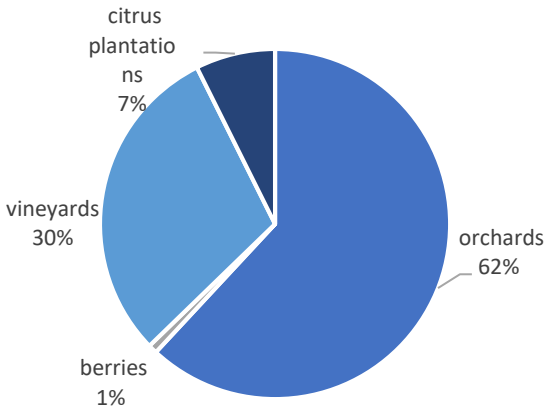
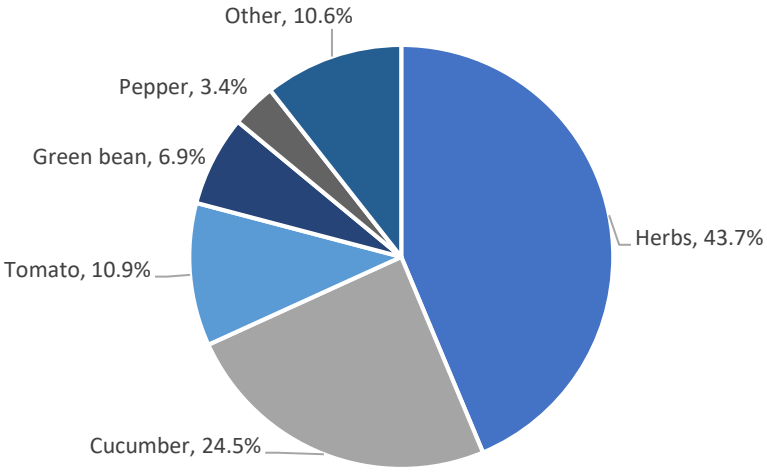


Figure 1: Distribution of land under permanent crops



In Georgia greenhouses are mainly covered by herbs, cucumber, potato and green bean, they constitute more than 85% of total greenhouse area.

Figure 2: Distribution of greenhouse area by crops



The main variables of the interests are: use of fertilizers, use of pesticides, sufficient irrigation and use of harvesting machinery. All these variables are dummy variables and get 1 or 0, depending on whether the farmer uses mentioned production practice or not. Besides, variables that are included in the regression analysis are: sown area of the crops, capital expenditures, credit, expenditure on crops, presence of storage facilities and regional dummies. The regional dummies vary in the regressions of different crops considering crop varieties in different regions and crop characteristics depending on the location, for instance for white grapes three regional dummies were selected: for Kakheti, Imereti and Racha-Lechkhumi and Kvemo Svaneti regions.

The table below shows the descriptive statistics for annual and permanent crops.

Table 1: Characteristics of annual crops

Crop	Crop yield		Harvested area		Characteristics of good production practices				Number of Observations
	mean	Standard deviation	mean	Standard deviation	Percent of farms using irrigation	Percent of farms using fertilizers	Percent of farms using pesticides	Percent of farms using harvesting machinery	
Annual crops									
Maize	2,235.3	2,499.2	0.44	1.9	13.4%	55.7%	16.3%	3.7%	3079
Wheat	2,027.7	1,036.5	6.35	14.99	7.0%	39.8%	12.9%	65.9%	1327
Potato	8,928.8	6,601.4	0.19	0.65	21.2%	40.9%	33.3%	21.8%	3120
Permanent crops									
White grapes	2.02	3.05	0.5	1.98	14.1%	12.4%	87.3%		1402
Red grapes	1.87	1.55	0.45	2.19	19.2%	17.3%	76.7%		516
Hazelnut	2.18	2.45	0.65	2.2	22.0%	17.3%	42.5%		294

Methodology

Micro Model – Regression Analysis on Crop Level

Evaluation of the impact of good production practices on the crop yield is based on multiple regression analysis on crop level, since presented practices are associated with different effects for different crops. Consequently, different equations were constructed for the following crops: wheat, maize, potato, white grapes, red grapes and hazelnut. Different practices, such as: irrigation, fertilizers, pesticides, harvesting or sowing technologies differently determine crop yields by crops, for instance, fertilizers have moderate impact on the yield of hazelnut, however its impact is much higher in the case of grapes and maize, while irrigation will lead to the higher impact on yield of hazelnut, maize and grapes, compared to the barley, bean or potato.

The regressions were not constructed for vegetables and herbs, since greenhouses can be considered as modern production practice for those crops and difference for those crops in crop yield between open ground production and greenhouse production was calculated.

The cross-section regression model for mentioned crops has the following general form:

$$\log(crop\ yield_{ij)} = a + b_1 irrigation + b_2\ use\ of\ pesticides + b_3\ use\ of\ fertilizers + b_4\ capital\ expenditurees + b_5\ region + b_6\ use\ of\ harvesting\ machinery + b_7\ credit + b_8\ plot\ size$$

The crop yield for annual crops is measured as the ratio of crop production and harvested area and is expressed in logarithmic values, subscript i denotes individual plots and j - different crops, for instance crop yield for wheat, where the number of plots is 1327 and i varies from 1 to 1327. The crop yield for permanent crops is measured as the ratio of harvested production and number of seedlings at growing age.

Variable irrigation describes the presence of irrigation, $pesticides$ describes the use of pesticides, $fertilizers$ describes the use of fertilizers, *capital expenditures* characterize the amount of capital costs, *region* denotes plot location factor, credit denotes the amount of credit and plot size denotes the harvested area of plots. Use of harvesting and sowing machinery characterizes the utilization of mentioned technology and relevant machinery was selected individually for different crops, however based on the data this variable is applicable for wheat, maize and potato.

The regressions are constructed separately for different crops and look at disaggregate yields by following 6 crops: Wheat, Maize, Potato, White grape, Red grape and Hazelnuts. The agriculture credit and crop expenditures are not significant variables in the regressions of wheat and maize and incorporation of those variables in the regression does not affect the coefficient of variables of interest. The capital expenditure is not significant variable in the regression of potato and inclusion of this variable does not affect regression results. Credit is not significant variable in the regression of white grape.

The following variables - irrigation, use of pesticides, use of fertilizers and region - are dummy variables. Subsequently, for estimation of percentage change of crop yield associated with irrigation, pesticides or fertilizers, the following formula is used: $100 * (e^b - 1)$, where b represents coefficient of the relevant variable.

The mentioned regressions have some limitations, more precisely omitted variable problem, since one of the main determinants of crop yield – at least climatic factors and soil quality are not considered due to the absence of relevant data, however coefficients of the variables is likely to provide unbiased estimates, since the omitted variables are not correlated with the variables of our interest. The bias of coefficient estimates due to the omitted variable is depended on correlation between omitted variable and explanatory variables and the possible coefficient of omitted variable on dependent variable. Since the possible correlation between omitted climatic and soil characteristics is likely to be near zero, the regression does not face biasedness problem. Considering above mentioned aspects the regressions provide the useful estimates as inputs in macro model.

The regression models do not face collinearity problem. Residual diagnostic of regressions also shows acceptable results, since the residuals are normally distributed and there is no heteroscedasticity. The heteroscedasticity was checked based on Breusch Pagan, White and Glasjer heteroscedasticity tests.

Macroeconomic Model

The macro-econometric or so-called dynamic IO model is considered appropriate tool to analyze the economic impacts of sectoral policies, since Input-Output model envisages sectoral interdependencies and effects of any changes in demand components. The model gives possibility to use mechanism for performing scenario analysis. Research can specify sets of quantified assumptions which will be automatically injected into the model at runtime. The supply and use tables provided

by National Statistics Office of Georgia (GEOSTAT) transmitted to the Input-Output tables represent the main part of the model. The Input-Output models were applied in several studies to evaluate broad economic effects of any policy changes in specific economic sectors.

