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CROSS-BORDER ALLIANCE FOR CLIMATE-SMART AND GREEN AGRICULTURE IN THE BLACK SEA BASIN

Subsidy Contract No. BSB 1135

FEASIBILITY STUDY

CLIMATE-SMART AGRICULTURE IN THE BLACK SEA BASIN REGION OF ARMENIA

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The project **Cross-Border Alliance for Climate-Smart and Green Agriculture in The Black Sea Basin (AGREEN),** Ref. No. BSB 1135 is funded by the Joint Operational Program for Cross-Border Cooperation under the European Neighbourhood Instrument "Black Sea Basin 2014-2020", under Priority 1.2 "Increasing cross-border opportunities for trade and modernization of agriculture and related sectors".

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1. General description of the paper

1.1. Abstract

Agriculture in the Republic of Armenia (RA) is one of the most important sectors in terms of contribution to the Country's Gross Domestic Product with the 13% share in 2019. It is highly vulnerable to climate change-induced environmental challenges. Climate Smart Agriculture (CSA) practices in RA include organic production, greenhouses, intensive orchards and farms, as well as agricultural productions that contain one or more elements of CSA, such as drip irrigation, use of cover crops and mulching, anti-hail systems, intensification of production, etc. The CSA practices and practices with CSA elements are gaining more and more popularity in the country.

The feasibility study, aimed at the understanding the state of art and potential of CSA in Armenia revealed multiple challenges and interrelated opportunities for this practice in the country.

The low land resource use efficiency in the country mainly due to the small size of farms and subsequent violation of agrotechnological practices, irrigation regimes and norms, as well as rotations pose not only a strong challenge for the CSA in Armenia, but also demonstrate a big potential for the promotion of efficient use of land, including degraded areas.

There are multiple stakeholders in place in the country as well. These include state agencies involved in agriculture, such as the Ministry of Economy with its State Service for Food Safety, the Ministry of Environment with the Bioresources Management Agency, and the National Institute of Standards; the advisory services in Armenia, such as private extension services; NGOs; as well as The Greenhouse Association of Armenia (GAA) and Organic Armenia Agricultural Association.

Financial incentives include multiple programs for financial aid/co-financing agricultural productions that have reduced environmental and climate change effects by the Ministry of Economy RA (2019), and foreign investment is mainly sourced from Russia, the USA and Europe.

The domestic market for organic products is still in the stages of development, with multiple specialized online and offline stores and supermarkets offering a selection of both local and imported organic products, such as bread, honey, herbal teas, juices, cosmetics, soaps, fruits and vegetables, processed products, dried fruits, etc.

There is no direct governmental policy concerning CSA in RA. Yet, the legal framework that aims at mitigating climate change, reducing greenhouse gases, increasing adaptation, consists of international agreements signed by Armenia, conventions, relevant laws, government decisions, strategic documents, and other legal acts that allow the implementation of relevant government policy and

strategy. Moreover, there is a recent tendency for shift in government policy to address and adapt to the challenges of climate change in agriculture in recent years, including a focus on the increasing intensity of climatic hazards posed by climate change. However, the work done in this direction is not yet systematic, but partial, requiring a more coherent, coordinated approach to reduce the negative impact of climate change.

Multiple challenges have been identified in the implementation of CSA practices in Armenia. These include increasing work intensity and/or need for better machinery, the lack of knowledge and expertise and the inertia to follow already established traditional methods, inefficient crop residue management strategies, difficulties and overall wrong methods in organizing measures to control crop diseases and pests. Consumer awareness about the principles and benefits of CSA remains low in Armenia. The growth of the CSA market is further challenged by low purchasing power, unstable supply, lack of branding, fluctuating quality, as well as a small range and volume of products available.

Yet, with all the mentioned challenges, CSA offers multiple benefits for Armenia including socio-economic sustainability in form of increased income, more employment, specifically for women, new export markets, as well as better food security and safety. The environmental benefits of CSA in Armenia are twofold. Introduction of CSA practices can simultaneously mitigate greenhouse gas emissions and climate change effects from agricultural practices and utilize adaptation mechanisms to face climate change induced environmental risks.

Many agricultural sector characteristics, such as increasing interest in CSA related practices with increasing incentives, investments, shift in government policy to address and adapt to the challenges of climate change in agriculture, growing local and international markets suggest high feasibility of CSA in Armenia.

2. Introduction

2.1. The agricultural sector in Armenia

Agriculture in the Republic of Armenia (RA) has been and still is one of the most important sectors in terms of contribution to the Country's Gross Domestic Product (GDP). In 2014, the value added of agriculture in GDP of Armenia comprised 20% showing a steady increase after 2008-2009 financial crises. Since 2014, the share of agriculture in the total GDP has been steadily decreasing and reached 13% in 2019. However, over the years agriculture has been improving with the targeted government support, private sector investments, and support from international organizations.

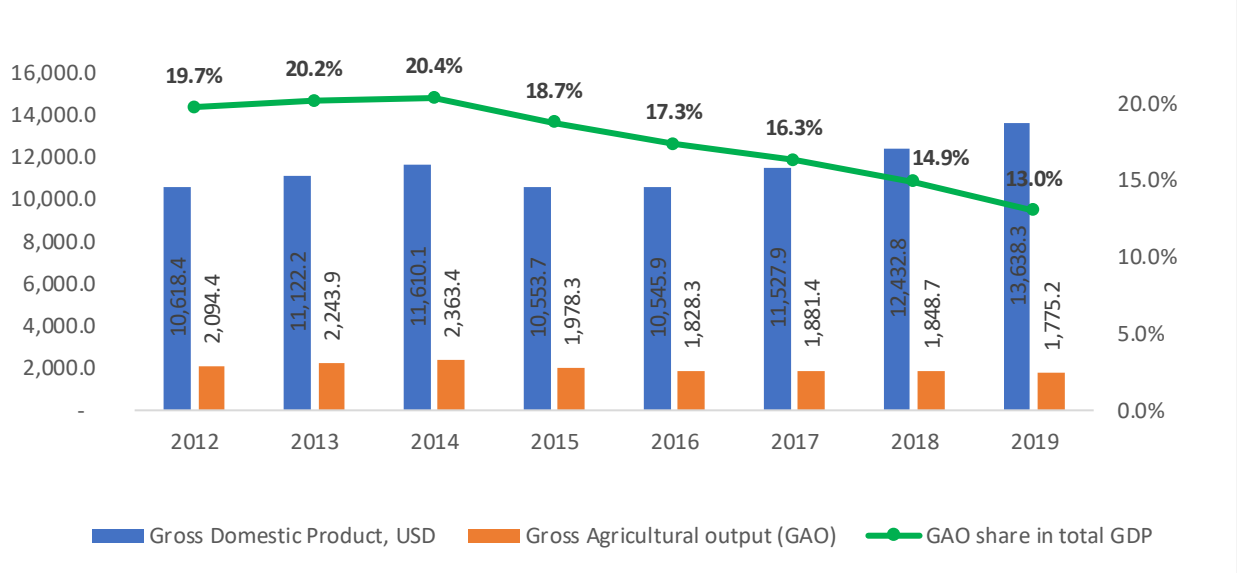


Figure 1 Volume of Gross Domestic Product (GDP) and Gross Agriculture Output (GAO) of RA, in millions USD

The Gross Agriculture Output (GAO) of Armenia is comprised of two main sub-sectors - plant growing/crop production (46.8% in 2020) and animal husbandry (53.2% in 2020) (Statistical Committee of RA, 2020). Additionally, at present, there are approximately 350 registered fish farms in the country, the total with 5.5 thousand tons of yearly fish production (Statistical Committee of RA, 2020).

Table 1 The Gross Agriculture Output of RA, in billions AMD

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total	841.5	919.1	983	945.4	878.5	908.6	892.9	852.8	819.3
Crop production	516	572.8	595.2	550	486.7	469.3	415.8	410.4	383.8
Animal husbandry	325.5	346.3	387.8	395.4	391.8	439.3	477.1	442.4	435.5

Approximately 40% of the country area is not suitable for agriculture. As of 2017, the total area of Armenia's agricultural land covers 2,043.8 thousand hectares

(Cadaster Committee, 2020). The agriculture area irrigated by the Water Use Associations (WUAs) operating in Armenia represents only a 62% of the total agricultural area (GEF, 2014). Due to semi-arid climatic conditions in the country, there is a strong reliance on irrigation especially in the south-western part of the country, where more than 80% of agricultural product value is currently obtained from irrigated land (Avetisyan S., 2010).

The GAO of commercial organizations have a small portion compared to those of family farms in both animal husbandry and plant growing/crop production sectors (ICARE, 2020). More than 40% of Armenia's agricultural production is for self-consumption on farms and is essential to food security in rural areas (Stanton et al., 2009).

