AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
ԱԳՐՈԳԻՏՈՒԹՅՈՒՆ ԵՎ ՏԵԽՆՈԼՈԳԻԱ АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

UDC 664:631.95(479.25)(479.22)(478.9)
doi: 10.52276/25792822-2025.sp-5

A Comparison of Climate Smart Food Systems in Armenia, Georgia, and Moldova: Policy Implications for Armenia

Mark Driscoll
Tasting the Future
Vardan Urutyan
Agribusiness Department, Armenian National Agrarian University
Alen Gasparian-Amirkhanian
Acopian Center for Environment, American University of Armenia
Ivana Mijatovic
Stockholm Environment Institute
Gohar Badalyan
Agribusiness Department, Armenian National Agrarian University

mark@tastingthefuture.com, urutyan@anau.am, alen@aua.am, mijatovic.ivana@fon.bg.ac.rs, goharbadalyan@yahoo.com

ARTICLE INFO

Keywords:
Agri-Food Sector,
Climate Change,
Climate- Smart Agriculture,
EU Green Deal,
Policy and Adaptation,
Sustainable Food Systems

ABSTRACT

In May 2020, the European Commission introduced the Farm to Fork (F2F) strategy (European Commission, 2020), a bold initiative aimed at overhauling Europe's food systems with a strong focus on sustainability and long-term environmental, human, and planetary health goals - in line with the objectives of the EU Green Deal (European Commission, 2021). The profound impacts of industrial food systems on climate change, biodiversity, and public health are often overlooked. Globally, food systems account for nearly one-third of greenhouse gas emissions (Crippa et al. 2021), are the primary causes of biodiversity loss (Boakes, et al., 2024), and play a substantial role in health conditions such as cardiovascular diseases, cancer, and type 2 diabetes. To build on these efforts, the EU Strategic Dialogue on Agriculture recently introduced a document of recommendations called "A Shared Prospect for Farming and Food in Europe."(European Commission, 2024). The initiative aims to reform the EU Common Agricultural Policy (CAP), create Just Transition and Nature Restoration Funds, and advocate for more sustainable diets – new directions for advancing the Farm to Fork agenda that will shape European policy in the future.

Food systems are critical for ensuring food security, supporting sustainable development, and addressing the challenges posed by climate change. This paper explores lessons learned from three GUMA project countries: Armenia, Georgia, and Moldova. A qualitative analysis was conducted using data gathered from diverse sources, including official statistical agencies, international donor organization frameworks, and sectorial data. In addition, for Armenia specifically, the study incorporates insights from surveys of key actors across state, academic,

and private sectors. All three countries face challenges related to rising temperatures leading to heat stress and droughts, soil health and degradation, and the prevalence of smaller farm sizes. Additional issues include low levels of organic production, limited access to markets and finance, underdeveloped or no agricultural extension services, significant post-harvest food loss and waste, food insecurity, and insufficient adoption of healthy and sustainable diets. Furthermore, these challenges are worsening because of the lack of governmental or international incentives to promote climate-friendly and sustainable farming programs and gaps in governance and strategic planning. The study highlights key lessons from climate-smart food systems in Armenia, Georgia, and Moldova, offering comparative insights and actionable recommendations to guide policy development and advance sustainable agricultural practices in Armenia.

Introduction

In May 2020, the European Commission introduced the Farm to Fork (F2F) strategy (IBID), a bold initiative aimed at overhauling Europe's food systems with a strong focus on sustainability and long-term environmental, human, and planetary health goals - in line with the objectives of the EU Green Deal (IBID). The profound impacts of industrial food systems on climate change, biodiversity, and public health are often overlooked. Globally, food systems account for nearly one-third of greenhouse gas emissions (IBID), significantly contribute to biodiversity loss (IBID), and are closely linked to major health issues including heart disease, cancer, and type 2 diabetes.

Reinforcing these objectives, the EU Strategic Dialogue on Agriculture recently presented a new set of proposal under the title "A Shared Prospect for Farming and Food in Europe" (IBID). The initiative aims to reform the EU Common Agricultural Policy (CAP), create Just.