The macroeconomic variables in the model give an overview of the economic processes in a country. It is a recording of how production is distributed among consumers, businesses, government and foreign nations and shows, how income flows to these groups and how they allocate these flows to consumption, savings and investment. Thus, the information generates a basis for sectoral economic analysis, policy formulation and evaluation of broad economic effects. The IO tables represent a snapshot of the flows of products and services produced and consumed in the economy, disaggregating the monetary flows between industries, the consumers, and the suppliers of production factors in the economy.

The national accounts data in the model is provided on annual basis (source of the data is GEOSTAT).

Based on the national accounts several regressions were constructed, including:

- Consumption expenditure of households (constant prices) regressed on lag GDP and AR process
- Consumption expenditure of general government (constant prices) regressed on lag GDP and government efficiency index
- Gross fixed capital formation (constant prices) regressed on lag GDP and interest rates
- Export of goods and services (real terms) regressed on World GDP and Real Effective Exchange Rate
- Import of goods and services (real terms) regressed on GDP and Real Effective Exchange Rate.

The following projected variables are expressed in current prices by using relevant price indices: CPI, GDP deflator, export price index and import price index.

After estimating final demand components mentioned above, based on IO tables they can break down into economic activities and sectoral parameters describing import share in specific economic activity, export, or consumption can be simulated in the model. The model has possibility to simulate productivity increase in the following sub-sectors of plant growing: growing of cereals and other crops; growing of fruits, nuts, beverages and spice crops; growing of vegetables, horticultural specialties and nursery products.

Considering the AGRIS survey results, several scenario simulations were tested in the model. The study makes different simulations for different subsectors of plant growing: vegetables and fruits, nuts and spice crops.

Since the simulations are executed in the model, the model recalculates the final use that represents the sum of household consumption, government consumption, capital formation and export. GDP is measured as final use minus import.

To evaluate the agriculture employment, different employment status workers in agriculture - employers, employees, own account workers and contributing family workers - are related to agriculture output. The total agriculture employment represents the sum of employers, employees, own account workers and contributing family workers.

Results

Results of the Regressions

The regression analysis proved the significant and positive correlation of different production practices, like irrigation, pesticides, fertilizers and harvesting machinery with crop yield. All of the mentioned variables are significant and positively affect the outcome – crop yield. The irrigation, use of fertilizers and use of pesticides represent the significant factors in all regressions. Moreover, use of harvesting machinery (wheat harvester, maize harvester and potato spinner) is significant factor in those regressions, where it was applicable.

The irrigation and use of harvesting technologies have highest positive impact on the yield of maize. The impact of irrigation is highest in the case of maize, red grapes and hazelnuts. The use of harvesting technologies increases the crop yield of maize by 77% and crop yield of wheat by 41%, while harvesting machinery is least used in the case of maize. In general, these production practices can double the crop yield, however in the case of maize, the use of mentioned production practices can increase crop yield 3-folds. The use of fertilizers can significantly support crop yield of grapes.

The table below summarizes the regression outputs for each crop.

Table 2: Summary of coefficient estimates of interested variables for different crops

Factors	Wheat	Maize	Potato	White grapes	Red grapes	Hazelnut
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Irrigation	0.58*** (0.1324)	0.66*** (0.0408)	0.21*** (0.0332)	0.24*** (0.0656)	0.45*** (0.1003)	0.55*** (0.1487)
Fertilizer	0.19*** (0.0617)	0.25*** (0.0303)	0.16*** (0.0351)	0.43*** (0.0657)	0.28*** (0.1058)	0.10* (0.0618)
Pesticides	0.13* (0.0921)	0.23*** (0.0404)	0.18*** (0.0396)	0.10* (0.0662)	0.11* (0.0719)	0.13* (0.0832)
Harvesting machinery	0.34*** (0.0674)	0.57*** (0.0820)	0.31*** (0.0395)			

* - significance at 10%, ** - significance at 5%, ***- significance at 1%.

Table 3: Regression variables - coefficients and significance, annual crops

Variable		Maize		Wheat		Potato	
Name	Description	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
Capital expenditures	Amount of capital expenditures (thousand GEL)	0.01	0.01	0.04	0.27		
Area	Harvested area of crop – ha, in log-s	-0.16	0.00			-0.13	0.00
Credit	Amount of agriculture credit – thousand GEL					0.00	0.29
Crop expenditures	Amount of expenditures spent on crop - GEL					0.00	0.01
Irrigation	Dummy variable, 1 if plot was irrigated sufficiently, 0 if it needed irrigation and was not irrigated	0.66	0.00	0.58	0.00	0.21	0.00
Machinery	Dummy variable, 1 if harvesting machinery was used, 0 otherwise	0.57	0.00	0.34	0.00	0.31	0.00
Fertilizer	Dummy variable, 1 if fertilizers were used, 0 otherwise	0.25	0.00	0.19	0.00	0.16	0.00
Pesticides	Dummy variable, 1 if pesticides were used, 0 otherwise	0.23	0.00	0.13	0.10	0.18	0.00
Storage	Dummy variable, 1 if farm has storage			0.06	0.28		

Table 4: Regression variables - coefficients and significance, permanent crops

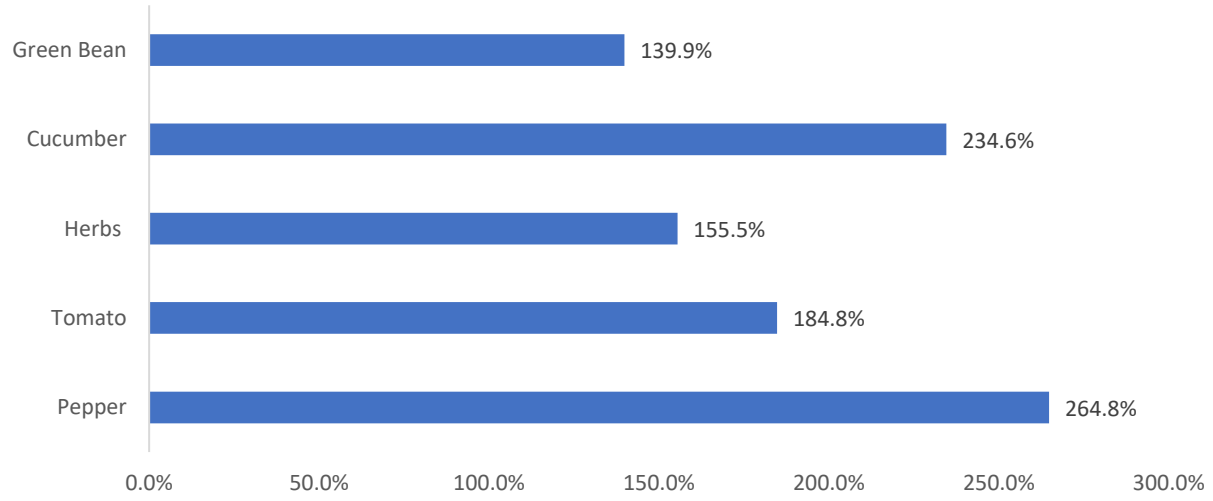
Variable		White grapes		Red grapes		Hazelnuts	
Name	Description	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
Capital expenditures	Amount of capital expenditures (thousand GEL)	0.04	0.01				
Area	Harvested area of crop – ha, in log-s	-0.15	0.00	0.02	0.46	-0.17	0.00
Credit	Amount of agriculture credit – thousand GEL			0.0043	0.23		
Crop expenditures	Amount of expenditures spent on crop - GEL	0.00	0.27			0.00	0.45
Irrigation	Dummy variable, 1 if plot was irrigated sufficiently, 0 if it needed irrigation and was not irrigated	0.24	0.00	0.45	0.00	0.55	0.00
Fertilizer	Dummy variable, 1 if fertilizers were used, 0 otherwise	0.43	0.00	0.28	0.01	0.10	0.09
Pesticides	Dummy variable, 1 if pesticides were used, 0 otherwise	0.10	0.14	0.11	0.04	0.13	0.10

Based on the results provided in table 2, it is relevant to estimate percentage change of crop yield associated with irrigation, pesticides or fertilizers that are calculated by the following formula: 100 * (e^b-1), where b represents coefficient of the relevant variable. Based on the subsequent calculations, it is clear that percentage change of crop yield associated with irrigation varies from 23% (potato) to 94% (Maize). The percentage change of crop yield associated with the use of fertilizers varies from 11% (Hazelnut) to 28% (Maize) and while the same effect for harvesting technologies ranges from 36% to 77%.