Table 2 The production area and the volume of the main agricultural crops in Armenia

	2019		2018		2017	
	Area, ha	Total production, 1000 tons	Area, ha	Total production, 1000 tons	Area, ha	Total production, 1000 tons
Grain and leguminous crops	121,179	198.7	130,163	337.6	155,247	302.5
Vegetables, including greenhouse crops	20,616	621.6	21,658	628.2	28,280	861
Melons	4,257	128	4,602	126.8	6,812	215.8
Fruits and berries	43,411	291	43,035	343.4	42,269	361.6
Grape	16,497	217.5	16,099	179.7	15,814	209.9

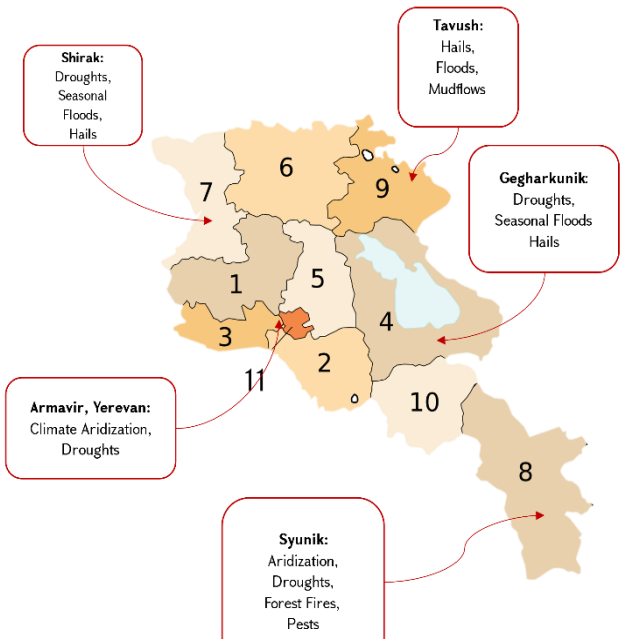
In terms of volume, vegetable crops are the predominant products in 2017-2019, followed by fruit and berry production (Table 2).

There is a positive production trend of ecologically clean and environmentally friendly products in Armenia as well. However, it is not a large sector and needs financial support for certification and promotion. Specifically, greenhouse operations (mentioned above) with hydroponic mode of production, intensive gardens and farms, as well as organic crop production demonstrate high rate of increase, suggested the increasing popularity of these CSA applications in the country (see Chapter 4).

2.2. Climate change and the impacts on Armenia

Armenia's climate is influenced by the Caucasus Mountains, and ranges from dry sub-tropical to cold alpine (USAID, 2017). The average annual temperature in Armenia (1960-2015) is 7.6°C, varying from -8°C in the high mountains to 12 to 14°C in low valleys. The average annual precipitation is 524 mm (1960-2015), over 40% occurring April through June; with average annual precipitation of 200 to 250 mm in low-land areas, and 800 to 1,000 mm at higher altitudes (USAID, 2017).

Picture 1 Potential climate change effects in different regions in Armenia (source: USAID, 2014)



According to the World Resources Institute, Armenia is ranked 34th among the 164 UN member states in terms of water stress, as a country with high baseline level of water stress, with 57.8% stress level in 2017 (UNDP, 2020).

A relative shortage of land and a need for better management of water resources make agriculture, in particular irrigated agriculture, in Armenia vulnerable to changes in environmental conditions. Severe climatic phenomena already occurring with increasing frequency and duration and also threaten agriculture (Pic.1).

Climate change will greatly affect atmospheric precipitations in Armenia. Thus, decline in precipitations by up to 2.7% by 2040, 5.4% - by 2070 and 8.3% - by 2100, relative to the baseline annual average (592 mm) for 1961-1990 are projected for the country. In addition to the decreased precipitation levels, more irregular spatial distribution of precipitation is also expected (UNDP Armenia, 2020). During the period of 1935-2016 the climate in the north, south and central regions of the country has become more arid, while precipitations have increased in the Shirak plain, in the Lake Sevan basin and in the Aparan-Hrazdan regions (UNDP Armenia, 2020). Temporal irregularity of precipitations is also projected, with a 22 to 32% increase in extreme rainfall days, and 7 to 11% increase in the number of consecutive days is expected by 2050 (USAID, 2017). Stronger effects are expected from June to September, when the estimates of likely precipitation reductions range between 7 to 10% in monthly average by 2050 (USAID, 2017).

Projections that take into account the reduced precipitation scenario suggest that there is likely to be less water in rivers and streams because of reduced winter

snowpack and spring runoff. The reduced river flow and lake levels might impact the groundwater reserves, through the delicate balance of discharge and recharge.

Currently, the global climate change impact on the freshwater sources in Armenia has already been recorded. Long-term meteorological monitoring revealed a 3–5% reduction of the maximum and minimum flows and their nonuniform seasonal distribution in the most part of rivers (UNDP Armenia, 2020). In 2030 the atmospheric air temperature will increase by 4.7°C and the total river runoff will decrease by 0.48 bln m3 (by 6.7–7.4%) compared with the base period (1961–1990). The snow cover is expected to decrease by 20 to 40% in 2100 (World Bank, 2012).

The discharges of groundwater springs of Ararat Artesian Basin supplied by groundwater have been reported to be reduced considerably. In particular, the discharge of the Metsamor-Aknalich group of springs, which is the water source for many irrigation canals and pump stations, has reduced from 17.8 m3/s (1983) to 3.0 m3/s (2013) (USAID, 2014).

Climate change is also likely to decrease water supply in transboundary basins. Future streamflow is assessed to decrease by 45–65 % in the Khrami-Debed basin (Armenia/Georgia) and by 59–72% in the Aghstev basin (Armenia/Azerbaijan) by the end of the century (Stanton E. A., 2009).

The climate change impact on water resources is more evident in the central part of the country (the Hrazdan and Metsamor Rivers Basins), which is overpopulated and scarce in water resources, as well as in the southern part of the country (the Voghji and Meghriget Rivers Basins), where the climate is dry (UNDP Armenia, 2020).

Extreme events such as hail, spring frosts, floods, mudflows, droughts and forests fires in recent years caused significant agricultural damage, with subsequent economic losses. It is reported that by 2050 there will be an increase in average annual temperature of 1.6 to 2.2°C, an increase in the number of “hot” days and nights; a decrease in the number of “cold” days and nights (USAID, 2017). This longer dry periods, together with the estimated changes in precipitation and water flows, increase the risk of drought in Armenia. High temperatures and hot winds occur between 120 and 160 days per year in the Ararat valley and other lowlands, making these regions more vulnerable (UNDP, 2013). Studies have shown that droughts are observed in the lower regions of Armenia almost every year, and in the foothill regions recurrence of droughts is about 50% (USAID, 2017). According to drought indices, the number of strong and very strong droughts during the period of 2000-2017 increased by 33 days relative to the baseline average (87) for 1961-1990 (UNDP Armenia, 2020). Based on the data from meteorological stations, positioned according to the zoning, drought assessment results show that in recent years the upper boundary of the drought zone has expanded to include mountainous areas, and the droughts start earlier.

Soil humidity is also expected to decrease by 10 to 30%, moisture availability for various crops will decline by 7 to 13%, and the water deficit of land will increase by 25 to 30% (World Bank, 2012). Therefore, rain-fed farming in pre-mountainous and lower mountainous areas may decline.

Drought-prone marzes have above average levels of poverty, such as Shirak (77.3%), Lori (61.7%), and Aragats (57%). Droughts in Armenia significantly affect the economy. The frequency and intensity of droughts varies; in the most arid areas, severe drought occurs once or twice per decade. Armenia's environment is vulnerable to drought, which intensifies desertification processes and aggravates secondary salinization. Approximately 80% of the country is threatened by desertification in various degrees (and over half by severe desertification) (ICARE, 2020).

Hailstorms are among the most severe natural hazards for the agriculture sector. Average annual losses are US$ 30 to 40 million. About 370 villages are located in hailstorm risk areas, or 15 to 17% of the country's agricultural area (UNDP, 2009). Around 122,000 hectares of land in Armenia is vulnerable to landslides, which are mostly triggered by heavy precipitation (UNDP, 2013) Mudflows are also a serious threat in medium-altitude mountainous areas. More than 3,500 landslides of various sizes have occurred in Armenia (Boynagryan V., 2008).

By 2030, yields of main agricultural crops are predicted to decrease by 8 to 14% without adaptation (*e.g.*, 9 to 13% for cereals, 7 to 14% for vegetables, 8 to 10% for potato and 5 to 8% for fruits). Pasture area and yields are also forecasted to decline by 4 to 10%, including 19 to 22% in the most valuable pastures in the subalpine and alpine zones. Grassland yield could potentially decrease by 7 to 10% which could reduce fodder production (UNDP, 2020). In Armenia, an estimated 24% reduction in river flow is projected to result in a 15 to 34% reduction in the productivity of irrigated cropland. To give a more concrete example: the expected loss in yield for grapes and wheat would be 21% and 25%, respectively, amounting to 65 to 145 billion AMD (Stanton E. A., 2009). To put this in perspective: these estimated losses would amount to an annual loss of to 5% of current levels of GDP.