Based on the output provided in table 2, the impact of sufficient irrigation, pesticides and fertilizers is significant.

As mentioned above, for vegetables and herbs modern production practice can be considered production in greenhouses. Based on AGRIS data, the difference in crop yield between greenhouses and open ground was calculated. The data shows that greenhouses provide for more than doubling of average crop yield. The highest impact was observed in the case of pepper and cucumber.

Figure 4: Difference in crop yields between open ground and green house



Multipliers

Based on the supply and use tables of the economy, the first-tier revenue and investment multipliers of plant growing sub-sectors were calculated. Output multipliers reflect cumulative revenues that would be generated in the economy by 1 additional GEL worth of final demand for a product of a given sector.

For calculation of revenue multipliers, the Leontief-Inverse matrix is used. The Leontief-Inverse li_m is given as (I-A)-1 – the inverse of identity matrix i_m minus input coefficient matrix an_m. The input coefficient matrix represents ratios between sectors' inputs and its output.

Revenue-to-Investment Multipliers: measure the impact of 1 mln. GEL increase in final demand for each economic activity's output on investments generated in the economy in all stages of production.

The investment multiplier is calculated by multiplying vector of input coefficients for gross capital formation to Leontief-Inverse matrix.

Vegetables, horticultural specialties and nursery products provide higher direct and indirect impact on the economy, while increasing production of cereals and other crops has lowest direct and indirect effect on gross output. In all subsectors of plant growing, investment multipliers are very low, thus proving the low capital expenditures in agriculture sector and lack of technology upgrade and adoption of modern production practices or agro-technical activities. The investment multiplier is higher in the case of fruits, nuts, beverages and spice crops.

Table 5: Revenue and Investment Multipliers of agriculture, plant production sub-sectors

		Revenue Multipliers			Investment Multipliers		
	Initial effect	Direct effect	Indirect effect	Type I	Direct effect	Indirect effect	Type I
Cereals and other crops n.e.c.	1	0.19	0.11	1.30	0.00	0.00	0.00
Fruits, nuts, beverage and spice crops	1	0.22	0.13	1.35	0.06	0.01	0.07
Vegetables, horticultural specialties and nursery	1	0.29	0.13	1.42	0.00	0.01	0.01

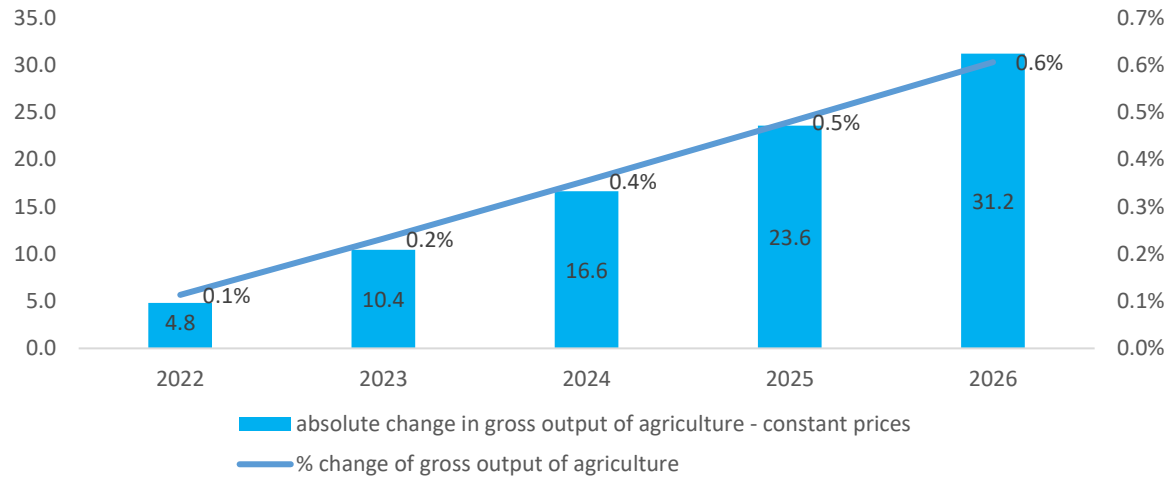
Results of Macroeconomic Model

Scenario for vegetables:

For vegetables, more prevalence of greenhouse can be considered as good production practice. The sown area of vegetables amounts to 12.7 thousand hectares. The average area of greenhouse amounts to 0.05 hectare. From the data the share of parcels in open ground sown area that are covered by vegetables were identified and parcel size ranges from 0.05 ha to 0.2 ha. This share amounts to 25.7%. The scenario envisages the 2% substitution of vegetables open ground parcels with area from 0.05 ha to 0.2 ha by greenhouses, overall, it means increase of greenhouse area by 0.33 thousand ha in 5 years.

The positive impact of mentioned scenario on agriculture output in constant prices by 2026 amounts to 31 mln. GEL (+0.6%) compared to the scenario without additional greenhouse area.

Figure 5: Comparing additional greenhouses scenario to the scenario without additional greenhouse area – impact on agriculture output – mln. GEL



The positive impact of the scenario on GDP amounts to 41 mln. GEL – +0.1%, mainly comes from consumption increase and improving trade balance.

Figure 6: Comparing additional greenhouses scenario to the scenario without additional greenhouse area – impact on GDP – mln. GEL

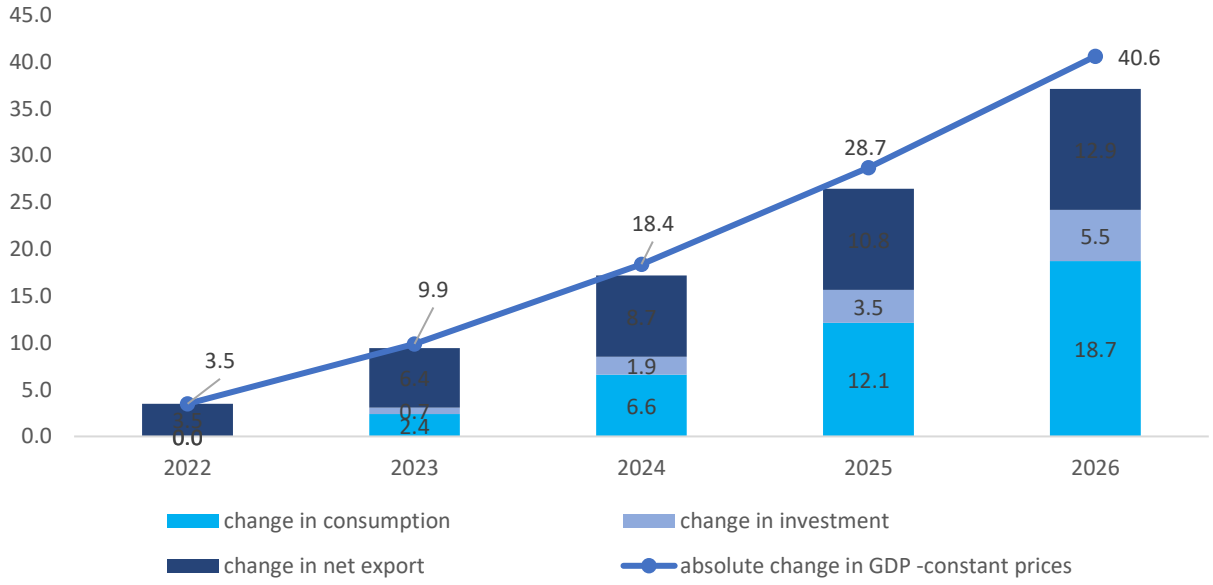
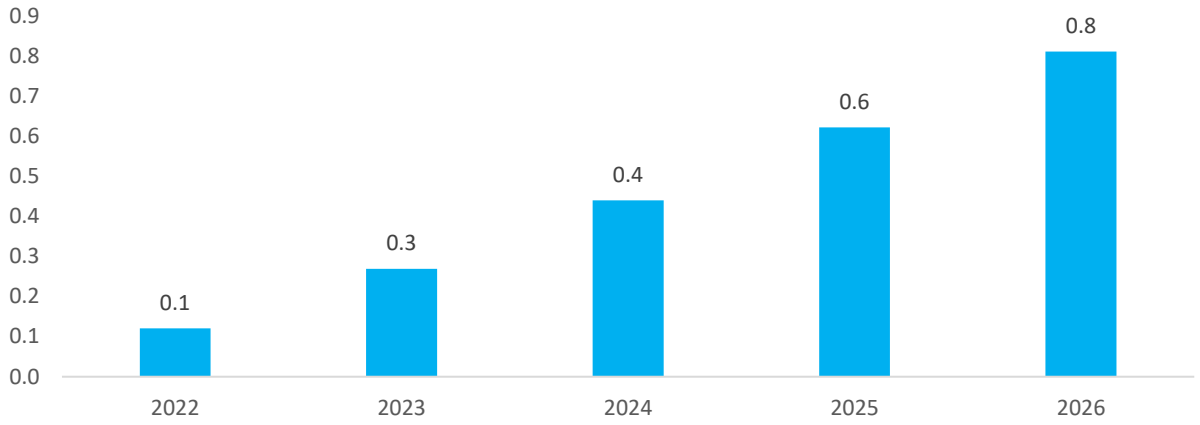


Figure 7: Comparing additional greenhouses scenario to the scenario without additional greenhouse area – impact on employment (thousand)

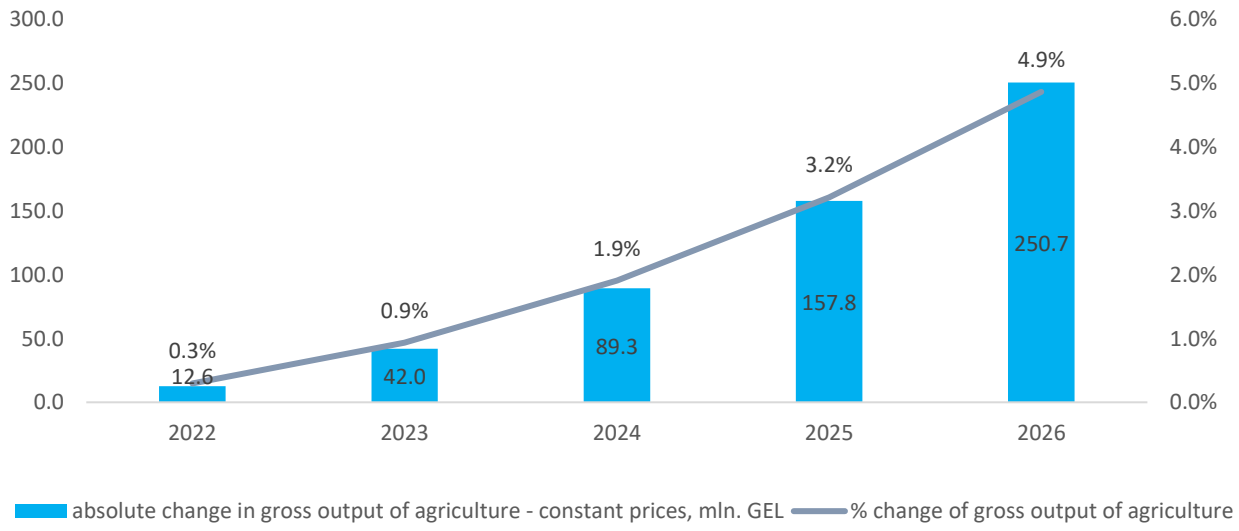


Scenario for fruits, nuts and spice crops:

This scenario envisages 10% increase of grapes and hazelnuts sown area with proper irrigation, using fertilizers and pesticides, thus meaning increase of sown area of permanent crops with good production practice by 8.8 thousand ha by 2026.

The mentioned scenario provides significant economic benefits, since it directly increases the export potential of agricultural products. The moderate increase in prevalence of modern production practices in fruits production can increase gross agriculture output by 4.9% in five years.

Figure 8: Comparing 10% increase of grapes and hazelnuts sown area with proper irrigation, using fertilizers and pesticides to the scenario without additional increase of good production practices – impact on agriculture output



In line with increasing agriculture output, positive impact on GDP is quite high as well, mainly due to the improving net export. As it was mentioned above, increasing competitiveness of fruit sector enhances the export potential, since self-sufficiency of fruits exceeds 100% and export of fruits exceeds the import.

Figure 9: Comparing 10% increase of grapes and hazelnuts sown area with proper irrigation, using fertilizers and pesticides to the scenario without additional increase of good production practices – impact on GDP, mln. GEL

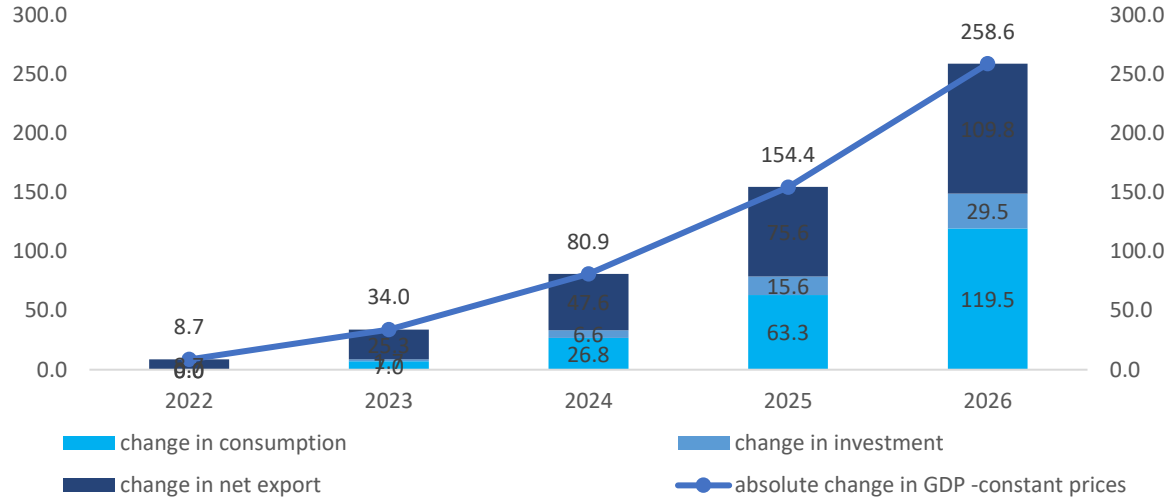
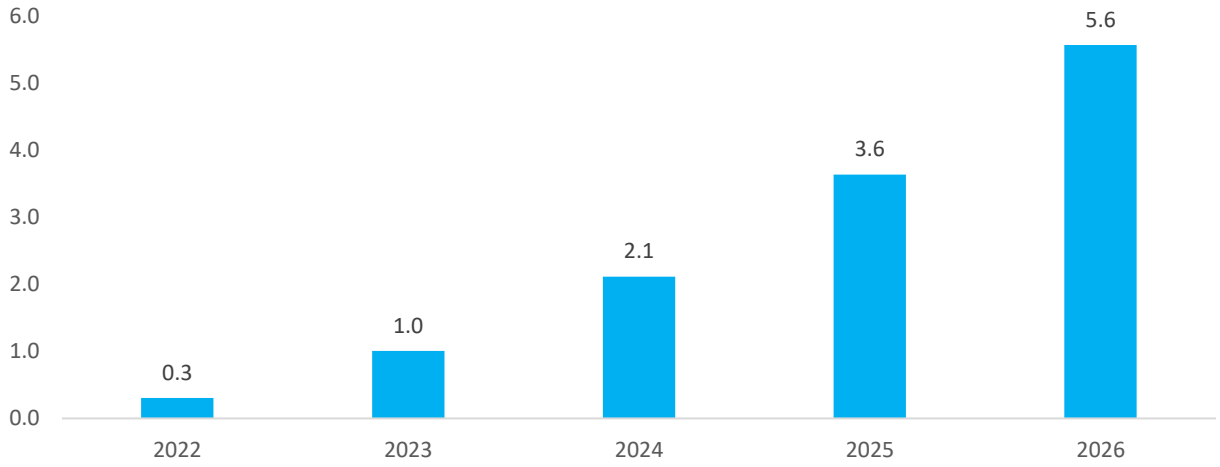