The potential impacts of climate change on the livestock sector will result, in part, from impacts to the pastures used for grazing. Climate change scenarios forecast that, by 2030, total pasture yield will decrease between 4 and 10% (World Bank, 2012). In the same time period, the productivity of the most valuable pastures, those in the sub-alpine and alpine zones, will decline by 19 to 22%. Availability of fodder resources by 2030 is projected to be adequate (World Bank, 2012). However, the overall conditions of the majority of pastures are insufficient and if conditions are not improved, degradation could worsen (UNDP Armenia, 2020): reduced fodder in the winter may cause animal grazing to start earlier and end later, which can result

in increased degradation of pastures. Livestock diseases may also increase, in particular natural outbreak sites and contagious diseases (World Bank, 2012).

Another important component of agriculture in Armenia that will most likely suffer under the negative impacts of climate change is aquaculture. Aquaculture farms use underground fresh water unsustainably in flow through systems and without water circulation despite existing alternatives (Stanton E. A. et al., 2009).

Although there are no projections on water demand change in Armenia, it is expected that climate change could change water demand in the country (GCF-UNDP, 2020). The average water abstraction in 2013-2017 in Armenia was 3,027 mln m^3 per year, 40% of which was groundwater. Approximately 61% of water is used for irrigation, 39% for industrial uses, in households, and in fish farming. The overwhelming water use increases are likely to occur in the domestic and industrial sectors. With less precipitation, more rapid evaporation, and lower levels of soil moisture, a greater share of Armenia's farmland will likely need irrigation, and each hectare will need more water for productivity. Climate change will increase the need for irrigation water, and the conflict not only between domestic, industrial, and agricultural sectors, but also between different sub-sectors of agriculture (USAID, 2017).

In addition to the agricultural and water sector, ecosystems (and services reliant on ecosystems such as provisioning for survival), human health, and infrastructure are sectors equally to be burdened under the predicted climate change. Forests, which cover 11% of the country, are at risk due to increased aridity, which reduces growth rates and regeneration, making trees more susceptible to pests, diseases, and forest fires (USAID, 2017). Ecosystem changes expected to occur with climatic shifts include a decrease in the alpine zone by 21%, and a vertical shift of 100 to 150 meters; an expansion of semi-desert and desert areas by 30%; a vertical shift by 150 to 200 meters and a 4% expansion of the steppe belt; vertical movement of the forest belt by100 to 200 meters; and an increase in evaporation from Lake Sevan of 13 to 14%. More frequent and longer heatwaves pose health risks, especially to vulnerable populations (World Bank, 2012).

With growing global demand and increased agricultural vulnerability under climate change, food security risk could increase substantially for Armenia. Existing inequalities between rich and poor populations and vulnerable communities within Armenia are expected to be exacerbated due to climate change, and place a strain on institutions, food supply, and rural growth. Additionally, the country's weak financial position and institutional capacity to respond to natural climate hazards also pose a threat to future sustainable agricultural production and rural development. Food security and nutrition also have a gender dimension. Ensuring food security and nutrition at household and community levels requires investing in

nutrition-sensitive agriculture, which is likely to suffer from the impacts of climate change.

Climate change may also play a role in food safety. A growing number of pests and diseases could lead to higher and even unsafe levels of pesticide residue and veterinary drugs in local food supplies. And changes in rainfall, temperature and relative humidity can readily contaminate staple food crops with fungi that produce potentially fatal mycotoxins.

Risks and vulnerabilities are further exacerbated by the relatively low productivity stemming from a lack of adaptive capacity to the present climate, also known as adaptation deficit. Assessing adaptive capacity of Armenia is challenging, because financial resources are the most limiting factor, as most adaptation measures require relatively large-scale investments.

2.3. SWOT analysis of the climate-smart agriculture in Armenia

CSA practices in Armenia include organic production, greenhouses, intensive orchards and farms, as well as agricultural productions that contain one or more elements of CSA, such as drip irrigation, use of cover crops and mulching, anti-hail systems, intensification of production, etc. The CSA practices and practices with CSA elements seem to be gaining more and more popularity in the country.

Strengths	Weakness
➢ Increasingly popular ➢ Easy to find beneficiaries ➢ Easy to adapt the current agricultural practices to CSA ➢ Foreign donor and RA government incentives in place for the development of the certain practices that represent a form of CSA, such as organic agriculture, or hydroponic greenhouses. ➢ Open minded agricultural community ➢ Successful organic export cases ➢ Market access and marketing opportunities, partnership possibilities with BSB/ EU countries for organic products.	➢ Lack of CSA-related education ➢ Lack of national legislation ➢ Lack of national and international market ➢ Lack of branding ➢ Lack of consumer awareness ➢ Lack of expertise, confusion and overlapping with organic agriculture ➢ Lack of standards, certifications, definition. ➢ Lack of meteorological observations for agriculture ➢ Poor organization of the sector ➢ No clear framework and strategies for development of CSA ➢ Virtually uncontrolled pesticide and fertilizer market in the country. ➢ Lack of data analysis ➢ Lack of comparative studies

	➢ Lack of pilot projects, ➢ Luck of government actual support.
Opportunities	**Threats**
➢ Existence of Government incentives, mainly subsidies ➢ Existence of international donor foundations ➢ Existence of business investors ➢ Potential new international and local markets ➢ New courses and educational modules, specifically in Armenian National Agrarian University, other educational institutions, NGOs, governmental organizations, etc. ➢ Development of controlled pesticide and fertilizer market ➢ Development of a CSA brand ➢ Addressing water and land resource shortage challenges.	➢ High probabilities of force major events, such as wars and conflicts ➢ Climatic hazards ➢ Geopolitical situation and relationships with neighbors ➢ Obstacles to enter the EU and international market.

3. Methodology of the Study

Primary and secondary data have been used to analyze the feasibility of CSA in Armenia. Primary data has been collected via questionnaires and interviews.

More than 100 participants have been involved in providing information through online questionnaires. The main purpose of this research was to define the degree of awareness and acceptance of the CSA concept within the various stakeholder groups in Armenia.

Twenty interviews have been conducted with the field professionals, including farmers, representatives of cooperatives, producers, branch associations, extension service providers, stuff of higher education institutions, local and regional authorities and other relevant organizations.

Secondary data has been mined from available reports from international organizations (UNDP, World Bank, USAID, FAO, GACSA etc.), published research from leading academic institutions and international best practices.

4. State of art of organic and green farming and sustainable agricultural practices

4.1. Attitude toward CSA in Armenia

The interviews with farmers/producers or representatives of the local authorities and academia demonstrated fairly high awareness about CSA in Armenia. The CSA was perceived to be advantageous for environmental and human health, with contrasting opinions about the costs of production. The main challenges of CSA application included limited awareness and thrust among the farmers; legislative incomplete field; confusion with organic farming (see SWOT analysis above).

A great share of the farmers was trying to implement CSA elements in their businesses. Identically, academia representatives demonstrated high willingness to incorporate CSA related studies in their curricula.

All respondents were motivated to further increase their efforts in CSA direction in production, educational, legislative and other directions.

Online survey was conducted, and quantitative data was collected from 115 respondents. The majority of the survey participants were young (19-35 years old, 56.5%) and middle-aged (36-50 years old, 27.0%) people (See Figure 2).

The majority (55.7%) of respondents were from Yerevan, followed by Kotayk (8.7%), Aragatsotn (7.0%), Artsakh Republic (7.0%) (See Figure 3).

The education level of the respondents was mainly Higher (72.2%). However, there were respondents with postgraduate degree (13.9%) and vocational education (10.4%) (See Figure 4). Regarding the sector of the occupation, the majority of the respondents were from Agriculture (29.6%), education (26.1%), Service (9.6%) (See Figure 5).

According to the survey, the majority of the respondents (77.4%) agree that the increasing the productivity in agriculture sector and the income level of the producers is important in the country (See Figure 6). Moreover, majority of the respondents (69.6%) agree that all the stakeholders in Armenia should work towards climate change adaptation and stability (See Figure 7).

During the survey, the respondents were asked to score how much they are willing to support the development of the CSA in their region. The study revealed that the majority of the respondents (68.7%) are willing to support the development of CSA in Armenia. On the other hand, 14.8% of the respondents mentioned that they are not willing to support the development of CSA in their region (See Figure 8). Moreover, more than 60% of the respondents mentioned that the special brand/label is necessary for CSA in Armenia (See Figure 9).

The 77.4% of the respondents willing to purchase CSA labeled products (See Figure 10) and 56.5% of total respondents will pay more for CSA labeled products (See Figure 11).

4.2. Country-specific conditions for sustainable agricultural implementation

Unlike many other countries where the transition to organic/green farming has been initiated and promoted by external forces (such as market actors or donor-funded projects), the development of organic agriculture in Armenia has endogenous roots. Prompted by the food and bread insecurity of the early 1990s, Armenian farmers cleared thousands of hectares of traditional vineyards and fruit trees to shift to cultivation of cereals, and after the stabilization of economy, new vineyards and orchards have been established, also based on organic practices (EaP-GREEN, 2015). In 2013, the total area under organic agriculture and in conversion in Armenia made up 10,000 hectares – representing a six-fold growth since 2006 (EaP-GREEN, 2015).