Figure 3: Comparing 10% increase of grapes and hazelnuts sown area with proper irrigation, using fertilizers and pesticides to the scenario without additional increase of good production practices – impact on employment, thousand



Scenario for cereals and other crops:

This scenario envisages 10% increase of sown area with harvesting technologies for maize, wheat and potato.

Figure 11: Comparing additional sown area with harvesting technologies to no additional area with harvesting technologies – impact on gross output of agriculture (mln. GEL)

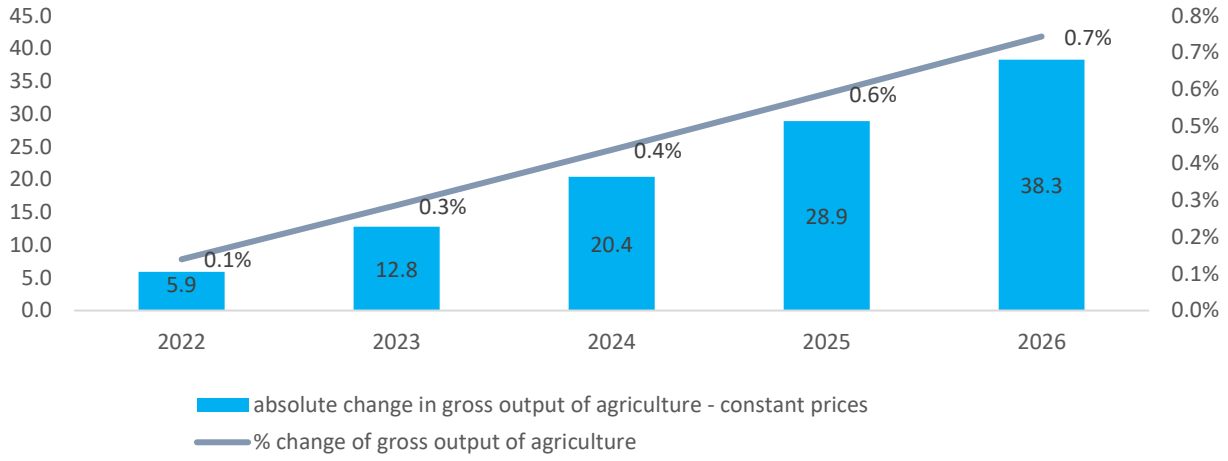


Figure 14: Comparing additional sown area *with harvesting technologies to no additional area with harvesting technologies – impact on GDP (mln. GEL)*

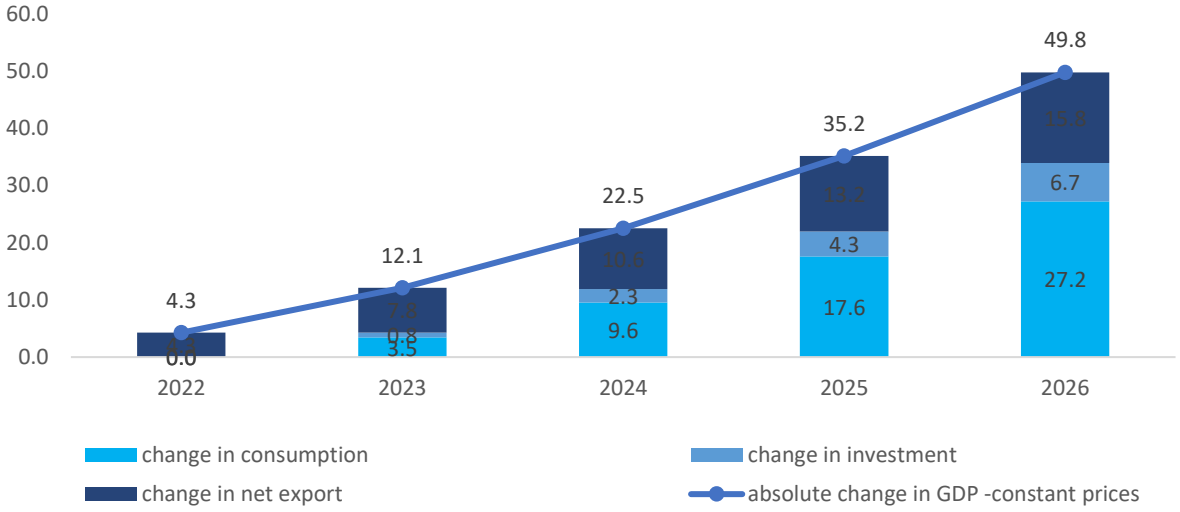
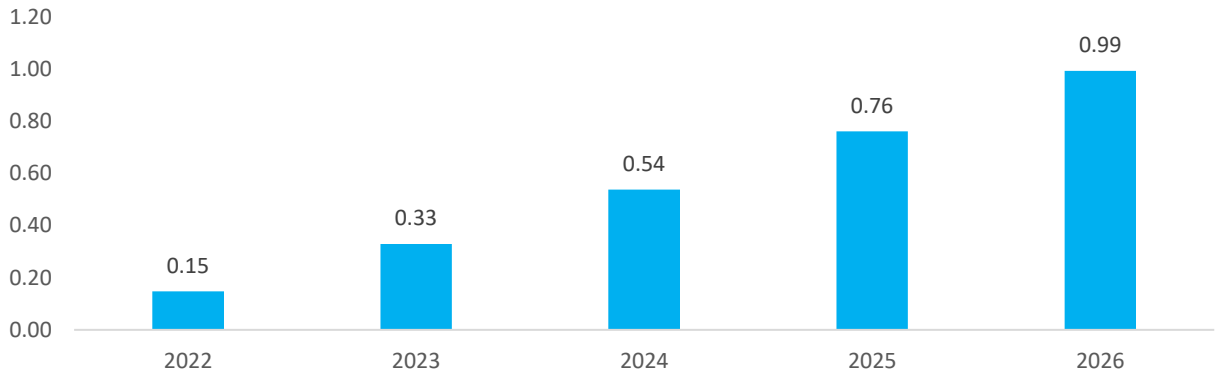


Figure 13: Comparing additional sown area with harvesting technologies to no additional area with harvesting technologies – impact on employment (thousand)



Limitations of the research

The research focuses on important issues for evidence-based agriculture policy implementation that have not been studied in Georgian reality. Taking into consideration no availability of previous estimations and evaluations, the research findings cannot be compared to any other evaluations, relevant for Georgia that considers national context. Moreover, data applied in the research does not yield significant coverage for some high potential crops, like barriers and citrus. Consequently, paper provides estimations for the crops that constitute majority (more than 80%) of cultivated sown area, however it does not capture positive implications of modern production practices for those high value-added crops that have important potential in Georgia.

The paper evaluates the impact of modern production practices on crop yield and wide economic effects due to the more prevalence of modern production practices, it does not evaluate the factors and root causes that determines the crop yield - causal effects. It applies the AGRIS survey data in the analysis and considering data characteristics and limitations it does not provide any qualitative estimates of different production practices, for instance whether the fertilizers are used correctly or considering different efficiency levels of different types of irrigation facilities.

In general, based on the available data, the paper provides significant estimates and analysis that can be successfully applied in policy implementation and planning, however in line with improvements in data coverage and availability there is significant room for further research regarding the adoption of modern production practices and considerations to support increasing agriculture competitiveness in Georgia.

Policy Considerations

Validation of the given analysis, model parameters and scenarios was carried out by the research team during targeted meetings with focus groups. A series of meetings were held with stakeholders during the research period. Meetings included representatives of the commercial sector in the field of crops (vineyard owners, almonds producers, blueberrie farm owners, producers of herbs and vegetables, apple plant owners, etc.). Apart from the private sector representatives, meetings were held with Georgian agriculture sector associations (Georgian Farmers' Association - Deputy Chairman of the Georgian Farmers' Association and other representatives of the Association, Georgian Hazelnuts

Growing Association – Representatives of Association). Within the project research team also held a series of meetings with the government agencies, and institutions including, some structural units of the Ministry of Environmental Protection and Agriculture (MEPA), and members of the Agrarian Committee as well as the Sectoral Economy and Economic Policy Committee of the Parliament of Georgia.

Despite differing views, the representatives of the commercial and public sectors agree on the need to promote modern production practice in the plant sector and increase the use of agro-technical means. At the same time the assessments voiced by the representatives of both the commercial sector and the relevant agencies of MEPA show that the low rate of use of modern production practices and agro-technical means in the agricultural sector of Georgia is caused by several main problems:

1. Lack of knowledge and information among farmers;
2. Fragmented, small land-plots owned by farmers, where there is less opportunity to commercialize the products, for instance the vegetables sub-sector;
3. Subsistence farming domination, that limits capability for commercialization of the sector;
4. Low irrigation coverage rate (amortized Soviet infrastructure), insufficient irrigation and non-relevant irrigation systems used;
5. Relatively increased but insufficient level of access to finance for the sector (lands aren't properly or fully registered to be used as a collateral, limited practice of banks excepting agricultural land as collateral, etc.).

Private sector representatives highlighted that along with the problems, there is a policy level implication. For instance, currently state focuses on "status quo" in agriculture. According to private sector representatives, it would be more efficient, if state considers agriculture as investment driven, rather than support driven sector. According to their opinion, it would be more effective if the government, while directing support programs and awareness-raising activities, focuses on so-called "dynamic farmers" (individuals and legal entities), whose profile is predetermined, and they own sufficient resources (agricultural and human, social, intellectual) to commercialize sub-sectors, rather than support subsistence farming. Accordingly, the issue of properly targeting beneficiaries of the support programs has been highlighted as one of the main priorities.

It was also underlined that state support programs do not cover a significant part of primary agricultural production, including crops. There is no autonomous support component for greenhouse-based production promotion, and it is presented only as a separate component of certain programs. According to the opinions, these circumstances should also be taken into account for the development of the sub-sector.

To verify these considerations, the research team analyzed 3 main state support programs managed by the Rural Development Agency (RDA), a legal entity of public law (LEPL) under the Ministry of Environmental Protection and Agriculture of Georgia: "Preferential Agro Credit" Program, "Plant the Future" Program, "Agricultural Mechanization" Program.

The analysis reveals that under the preferential agro-credit program, the subcomponent for the cultivation of new perennial orchards began only in February 2020, while the subcomponent for the renovation of existing orchards began in March 2021. Components for facilitating the arrangement and use of some agro-technical means, such as the drip irrigation sub-component, have been added to the program only from March 2021 for both new and renovated orchards. At the same time, it should be

noted that the program framework defines the nominal volume of support (as portion of commercial interest rate that might be subsidised by the state), the list of sub-sectors and production needs that might be considered eligible. Beneficiary selection and loan approval are carried out by financial institutions (commercial banks) and program does not set priorities, targets (KPIs) and geographical allocation of support. This significantly reduces the effectiveness of support in terms of economic feasibility, while the involvement of banks only ensures commercial feasibility and relative sustainability of the selected projects. Same can be stated about "Plant the Future" program, which mainly covers the financing of the nursery component and technical support in this regard. However, the program has a cluster approach, which takes into account the geographical appropriateness of the gardens at the stages of selection of project beneficiaries. One of the major drawbacks of the program is its non-standard approach to the beneficires, which implies that 80% of the seedlings needed for garden cultivation near the occupation line are co-financed by state, while in other cases the co-financing is only 70%. As for the agricultural mechanization co-financing program, it is one of the most sophisticated mechanisms to stimulate the use of agro-technical means in the sector, although there are some technical barriers that limit the access to the program. For example, the purchased equipment must be new, produced at least 2 years before the moment of purchase. Consequently, such restrictions do not correspond to the situation in the sub-sector, where the rate of use of agro-technical means is critically low.

In addition to the above considerations, according to stakeholders, despite the prevalence of traditional crops in the agricultural sector and their predominance in cultivated areas, special attention should be paid to high value-added crops, the efficiency of which requires relatively new production practices and agro-technologies. Especially when the sector is already familiar with few successful examples, such as plants of the berry (blueberry, blackberry) and curcumin (almond) family. It is noteworthy that the recent increase in the development of these types of plants was due to the increased access to relevant export markets, resulting in several large investments in the production, without financial support from the state. This fact is used by the representatives of the private sector as an argument that if state support will focus on the right products, the expansion of the crop yield becomes eventually possible by attracting commercial capital.

Summarizing the results of the communication with the private and public sector representatives shows that the problems associated with use of modern production practices and technologies in the crop producing sector are directly related to the challenges in the agricultural sector and the shortcomings of the state policy. Accordingly, it will be meaningful for summarizing the problems, as well as for the policy makers, if we will categorize the challenges based on a vertical principle, from the macro problems of the field to the main and technical problems in the crop production sector.

The formulation of sectoral challenges are as follows:

- In the field of plants, including vegetables and fruits, there is a low productivity rate, which should be enhanced by increasing commercial investment in certain sectors and their targeted support by the state, which in turn ensures investment in the introduction of modern technologies and increased use of agro-technical means. At the same time, it is necessary for the state to revise the legal framework of the irrigation process, in terms of tariffs, arrangement and use (increase of access), as well as to continue to improve the irrigation infrastructure.
- Despite state support, in some areas of plant production, such as horticulture, viticulture, partly fruit growing, and high value-added agricultural products, e.g. blueberries, there is still the problem

of warehousing and refrigeration, which is an important, indirect cause of seasonal import, hindering the development of the commercial interests in these sectors.

- Despite the existence of the state program of agro-insurance, there is insufficient scaling of insurance products, including medium and small producers. It is necessary to create a new affordable scheme and implement wide-scale information campaign. It is also important to improve the channels of supply of agro-insurance and trasnform it into an easily accessible product in the MEPAs extension centers and Houses of Justice of the Ministry of Justice, as well as online channels, etc.
- Without creating an attractive investment environment for private capital, it will be impossible to create a consistent and sustainable development environment for the sector, therefore it is necessary for the state to introduce the sufficient quality standards for exporting the final products of the sector, including relevant legal framework and implementation ecosystem. An example is the winemaking sector, which is one of the most profitable commercial activities in the country. The rate of return on equity in the sector is 30% and net profit is 20.8%, which became possible only after the state ensured the creation of the necessary ecosystem for the export of Georgian wine to high-income countries, including legal environment and quality control capacity.
- Development and support of nurseries play key role to ensure high quality seedlings, especially in the case of permanent crops, including berries.