The establishment of a local private certification body, in 2002, was an important step for the development of organic agriculture in the country – primarily because of the global recognition that the label has been able to attain. Currently, there are more than 12 certifying organizations in Armenia, that can provide local and international certification.

Today, most of the demand for organic raw materials comes from processing companies and most of the production is sold for export. Production of fruits, berries, alfalfa, grains and vegetables, collection of wild species (medicinal and aromatic plants), and beekeeping have been the main organic agricultural activities in Armenia since 2002. The raw materials are further processed into juices, nectars, beverages, concentrates, purees, individually fast-frozen berries, dried fruits and bread.

One of the advantages of the Armenian climate is the abundance of solar light and large number of sunny days particularly in the sub-mountainous regions, such as Kotayk, Aragatsotn, and Vayots Dzor. This important advantage to operate greenhouses due to the controlled growth environment and higher yields. The total area of greenhouses operating in Armenia has increased from about 30 hectares to 1,300 hectares in the years of 2011-2019. Soil based greenhouses and greenhouses using hydroponic technologies are the main types of greenhouses operating in Armenia. The main crops produced in Armenian greenhouses are vegetables (mainly tomato, cucumber, pepper, and greens), flowers (mainly rose, gerbera, dianthus, and alstroemeria) and seedlings (mainly of vegetables). Investments in the sector have grown drastically. Advanced technology greenhouses (particularly those equipped with Dutch and French technologies) are being established, ensuring high productivity and quality. Data on the volumes of agricultural production of greenhouse farms are not available. Official segregated statistics on greenhouse

production are not maintained. Improved high-tech greenhouse complexes are imported (Dutch and French complexes enjoy high reputation in the market).

Greenhouse production allows also cultivation of crop species widely used in wild harvest. This allows reduction of the pressure on the natural environment and increased productivity under the controlled conditions.

Slow introduction of more intensive production resulted in increased land productivity (by 64% from 2004-2015), driven by a strong increase in crop yields, with only little increase in the area under cultivation and modest shift to higher value crops. The area sown to high value crops (vegetables, fruit, berries, grapes) increased by only 14% (15,600 ha), during a period of rising demand for fresh fruit and vegetables on domestic and export markets (Christensen G., 2017).

The introduction of advanced irrigation systems, particularly drip irrigation systems, is becoming widespread not only in greenhouse operations, but also in intensive orchards. Drip irrigation systems are imported from different countries, such as Korea, EU countries, Israel, and China. Drip irrigation and nutrition-applying technologies have been used in greenhouse production of Armenia for over a decade. The productivity of tomatoes and cucumbers is several times higher in sophisticated greenhouses than in simple technology greenhouses.

4.3. National capacities

Land resources and users

Armenia is not rich with land resources. As of 2019, the total area of Armenia's agricultural land covers 2,043.8 thousand hectares or 66.7% of total lands, including: arable land - 446.0 thousand hectares (21.8%), perennial plantations - 34.8 thousand hectares (1.7%), hay meadows - 121.0 thousand hectares (5.9%), pastures - 1,050.8 thousand hectares (51.4%) and other lands - 391.2 thousand hectares (19.2%). Private farm households and commercial entities own 22.1% of agriculture land, 47% is under community ownership, and 30.2% belongs to the State (Irtek, 2019). Most of agricultural lands are located between 600 and 2,500 m from sea level.

The land resource use efficiency in the country, however, is low. Thus, from 446 thousand ha of arable lands in 2018 only 55% was used for agriculture.

There are many interrelated reasons for such a low level of land use in the country, including social, economic and environmental aspects. One of the main reasons for this is the small size of farms, with 340,000 very small farms of less than 1.4 ha in size, which hampers the efficient organization of agricultural practices. This small size of farms, together with disconnected nature of agricultural farms and overall fragmentation resulted in violation of agrotechnological practices, irrigation regimes and norms, rotations, which in turn caused high level of land degradation, specifically erosion and desertification and subsequent low yields. Thus, current

land degradation occurs in 80% of lands in the country, while desertification affects 43% of the lands.

However, current CSA practices in the country have a big potential to promote efficient use of land, including degraded areas, in Armenia. Thus, promotion of greenhouse establishment on degraded lands, that are unsuitable for agriculture, can make use of these lands, leaving the productive lands for non-greenhouse productions. Intensification of production can indirectly affect the land resources in the country, providing increased production per unit of area, and therefore, efficient use of land resources. Incorporation of CSA and organic farming elements, such as drip irrigation, use of cover crops and mulching, precision use of fertilizers, use of organic fertilizers, as well as modern, less impactful tillage will allow improvement of soil quality over time.

Stakeholders and relevant institutions

Main state agencies involved in agriculture, also including CSA, in Armenia include the Ministry of Economy with its State Food Safety Service, the Ministry of Environment with its Bioresources Management Agency, and the National Institute of Standards. By the scope of operations, the National Food Safety Service provides regulatory services to the organic sector, especially concerning regulations of organic/bio labelling in the market, and monitoring organic production process, the National Institute of Standards can support with the creation of national organic standards and implement the operations oversight. "Hydrometeorology and Monitoring Center" SNCO of the Ministry of Environment RA is responsible for monitoring of water, soil and air quality.

Other bodies that can be directly involved in organic and CSA sector development are the advisory services in Armenia, such as private extension services - Farm Service Centers (FSC), administered through Center for Agribusiness and Rural Development (CARD).

Main NGOs involved in the promotion of organic agriculture, that have been active in the field for a long time, which allows them to successfully cooperate with international organizations and bring organic agriculture development related projects to Armenia are SHEN, Ecoglobe, NABU, Green Lane, CARD, ACBA bank and ACBA Federation and AWHHE, etc.

Currently, there are approximately 60 certified organic producers in Armenia, including honey producers. The specifics of production are such, that mainly small producers are involved in the sector.

International stakeholders include the foreign organization such as Austrian Development Agency (ADA), Austrian Development Corporation, the United Nations (UN) agencies such as United Nations Development Programme (UNDP), Food and

Agricultural Organization (FAO), World Food Programme (WFP) and Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), etc.

Greenhouse crop production in Armenia is attractive for investors sector with high growth potential in both production and export, and such is mainly promoted due to economic benefits. It has demonstrated a high growth rate and marked profitability, particularly during the recent four years, when the total area of greenhouse farms increased by nearly 2.5 times, from 510 hectares in 2011 to 1220 hectares (2016). At the same time, the technological sophistication of greenhouse farms has rapidly increased. Most newly built and under-construction large greenhouses are equipped with and deploy modern technologies.

The Greenhouse Association of Armenia (GAA) has worked in the greenhouse sector since 1999; the Association has 23 members (with a total area of 12 hectares).

Organic Armenia Agricultural Association, established in 2019, aims to provide a strong and unified national voice for domestic certified organic farmers, producers and processors and to build and support a producer-led national organic movement and national policy platform.

4.4. Existing policies and instruments for funding

There is no direct governmental policy concerning CSA. The legal framework in the Republic of Armenia, aimed at mitigating climate change, reducing greenhouse gases, increasing adaptation, consists of international agreements signed by Armenia, conventions, relevant laws, government decisions, strategic documents, and other legal acts that allow the implementation of relevant government policy and strategy. There are also a number of government decisions on sectoral policies and strategies to address climate change challenges. These decisions concern the use of water and land resources, the management of forests in specially protected areas, the protection of the environment and biodiversity, the fight against desertification and contain certain provisions dedicated to tackling the challenges of climate change.

RA Land Code, "On Phytosanitary", "On Pedigree Animal Husbandry", "On Organic Agriculture", "On Beekeeping", "On Pedigree Animal Husbandry", "On Fodder", "On Seeds", "On Food Safety", "Beekeeping" The RA laws on "Protection of plant varieties", "On alcoholic beverages with grape raw materials" are the main laws regulating the sector. However, these laws do not directly address the challenges of adaptation and mitigation of climate change.

Overall, there has been some shift in government policy to address and adapt to the challenges of climate change in agriculture in recent years, including a focus on the increasing intensity of climatic hazards posed by climate change. However, the work done in this direction is not yet systematic, but partial, requiring a more coherent, coordinated approach to reduce the negative impact of climate change.

Organic legislation became part of the official agenda of the Armenian Government through a partnership program with the EU. The 2008 Law of the Republic of Armenia on Organic Agriculture entered into force in May 2009. This law describes the principles for the management of organic agriculture, defining the practice as one that is in harmony with agricultural ecosystems and implemented in compliance with the requirements of relevant technical regulations and other normative documents. The law also recognizes:

- The main principles of organic agriculture in Armenia;
- The Armenian government's role in regulating organic agriculture, including establishing a procedure to maintain a registry of economies entities engaged in organic agriculture, as well as establishing a catalogue of and procedure of use for additives in food processing;
- The government's role in establishing the procedure for the conversion agricultural land use to organic practices; and
- The need for the Armenian government to provide assistance in organizing business forums, training and financing for organic agriculture.