Challenges, that hinder the adoption of good production practices in crop sector includes the following:

1. One of the important challenges that limits the adoption of good production practice is land fragmentation. The share of farmers who own less than 1 hectare amounts to 72% and at the same time these holdings are very fragmented.
2. Non-productive distribution of agricultural crops. The sown area of annual crops dominated by traditional, maize and wheat constitute more than 60% of sown area of annual crops. While the identified multipliers of cereals, corn and wheat are among the lowest in the vegetable sub-sectors. The sown area of permanent crops is dominated by fruits and vineyards.
3. The volume of sown areas of highly productive plant products is very low. For example, berries account for less than 1% of sown area of permanent crops. Planting areas of high value-added and high-multiplier vegetable crops are also low, as is the level of use of modern production practice used in this regard, although the yield of vegetable crops, for example, increases significantly as a result of the use of greenhouses.
4. Moderate access to finance that is essential for the use of modern production practices and agro-technologies. As of today, less than 1% of farmers use agriculture credit and average amount of credit is 24 000 GEL. At the same time, the coverage rate for farmers enrolled in the state agro-insurance program is very low.
5. Amelioration and irrigation problems - the AGRIS data showed that significant part of sown land with irrigation system is not sufficiently irrigated. More precisely, 21.1% of cultivated land area that has irrigation system is not irrigated sufficiently. Not sufficiently irrigated land amounts to 30.5% in the number of those parcels, which has irrigation system. In case of permanent crops, not sufficiently irrigated land amounts to 25% of the area of those parcels that has irrigation. Most widespread types of irrigation are canal and tube well irrigation. As

the evidence suggests, best results are achieved by using mixed structure of irrigation systems, while the least productive is canal system. The biggest part (around 90%) of the irrigation system in Georgia is based on canal system.

Policy Recommendations

Below are the key policy recommendations that will support productivity growth in the crop production sector and facilitate the implementation of modern production practices.

In the opinion of the project team, the State should consider agriculture as a commercial, rather than "social" sector, as such an approach will significantly support the development of the sector. The main essence of these recommendations is to increase investments in the agricultural sector. This will ultimately facilitate the application of modern production practices. At the same time, it will be important to encourage large investments in such a way that products from local, small producers can be purchased in a consolidated manner if these manufacturers meet the set quality and production standards. These recommendations are divided in two parts, implementation of which require the active interest and involvement of all players, including the private sector.

"Wider" policy recommendations

- Encourage large private investments in agriculture – as described above, agriculture is severely underserved in terms of private investment. Government should prioritize agriculture in its investment attraction policy and encourage local as well as foreign systemic investors to invest in agriculture.
- In order to increase overall impact on economy through export promotion, Government might think of a design of specific support programs for those farmers and systemic producers in agriculture, who are willing to comply with international standards to export to the international markets, including the EU market.
- Investors in Georgia's agri-food value chain also face an acute shortage of storage infrastructure and sorting facilities. The lack of acold chains, specialised food industry logistics and other forms of value chain infrastructure generates added costs for businesses. The government should increase the effort to build up the value chain in agriculture, including not only production of crops, but warehousing and transportation.
- PPPs in value chain infrastructure are currently not commercially viable. However, if the state elaborates dedicated framework for PPPs in the sector, especially with improvements to irrigation infrastructure and supporting services, the cooperation with private sector can become more feasible.
- Efforts to establish linkages with food processors and retailers can be particularly beneficial for small-scale producers of high-value food products. This will show more prospects to entrepreneurs regarding the development of the sector, and the opportunity to earn higher returns. This will facilitate the use of modern production practices and technologies as one of the essential prerequisites for increasing competitiveness.
- Increasing farmers' awareness about modern production practices and provision of agricultural extension services - existing centers of extension, are not equipped with the sufficient human / material-technical basis and their activities are not standardized. It is necessary to develop

and implement proactive engagement mechanisms, establish a cohort of extension officers and introduce portfolio management principles.

- Strengthen insurance system to reduce losses from wind and hail - it is necessary to popularize agro-insurance, at the same time the system needs to be more flexible and affordable.

"Narrow" policy recommendations:

- As the lack of collateral remains severe problem for agricultural producers, government should evaluate possible mechanisms. There are three ways of possible government intervention: 1) encourage land registration; 2) In the meantime, offer special products to tackle collateral problems (such as incorporation of agriculture sector in the state credit-guarantee schemes); 3) Work with the National Bank of Georgia (NBG) to facilitate acceptance of the land as collateral by the commercial banks.
- Provide access to high-quality substances, fertilizers and pesticides and other materials needed for agro-technical activities - this can be done under the state support program, using appropriate budgetary resources.
- Redefine the circle of beneficiaries of plant production support programs, taking into account the "quick win / quick result" principle, where the state only supports producers of high value-added and export-oriented products or where significant volumes of products are produced.
- Given the model scenarios discussed in the study, the state should focus on plant products that have the greatest impact on industry output on the one hand, and the use of modern manufacturing practices increases yields the most, on the other. For instance, even modest increase of modern production practices in fruits shows substantial economic effects due to the increasing export potential. Besides, increasing competitiveness of fruits positively affects agriculture investment, since this economic activity provides higher investment multiplier. However, investment multipliers are very low in every sub-sector of crop production.
- Define policies for individual plant products over the next 5-7 years, including the introduction of private sector involvement KPIs for individual plant products and the implementation of best-case scenarios by exploring the most optimal ways to promote culture.
- Promoting Agro Service Provider Production Practices - If the state fails to provide a direct effective subsidy to facilitate primary production, it should use the competence of the private sector and offer agro services to the market by supporting intermediary sector development.

Conclusions

The present study showed significant economic benefits of modern production practices not only on agriculture output, but GDP and trade balance as well. Increasing the share of harvesting technology in cereals, support for greenhouses and more prevalence of modern production practices in fruit yields have important economic effects. The significant and positive impact of harvesting technologies on agriculture competitiveness highlights the importance of agriculture service development. Even modest increase of modern production practices in fruits shows substantial economic effects due to the increased export potential. Besides, increasing competitiveness of fruits positively affects agriculture

investment, since this economic activity provides higher investment multiplier, however investment multipliers are very low in every sub-sector of crop production. The low investment multipliers emphasize the need for investments, thus in turn supporting rapidly growing agriculture competitiveness.

Gradual substitution of open ground cultivated land of vegetables with greenhouses can be considered important source of increasing agriculture output and GDP. In addition, development of irrigation has special importance for increasing productivity of permanent crops.

It should be noted that the state should pay special attention to the growth of private investments in the sector. This may be achieved by proposing specific investment policies for agriculture, strengthening policies to increase access to finance, and revising wide policy priorities. Without the growth of private capital, it will be impossible for the sector to rapidly develop the use of agricultural technology and introduce modern production practices.