The sector was included in the Strategy for the Sustainable Development of Agriculture for 2010-2020. It provides an important mechanism for the realization of several strategic goals, including: protecting natural and environmental landscapes, developing agro-tourism, developing a food safety system that is in line with international standards; and improving sales and export volumes of agricultural and agro-processing products (EaP-GREEN, 2015).

In 2019 Ministry of Economy of the RA has developed multiple programs for financial aid/co-financing agricultural productions that have reduced environmental and climate change effects. These include "Co-funding program for installation of modern drip irrigation systems" (Irtek, 2019), "State support program for construction or update for small and medium sized smart livestock farms" (Arlis, 2019), Subsidization program for interest rates for loans for introduction of anti-hail systems in agricultural lands in Armenia" (Arlis, 2019), " State support program for establishment of vineyards, modern technological intensive orchards and berry gardens" (Irtek, 2019), "On approval of state support program for introduction and technological support for small and medium sized greenhouses" (Unified Website for Publication of Legal Act's Drafts, 2019).

Foreign investment is mainly sourced from Russia, the USA and Europe. Local investors comprise processing companies that purchase and lease land for production. There are multiple international organizations that developed and are currently developing organic and greenhouse CSA practices in the country. In 2009, the government provided a grant of 1 million USD for organic berry plantations in Armenia. Several NGOs, in particular Shen, have, with support of donors,

implemented community and agricultural development projects and planted approximately 160 hectares of organic orchards. In addition, the USAID in Armenia funded the Enterprise Development and Market Competitiveness project, in partnership with Ecoglobe, the organic certification body, in 2011. This program also supported the introduction of organic standards in small and medium enterprises in the herbal industry. The World Bank has also recently conducted a survey on agricultural value chains, which paid special attention to organic production. In fact, the World Bank has approved a 32.67 million USD financing for the Second Community Agricultural Resource Management (CARMAC) Project for Armenia to improve productivity and sustainability of pasture and livestock in eight regions of Armenia to increase high-value agri-food chains.

EU-GAIA is one of the largest agricultural project in Armenia funded by the European Union and co-funded and implemented by the Austrian Development Agency, Austrian Development Cooperation and co-implemented by UNDP. With a 11.7 million Euro budget, the project aims at development of Green Agriculture in Armenia.

4.5. Domestic and international markets for climate smart agriculture

The domestic market for organic products is still in the stages of development, with multiple specialized stores and general supermarkets offering a selection of both local and imported organic products, such as bread, honey, herbal teas, juices, cosmetics, soaps, fruits and vegetables, processed products, dried fruits, etc.

The organic products are also market via social media, including online stores, Facebook and Instagram.

There are a few stores that is exclusively selling local products. These include Agrology LLC, Gourmand, Green Day, Carrefour, among others.

Armenian organic products first began to be exported in 2008. Trade sources indicate that export products include honey, juices, nectars, preserved fruits, and semifinished products (purees and concentrates) derived from fruits and berries that are either cultivated or collected in the wild. Main markets for Armenia's organic produce in the EU are Germany, France, Hungary, and the Netherlands, while other export destinations include Russia, Kazakhstan and other Asian countries. Currently works are done to investigate the export markets in Canada, Japan, USA, and Arabic countries. Since 2017 the local organic producers also participate in international organic product exhibitions, further enlarging their markets.

The US market is considered important, and although actual export volumes remain limited, there are continuous efforts by exporting companies to establish partnerships and trade links with the US.

4.6. Benefits of climate-smart and green agricultural practices in Armenia

Socio-economic benefits

Armenia is a country exposed to multiple social risks, with 28% of households being at risk of becoming food-insecure if affected by shocks (EaP-GREEN, 2015). Rural poverty is a consequence of spatial discrepancies in terms of the availability of basic and productive infrastructure, particularly irrigation, which allows a more consistent production in most areas and usually more remunerating cropping patterns. The CSA can serve to increase socio-economic sustainability in the country. For example, agricultural employment fell from 461,500 in 2004 to 379,000 in 2015 – a decline of 18%, but women's employment in agriculture increased by 1% (2,200 people) during the same period Christensen G., 2017). Agricultural wages rose by 126% in real terms (Christensen G., 2017).

In general CSA practices have higher cost of implementation and can significantly increase the product prices, thus becoming a bottleneck in development of this sector, specifically in medium and small size productions.

Yet economic benefits can be derived from CSA production. In Armenia, organic products are sold at premium prices and cost in average 30-70% higher than non-organic counterparts. Their exports growing considerably, thereby contributing to farmers' incomes and to the country's overall trade balance. Greenhouse crop production in Armenia is yet another economic sector with both high production and export and, therefore, attractive for investors. It has demonstrated and continues to demonstrate a high growth rate and profitability. Large number of sunny days, which contributes to ensuring higher yield and longer duration of supply and high reputation of Armenian vegetables and fruits in the markets of Russia and other CIS countries (taste characteristics) also invests in socio-economic stability of the country (Christensen G., 2017).

A number of other socio-economic benefits can be derived from productive diversification. The additional income generated by new products, greater resilience to negative economic impacts (such as falling prices) and greater availability of food for the family not only have economic dimension but can largely improve social situation in the country.

Among the main benefits of CSA are creation of more employment both in farming and processing, and better food security and safety. It is important to consider the fate of any additional future production, and how much of it will contribute to food, feed, fiber and fuel production and to other ecosystem services.

CSA may play an important strategic role also in terms of rural area development. CSA in Armenia offers opportunities to revitalize the countryside and restore ecosystem functionality while also developing new local businesses and agro-tourism opportunities, according to UNEP's comprehensive assessment of the region.

Environmental and biophysical benefits

The environmental benefits of CSA in Armenia are twofold. Introduction of CSA practices can simultaneously mitigate greenhouse gas (GHG) emissions and climate change effects from agricultural practices and utilize adaptation mechanisms to face climate change induced environmental risks.

Armenia, with a predominant mountainous landform with arid climate conditions and vulnerable ecosystems, a particular history of droughts and uneven distribution of water resources, is among the most sensitive countries in the Europe and Central Asian Region to global environmental changes. Soil erosion and secondary salinization are major threats in the semi-desert landscapes that was heavily converted into arable land (80-90 % of the territory). Inadequate irrigation and soil cultivation practices, overexploitation of the underground water resources (e.g., borehole water exploitation exceeds up to 4.5 times the annual allowable water use), and mining activities in natural saline soils, are the main causes of natural ecosystem degradation, drying of marshes, habitat and species loss, and desertification processes. Overgrazing, land conversion into agriculture, uncontrolled harvesting of medicinal and edible species and human-made fires are responsible for a serious degradation and significant reduction of the area of natural pastures (e.g., from 1.4 million ha in 1940 to 804,500 ha in 2002) (Boynagryan V., 2008). Weed cover in pastures sometimes comprises 60-70 % of natural cover.

Of the 464,300 ha of arable lands in Armenia, 20.3% are eroded (IFAD-GEF, 2015). Inappropriate farming techniques and unsustainable extensive irrigation practices, especially on steep slopes in the meadow and steppe zones where shelterbelts do not exist, exacerbate erosion problems. Approximately 20% of irrigated areas in Armenia are affected by severe to moderate soil salinity, due to pour maintenance and operation of the irrigation system and inadequate irrigation practices. Soil salinization mainly occurs in the Ararat plain, where about 44% of the arable lands (35,000 ha) lands are salinized (Ghazaryan et al., 2020).

CSA farming systems use soil management practices that offer the best opportunities to reduce GHG emissions and soil degradation, build soil organic carbon and sequester atmospheric carbon. Among the most promising are reduction/elimination of synthetic nitrogen fertilizer applications; use of organic fertilizers and cover crops; and conservation tillage.

CSA is more resilient to climatic chocks, such as droughts, as a result of increased soil organic matter, biodiversity and management practices such as crop rotations. Improving soil organic matter by using practices such as cover cropping, organic fertilizers and reduced tillage have many benefits that increase soil health and resilience, including increased soil fertility, reduced soil erosion and salinization, improved water infiltration (which improves water conservation and limits the impacts of flooding). CSA practices not only protect and enhance the fertility of the

soil, break pest cycles, and build soil organic matter, but also protect farms from yield losses or crop failures that may increase due to changes in climate or the extreme weather events expected to characterize future climate change impacts. All these enhancements to resilience also have positive impacts on environmental and public health.

CSA enhances biodiversity and ecosystem services and preserves valuable traditional landscapes that can be important assets for eco-tourism development. This is particularly relevant for the protected areas of Armenia. According to the 5th communication on Biodiversity by MNP RA (CBD, 2014), many endemic and non-endemic species of flora and fauna are under the threat of disappearance due to active agricultural practices. These include not only terrestrial species that might be directly affected by agricultural practices, but also aquatic species, whose habitats degrade due to pollution from agricultural practices. Climate change will also have a negative impact on beekeeping due to declining honeybee crop yields and transmission and emerging infectious diseases of bees. At the same time, the honey vegetation, which is prevalent mainly in meadows and grasslands, is vulnerable to climate change adverse weather conditions (frequency, intensity, duration of rainfalls and windy days during the vegetation period, lack of days with temperatures over 10°C, etc.) and frequent hydrometeorological hazards (frostbite, hailstorms, heat waves, drought, etc.).

Reduced use of pesticides, plant diversification and rotation, combined with preservation of natural habitats in CSA create increased healthy habitat for beneficial insects, and in overall increase of the biodiversity. Yet another positive effect of CSA on biodiversity is from restoration of degraded pastures by organic practices (such as holistic management).

Armenia is a home for more than 252 crop wild ancestors, including several grains of extremely high agricultural importance. Moreover, there are hundreds of harvest plant and mushroom species, including food, medicinal, decorative species, species of wood insect repellents in Armenia. Expanding conventional agricultural production is a treat to these species due to potential degradation of their native habitats. Armenia has a wide range of traditional crop varieties that are ideally adapted to local climate conditions and are resistant to drought, diseases and pests (Hunter D. et al., 2011). These crops require lower levels of fertilizers and pesticides, making them excellent candidates for genetic resources for increased climate change adaptation capacity of agriculture in Armenia and worldwide.

Climate change mitigation potential of CSA in Armenia is also very strong. In Armenia total GHG emissions from the agricultural sector increased from 4% in 1990 to 13% in 2000 with an additional 4% attributed to agriculture from within the LULUCF category (land use, land use change, and forestry) (World Bank, 2012). Agricultural emissions contributed more than any other sector to methane (CH4) and nitrous

oxide (N2O) emissions nationwide, at 42% and 67%, respectively. According to Armenia's 4th National Communication on Climate Change8, national GHG emissions in 2016 comprised 9,801 thousand tons of CO2 eq. (net emissions) with the following emissions distribution by sectors: energy - 64.1%, agriculture - 22.3%, industrial processes and products use - 7.5%, waste - 6.0%. Rising temperatures and declining precipitation, as a direct result of climate change triggered by unabated GHG emissions, will adversely affect freshwater supplies, water quality, and hydropower potential.

Under this scenario, CSA can provide with multiple benefits to reduce GHG production in agriculture. There are a few general ways in which agriculture can mitigate climate change: reduction of on-farm fossil fuel energy use; reduction of the embodied energy of agriculture inputs such as fertilizers and pesticides; reduction of direct and direct emissions from fertilizer use, and removal carbon dioxide (CO_2) from the atmosphere and sequestration of carbon in soils and woody biomass.

Additionally, the reduction of fertilizer use reduces greenhouse gas, specifically N_2O emissions from agricultural activity. The main emission areas/sources of N_2O in Armenia, where since 2000, N_2O emissions have increased by about 51% are use of nitrogen-containing
fertilizers and animal husbandry (UNDP Armenia, 2020). The increase in agricultural prices in Armenia in recent years, the expansion of export opportunities, state support (e.g., subsidies for fertilizers), and the increase in farm incomes have contributed to increased volumes of inorganic fertilizer use in crops, which caused the increase of N_2O emissions from the managed soils. In 2017, direct N_2O emissions from managed soils were approximately 671 gG CO_2 eq., and indirect N_2O emissions from managed soils were approximately 182 gG CO_2 eq (UNDP Armenia, 2020). Reduction of fertilizer use, therefore, can directly affect GHG productions and mitigate climate change (UNDP Armenia, 2020). Yet another environmental benefit can arise from sustainable management of crop residues that can further decrease GHG emissions from agricultural sector.

4.7. Challenges before the implementation of CSA practices

Crop residues-benefits, conflicts and trade-offs

There is no estimations of the amount of crop residues produced in Armenia. Furthermore, no studies have been conducted on the potential use of these crop residues. Depending of the residue types, several approaches for their management exists in the country. Woody part of the residues, such as from vine and from pruning, are used as fuel in households. The non woody proportion of crop residues are generally either burnt in field, or left to decay, or feed for animals. The removal of crop residues (e.g. burning, black fallows) leaves only the crop's root biomass to be incorporated into the soil organic matter pool, which causes the accumulation of

soil organic carbon to decline. There is a large field of opportunities for CSA in Armenia this aspect. Under CSA mixing crop residues with soil (e.g. by disking or chiselling) may accelerate the immobilization of nutrients in the soil and make them unavailable for the subsequent crop during the early part of the growing season. Crop residues mechanically incorporated into the soil decompose more quickly than those left on the soil surface, and nitrogen immobilization can occur very early in the season. Incorporating crop residues rich in readily decomposable carbon, such as residues with low carbon-to-nitrogen ratio or liquid manure, generally induces a priming effect on soil organic matter and increases carbon dioxide emissions.

Dependent on the crop residue management approaches, several challenges in the country could be expected. First and foremost, increasing work intensity and/or need for better machinary might hinder the use of these approaches by already hard-working farmer communities. Secondly, the lack of knowledge on the topic and the inertia to follow already established traditional methods can further complicate the introduction of new approaches. On a positive side, if the positive effect of suggested crop residue management strategies is visible and can be demonstrated to the farmer community, the practices might be followed voluntarily.

Rotations and other diversification options

As a result of land privatization, a large amount of very small farms have been created in the country, hampering the use of efficient land management technologies. This resulted in a significant decline in crop yields, mainly due to violations of agrotechnological measures, lack of science- based crop rotations, incomplete and in some cases unilateral fertilization of lands, as well as land degradation and desertification.

After the collapse of the Soviet Union, the limited consumer market forced land users to reduce arable land, as well as areas of orchards and vineyards, which used to bring high incomes, replacing them with more affordable, relatively less risky crops - wheat, potatoes, vegetables. This resulted in reduced use of fertilizers. After the privatization of the land, the import of fertilizers sharply decreased, the use of mineral fertilizers was reduced more than 10 times, and the use of organic fertilizers was reduced almost 18 times. However, in the last decade the import volumes of mineral fertilizers have significantly increased.

The use of science-based crop rotation has a unique role in increasing soil fertility, preserving and ensuring high yields of crops, especially in the current conditions in the cuntry. The low level of land use in the current land relations primarily has a negative impact on soil fertility. Violation of soil cultivation technology, mainly monoculture agriculture, absance of crop rotations, unbalanced use of mineral fertilizers, limited use of organic fertilizers, anti-erosion works, neglect of soil moisture accumulation of the main isuees in the aspect. The fragmented lands and the small size of the farms have created difficulties for the use of crop rotation,

while without it it is impossible to solve the problems of maintaining the fertility of the lands and obtaining high yields. For many years, farms have been cultivating the same crops on the same land: wheat, barley, potatoes, vegetables, etc., which has led to soil erosion, declining fertility. Favorable conditions are created for the development of weeds, diseases, pests, which in turn leads to an increase in the volume of pesticides used. Only handful of agricultural productions in country use crop rotation, and the impact of this practiceon agricultural sector is negligable.

Yet, the agriculture sector in Armenia has been evaluated to be quite resiliant (Christensen G., 2017). This inherent resilience was attributed to low vulnerability to exogenous shocks, the low variability of rural household incomes and the capacity to recover rapidly from exogenous shocks. The sector's innate capacity to withstand shocks derives from its semi-subsistence nature – with most production grown for own consumption; and the highly, diversified crop and livestock production base of most farms. Exposure to climatic shocks remains, nevertheless, due to Armenia's low rainfall agroclimatic conditions and the limited area under irrigation. The high current reliance on drought tolerant cereal crops mitigates this risk to some extent; but severe droughts, although infrequent, can take their toll. The modernization and commercialization of agriculture, and associated emphasis on high value export crops will increase the sector's exposure to economic and climatic shocks. High value crops are vulnerable to drought and increased exports will raise the exposure to price and exchange rate risks.

More systematic land management including mixed farming systems, shifting crops from areas that are vulnerable to climate events (for example, from lowlands to highlands, away from areas vulnerable to drought and flooding from sea level rise), and agro-forestry practices (integrating field and tree crops on the same land) are recommended (Christensen G., 2017).

Weeds and their management

The official statistics of use of agrichemicals in Armenia does not distinguish between insecticides and herbicides, and therefore, total amount of insecticides is being reported. Although the share of herbicides in pesticides is not known, the overall pesticide use strategies reflect the situation in herbicide part.

During the Soviet era, Armenia was a region of extensive pesticide use. The average application of pesticides per hectare reached 35 kg and exceeded the Soviet Union's mean burden by up to 20–25-fold (UNDP Armenia, 1998). Based on the level of soil contamination with pesticides, Armenia was considered a "hot spot" for potential pesticide exposure and the accompanying health effects. Soviet Armenia had strong regulation concerning the use and application of pesticides. The availability of pesticides through importation, distribution, and application was controlled by the state's specialized enterprise "Armselkhozkhimia" (Armenian agrichemistry). After the privatization of lands (1991), the state plant protection system in Armenia

almost ceased to exist due to insufficient funding; the situation in the field of plant protection deteriorated sharply. Plant protection advice was provided by the State Advisory Service, which had been in place since 1994, as were other officials in the field, but the latter were quite small; they could not serve a large number of farms.