Acknowledgments

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Appendix – Tables and Figures

Figure 5: Distribution of agricultural holdings by agricultural orientation (%), 2020

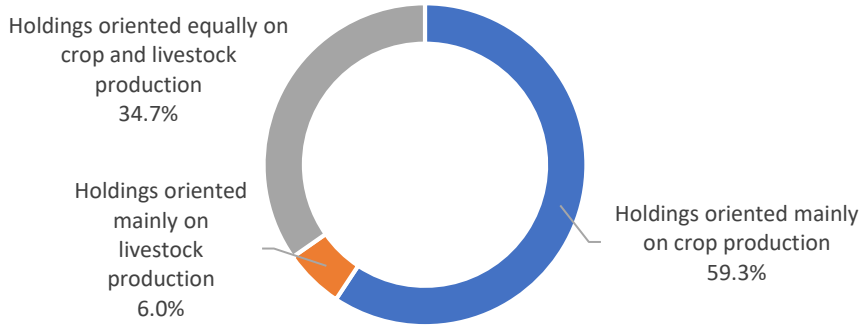

Figure 6: Distribution of agricultural holdings with orientation of plant growing by purpose of agricultural production (%)

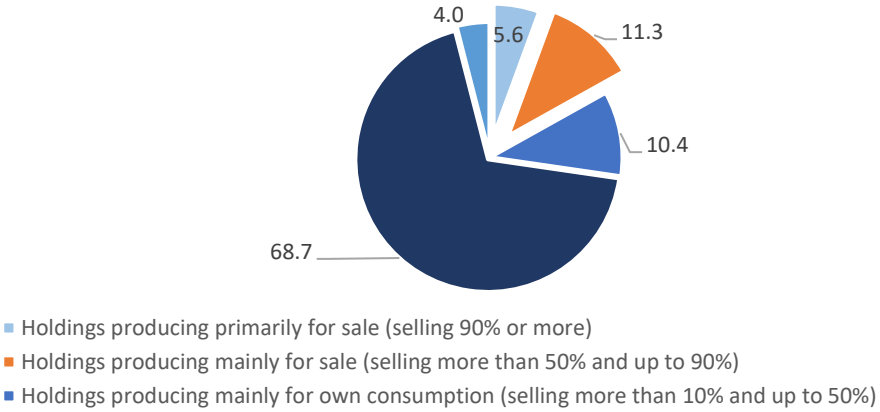

Figure 7: Cereal yield, tones per hectare

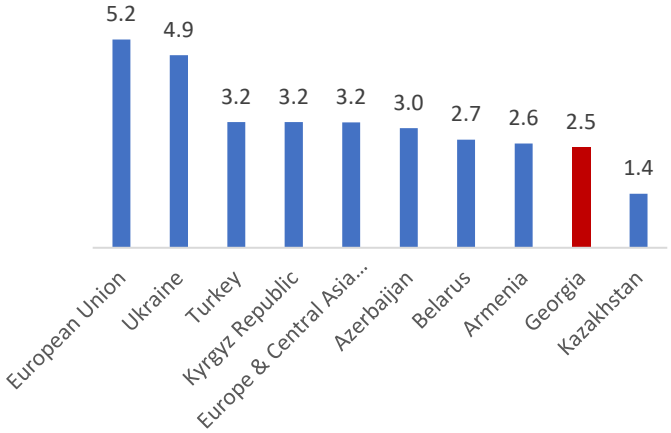

Figure 8: Potato yield, tones per hectare

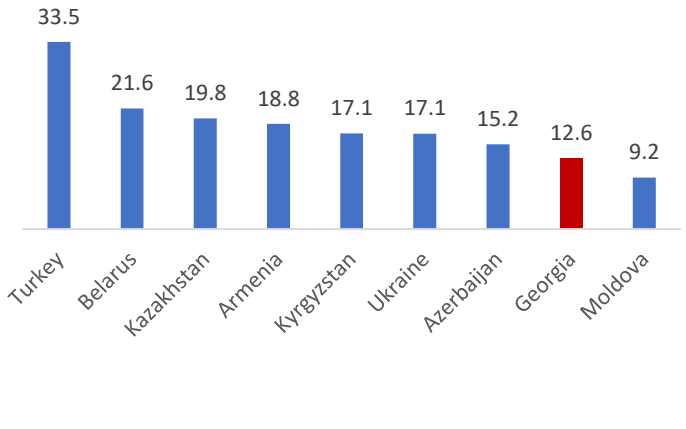

Figure 9: Self-sufficiency ratio by products - %

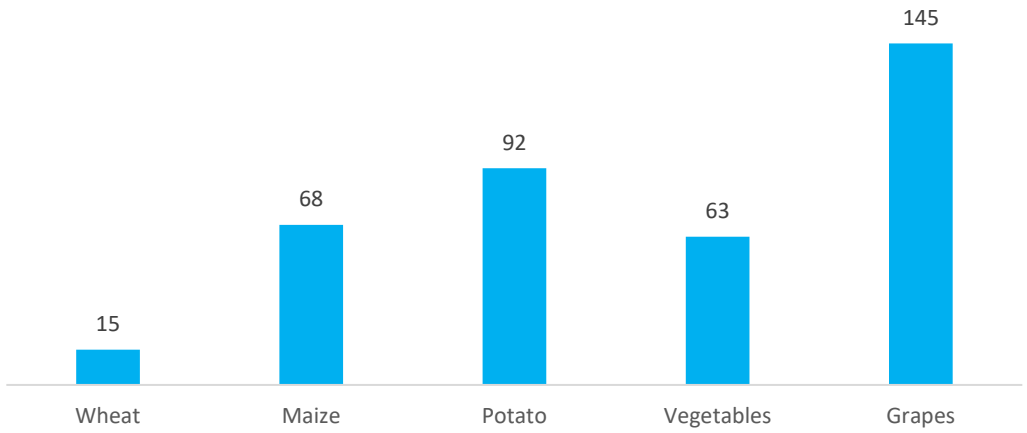

Figure 10: Export-import of food products, 2020 (mln. USD)

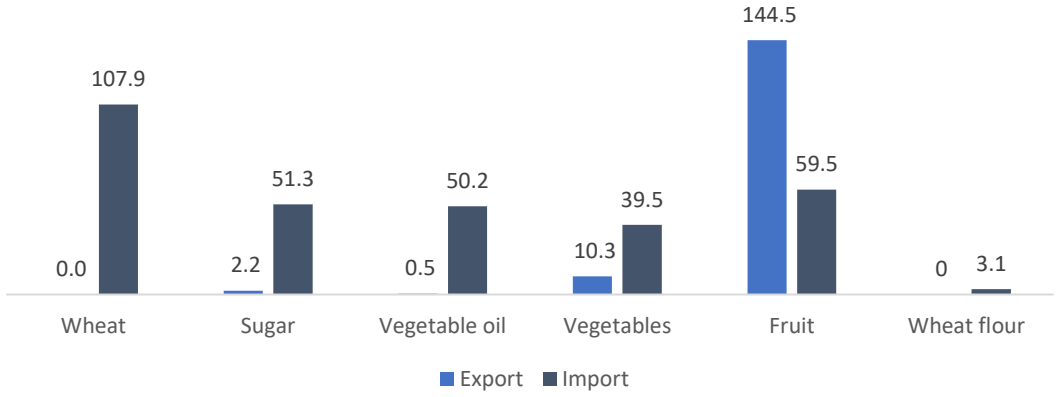

Figure 11: Distribution of farm holdings by holding size

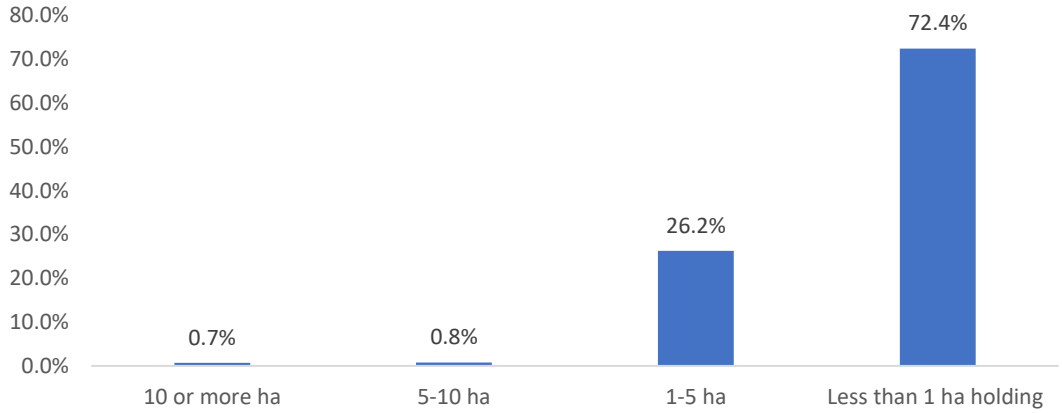

Figure 12: Distribution of land parcels by area size – permanent and annual crops