Due to lack of professional experience and skills, land users faced serious difficulties in organizing measures to control crop diseases and pests. In this regard, for years, as a result of the lack of systematic and follow-up measures, a number of diseases and pests have become widespread, and farmers faced large crop losses and found themselves in a desperate situation.

At present, the wrong methods and means of plant protection are often chosen due to economic problems, the terms of the control and the doses of pesticides are violated, resulting in reduced efficiencies. Often, some farmers do not carry out pest control due to lack of resources, knowledge and equipment, which in turn complicates the overall control work.

Farmers mainly independently diagnose the species composition of pests, determine the methods of control against them, the choice of pesticides, doses, application dates, frequency, etc. As a result of uncoordinated, professionally unreasonable actions, the fight against certain diseases and pests has become very difficult.

Plant protection in the country is mostly carried out with chemical pesticides, which do not always show the desired effectiveness, and can harm human health and pollute the environment. Pesticide doses, maximum allowable repetitions, waiting times, and safety rules are generally not observed. Integrated pest management is not carried out in a systematic way mainly no biological measures are applied, and the level of mechanical, agro-technical application of other methods of control is low due to the lack of necessary knowledge and resources. Currently several greenhouses in the country are attempting to use biological pest control practices, but these methods are not widespread. Often due to the use of outdated and defective equipment, the quality and efficiency of spraying is severely reduced, it is not possible to maintain the prescribed doses of pesticides and the cost of working fluid.

A recent cross-sectional study on pesticide use practices in the Ararat Valley of Armenia in 2000-2006 (Tadevosyan et al., 2013) demonstrated an extremely high pesticide use in the area; 82.8% of respondents used them. More than 150 brand names of pesticides were in use.

The current situation of pesticide, including herbicide use in Armenia demonstrates its non- sustainable nature and potential negative effect on the environment and human health. Since the early 1990s, Armenia has faced pesticide use risks typical for developing countries, including a wide assortment of pesticides on the market, poor knowledge of basic safety rules, poor compliance with rules, and low

availability of medical care. This poses a serious challenge to the country. Development of comprehensive system that regulates pesticide market in Armenia is of utmost importance. Additionally, educational campaigns to address the poor knowledge of basic safety rules, poor compliance with rules should be implemented.

Availability of appropriate scale machinery

Most of Armenian agricultural machinery and equipment has been inherited from the Soviet Union. Unlike other CIS countries, Armenia did not suffer a catastrophic decline in its farm machinery inventory during the privatization, and in 2006 there were 14,600 tractors and 1,700 combines in Armenian farms (Curtis, Glenn E., 2015).

The use of modern technology and modern management systems is low for a lower-middle income country. Only 30% of farmers use agricultural machinery in the country (Statistical Committee of RA, 2014). Over 95% of agricultural machinery and equipment have exceeded their anticipated operating lifetime thereby reducing safety and productivity levels resulting in high operation and service costs

The availability of appropriate machinery to carry out sustainable crop management practices increases productivity per unit of land. It also increases efficiency in the various production and processing operations and in the production, extraction, and transport of agricultural inputs, including coal and oil. The lack of appropriate machinery is a big challenge in implementation of CSA in Armenia.

Market saturation and global competition

Consumer awareness about the principles and benefits of organic and CSA farming remains low in Armenia. The growth of the CSA market is further challenged by low purchasing power, unstable supply, lack of branding, fluctuating quality, as well as a small range and volume of products available. For both domestic and export marketing, the links in the CSA value chains are underdeveloped. In addition, fluctuating export markets discourage long-term investments in CSA production, branding, marketing and trade infrastructure. There is also an insufficient capacity of producers and processors to ensure product quality and quantities for the international marketplace. Most producers also lack access to information about international markets and industry terms of trade.

Currently, organic products are subject to the same tariffs and quotas in major export markets as non-organic products. Therefore, organic producers have to comply with all the broader agri-food product export requirements, as well as standards and certification procedures that are specific to organic produce. For example, for exports to the EU, the certification body has to be accredited according to EU organic regulation, or the exporting country must be listed on the Third Country List, which recognizes some countries that have equivalent organic production rules and systems as the EU. All in all, this means that the regulatory barriers for organic products are higher than those for non-organic products.

Armenia's organic certification body, Ecoglobe, has obtained EU approval as an organic certification body, which greatly facilitates the accreditation process for Armenian organic producers. Another barrier for Armenian, as well as any other middle to low-income producers is that the EU-USA equivalency agreement for organic trade does not facilitate trade for producers outside the EU and the USA, even though they are technically also partnering under the agreement. This causes superfluous duplications of USA and EU equivalent certifications and creates the need for multiple accreditations of local certification bodies. The result is *de facto* discrimination of third country producers, compared to those based in the EU and USA. Additionally, some of the standards demanded by export destinations are difficult for producers in Armenia to fulfil. For example, the US standards are very detailed regarding composting procedures and it is difficult for producers in Armenia to ensure that all these requirements are met. Likewise, the EU and US requirements for organic seeds are hard to fulfil for virtually any country with a small organic sector, primarily because seed companies are not interested in supplying organic seeds to small markets and may offer high prices to small markets. There are no public organic standards in place in Russia or in the EEU, and thus there are currently no special barriers for exports of organic products to those countries.

In addition to regulatory demands, organic products also face special requirements from importers. For example, a buyer in the target market (such as the EU) might demand certification from a specific certification body because of its reputation or his or her personal familiarity with the label. In addition, various markets have strong preferences for certain organic labels (e.g., the BioSuisse label in Switzerland, Soil Association in the UK and KRAV in Sweden) and may also be required to comply with fair trade, climate neutral or other additional product certification. While compliance with several standards can provide new market opportunities, the complexities associated with their attainment constitute major market access barriers, particularly for small-scale producers. There are no such preferences for imports to Russia, as there are no national organic certification bodies operating in the country. Armenian products are well known in the Russian market and where they can easily compete with similar products from other sources.

Medium and small greenhouse producers of vegetables, as a rule, market their products via two distribution channels: direct selling and selling through intermediaries (brokers). Statistical data on production and export of vegetables, flowers and berries are not segregated by greenhouse and open-field productions. This means that no data are available on greenhouse crop production and export volumes. The geography of export is focused: greenhouse crops are mainly exported to Russia and, in small numbers, to Belarus and Georgia. Tomato and cucumber are mostly exported to Russia, flowers to Russia, Georgia, and Belarus, and berries (strawberry) - mostly to Russia.

At the same time, there are important developments taking place in the Russian market. Particularly, competition in the Russian market drastically intensifies, despite international economic sanctions against Russia and limitations applied by Russia lately on imports from Turkey. After lifting international economic sanctions against Iran last year, Iran's role in exporting vegetables and fruits to the Russian market will probably grow. As shown in tables below, prices offered by Iranian vegetable producers are rather competitive. At the same time, competition from other countries grows as well. Israel too, which has over 8,000 hectares under greenhouse crops, may play a serious role in supplying certain crops, such as strawberries, to the Russian market. In addition, there is such factors as notable expansion of greenhouse areas and developments in the Russian greenhouse sector, and Russian greenhouse producers also are serious competitors. To export vegetables from Armenia, it is necessary to obtain a phytosanitary certificate. Businesses have not reported problems associated with obtaining phytosanitary certificates.

5. Climate-smart agricultural practices and crop models in the BSB: Armenian cases

1. *Argrain LLC*- The farm is operating since 2009. It is of 200 ha size, located above 1,850m sea level. The farm work on a CSA manner, rotationally growing emmer, quinoa and chickpeas. Chickpeas are used to rotational improve soil quality and specifically Nitrogen balance. No synthetic fertilizers are used for the production. The soil is analyzed for the elemental composition, and if necessary, manure is used for improvement of soil nutrient balance. The fields are only rainwater irrigated, allowing decreased pressure on water resources in the region. There is no pesticide use in the farm. The soil is dug bit later, than the other neighboring farms. This allows to kill and mix the weeds with the soil, increasing its nutrient levels, and provides time lag to avoid main pests of the wheat, simply because the plant growth period falls later than pick activity time of the pest infestation. The plant residues are used as animal feed.

The entire production is exported. The farmer used to sell the products under the organic label until 2016, after which did not engage in certification. This, however, did not affect the market of the products.

2. *Achajur Community*- The vineyard occupies 1600m^2 area in Tavush marz of RA. This region is the most climate affected region in the country, with high level of water scarcity and soil pollution. One of the main problems in the area is the infestation of soils, and subsequently, vine with Grape phylloxera (*Daktulosphaira vitifoliae* (Fitch 1855)). The pest affects the growth of vines, and even if the grapes are grown, the wine production is hampered. As such the farm grows 6 different sorts of phylloxera resistant species, imported from France. Additionally, the soils are treated for phylloxera, and the combination of soil treatment and resistant plants allows production of high-quality grapes in degraded lands for wine production. Drip irrigation system is installed in the farm. Water, soil and grapes are periodically analyzed in the specialized laboratory, and depending on soil quality, precision methods of fertilization and pesticide use are practiced. The farm is currently building a nursery for production of phylloxera-resistant vine seedlings for local use and export. Woody plant residues are used for burning, replacing fuels from forests.

3. *Maquaponics LLC*- Aquaponics farm operating in Geghraquniq marz. The farm work on the patented technology of INTAG (Harrisburg, PA, USA), where aquaculture farm serves as a localized source of organic fertilizer. Organic inputs are dosed into the system to produce low cost, organic liquid fertilizers for the localized crop production system. Carps are grown as the main fish species. The solid waste from the fish are used to feed Californian worms, which digest the solid waste and excrete in in dissolvable form. These dissolved compounds act as a fertilizer for the growth of aquaponic plants. The farm is producing bok choy for the local market. The water

is fully recycled, no synthetic fertilizers are used for the plant growth. Since the farm is operating in a greenhouse, solar energy is used for heating purposes, reducing the pressure on fossil fuels and related GHG productions.

4. *The Amster Flowers Armenian-Dutch JV LLC*- The hydroponic greenhouse is located in Kotayk marz. The operation is based on Priva software that combines climate control, energy saving and optimal reuse of water. The farm grows tomatoes and cucumbers in an intensive manner, with the average yield of 40-47 kg per m^2. The operation parameters of the greenhouse are precision controlled for temperature, fertilizer and water use and are correlated with outdoor climate. The water is not recirculated.

5. *Gnel Mkhitarian farm*- The farm is located in Ashtarak. The farmer is practicing innovative agriculture, including growth of previously not cultivated vegetable sorts in Armenia, rotational systems, organic agriculture, precision use of organic fertilizers and compost, composting the leftovers and residues of the plants and crops, etc. The farm consists of open land and greenhouse operations. The production of rabbits and bees in the farm allows the circular economy operational mode.

The main innovative approach of the farm is the use of Baykal EM1 effective microorganisms to boost the plant growth and soil health (with a healthy and active soil worm community), to protect plants from pathogens. This allows avoiding pesticide use, and achieving high yields under varying environmental conditions.

6. Conclusions

In Armenia, Climate Smart Agriculture (CSA) practices include organic production, greenhouses, intensive orchards and farms, as well as agricultural productions that contain one or more elements of CSA, such as drip irrigation, use of cover crops and mulching, anti-hail systems, intensification of production, etc.

The feasibility study, aimed at the understanding the state of art and potential of CSA in Armenia revealed multiple challenges and interrelated opportunities for this practice in the country.

The low land resource use efficiency, mainly due to the small size of farms, subsequent violation of agrotechnological practices, irrigation regimes and norms, as well as rotations, lack of clear legislative background and financial incentives, as well as limited local and international markets, etc., pose not only strong challenges for the CSA in Armenia, but also demonstrate a big potential for the promotion of CSA.

Yet, with all the mentioned challenges, CSA offers multiple benefits for Armenia including socio-economic sustainability in form of increased income, more employment, specifically for women, new export markets, as well as better food security and safety. The environmental benefits of CSA in Armenia are twofold: climate change mitigation and adaptation mechanisms to face climate change induced environmental risks.

The main finding of the study is that the CSA practices and practices with CSA elements are gaining more and more popularity in the country and are highly attractive in terms of ecological, economic and social benefits for almost all stakeholders involved (including producers, consumers, research and local authorities' representatives), with the highlighted motivation of the stakeholders to further develop and support the CSA in the country.

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Annex 1. Survey results

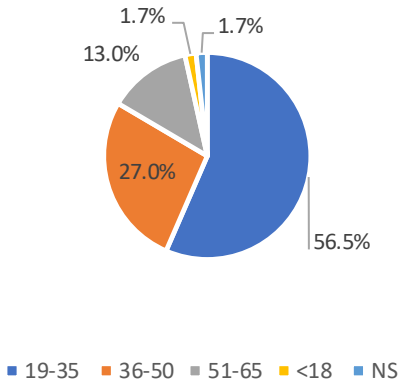

Figure 2 Age Distribution, %

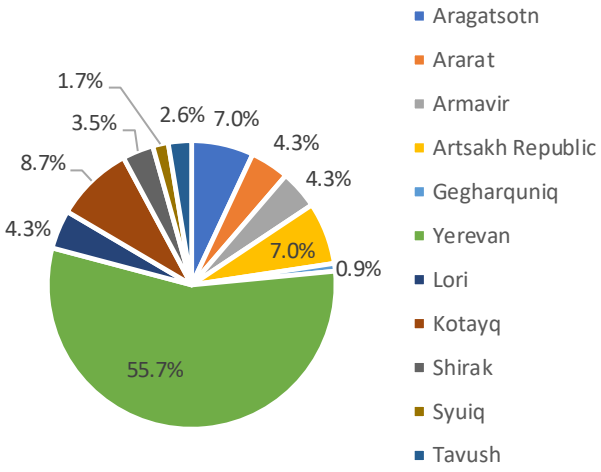

Figure 3 Place of residence, %

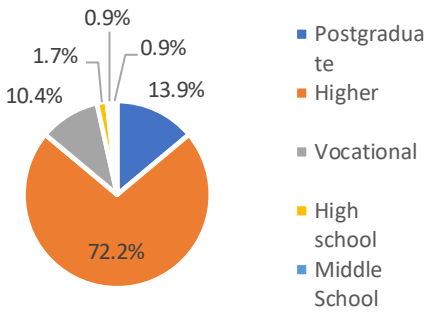

Figure 4 Education, %

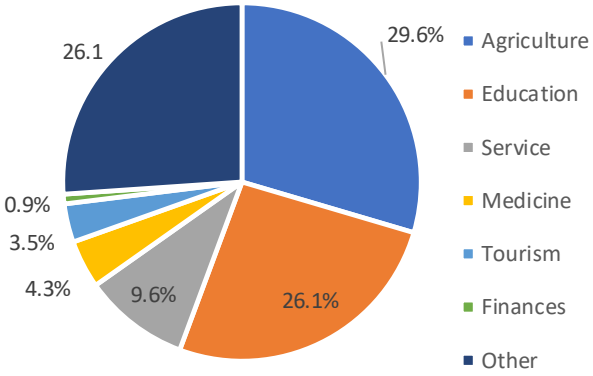

Figure 5 Sector of occupation, %

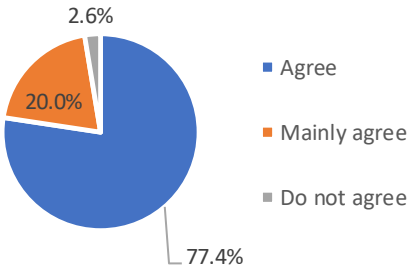

Figure 6 Respondents' opinion on productivity and income level increase, %

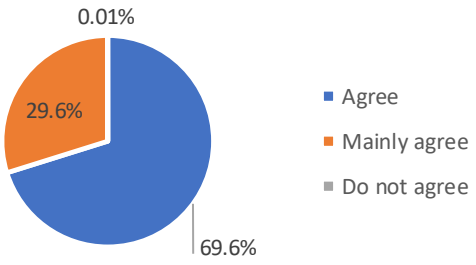

Figure 7 All stakeholders in Armenia should work towards climate change adaptation and stability, %

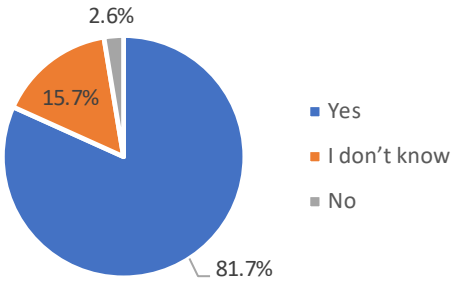

Figure 8 Willingness to support CSA Development, %

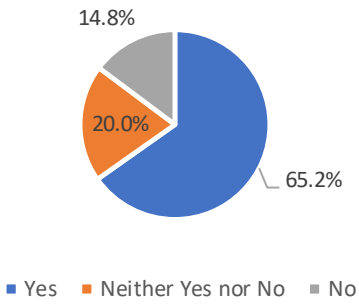

Figure 9 Necessity of brand for CSA, %

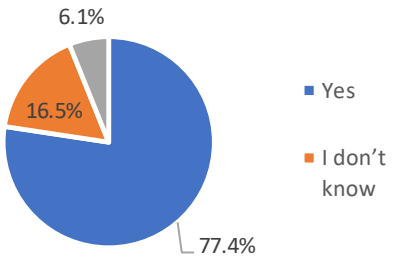

Figure 10 Willingness to purchase CSA labeled products, %

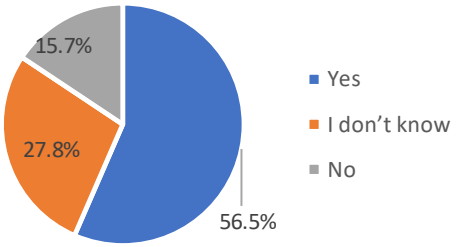

Figure 11 Willingness to pay more for CSA labeled products, %

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