Materials and methods

Agriculture, which accounts for 69% of the country's land area (ARMSTAT, 2025) and employs 22% of the total workforce (ARMSTAT, 2023), as a vital part of Armenia's cultural heritage and economy, standing as the third-largest sector in terms of Gross Domestic Product GDP contribution. Its key agricultural commodities include fruits (apricots, peaches, grapes), vegetables (potatoes, tomatoes, cucumbers), cereals (wheat, barley), and herbs. Armenia is also known for wine and brandy production, leveraging its ancient viticulture traditions. Livestock farming (cattle, sheep, pigs) is integral to agriculture, providing meat, dairy, and wool.

Table. Key Agricultural Indicators for Armenia, Georgia and Moldova

Indicator	Armenia	Georgia	Moldova
Agriculture GDP (%)	18	9	12
Arable Land (%)	44	39	52
Average farm Size (hectares)	2.5	1.2	3.0
Smallholder farming (%)	94	99.8	97.7
Top Exports	Fruits, Vegetables, Wine, Grans	Citrus, Grapes, Tea, Vegetables, Wine	Wheat, Sunflower seeds, Grapes, fruits

In its Nationally Determined Contribution (NDC) 2021-2030 (NDC, 2021), Armenia committed to implementing economy-wide climate mitigation measures to achieve per capita net emissions of 2.07 tCO2eq by the year 2050. Agriculture, the second most significant contributor to GHG emissions (18.5%) after energy (66.7%) (UNDP, 2020), is recognised as an important component within the NDC. There is a focus on several agriculture mitigation strategies, including improved nitrogen fertilizer application practices, the promotion of organic farming methods to decrease reliance on synthetic inputs and enhance soil health, improved irrigation strategies to reduce water loss, and the adoption of digital tools and innovative technologies to improve farm management and resource use efficiency.

Furthermore, the NDC also emphasises the importance of integrating climate change adaptation into national planning, specifically focusing on agriculture, which is particularly vulnerable to its impacts.

Armenian agriculture is a key contributor to and is also impacted by climate change. Armenia has experienced a rise in average temperatures, which affects crop yields and water availability. Changing rainfall patterns, increased frequency of droughts, and deforestation contribute to soil erosion and fertility loss, exacerbating the impacts of climate change (GEFF, 2025). Furthermore, melting glaciers in the Armenian Highlands and reductions in water tables have reduced long-term water availability for crop irrigation (WB, 2021).

Common Challenges in Armenia, Georgia, and Moldova

Whilst Armenia, Georgia, and Moldova are geographically and culturally distinct, they share common challenges across their respective food systems. Several of these challenges have been briefly outlined below:

1. Increasing temperatures leading to heat stress and droughts: The ability to feed growing populations with healthy and nutritious foods and ensure long-term food security is being compromised by the impacts of a changing climate. All three countries are experiencing increasing average temperatures, leading to heat stress for crops and livestock and a consequent drop in yields (IMFFA 2021, WB 2020, UNFCC 2024). Erratic rainfall patterns and more frequent and severe droughts also affect water availability and crop yields, compounded by inefficient and unsuitable ageing irrigation systems. Salination of soils in irrigated issues also occurs (FAO 2021). Managing water resources sustainably remains one of the critical challenges across all three countries, alongside adopting climate-resilient organic and agroecological agricultural practices.

2. Soil health and degradation: Soil erosion and degradation, particularly in hilly areas, are significant issues across all three countries. This typically stems from practices such as excessive grazing, high-input farming, and deforestation. In Armenia, for example, unsustainable livestock practices on the Alpine grasslands have resulted in soil degradation and the loss of critical alpine grasslands (WB 2023). In Georgia, 35% of the country's agricultural land is degraded (NSOG, 2025): in Moldova an estimated 2 million hectares have been affected by degradation (Tamara, 2015).

3. Smaller farm sizes compared with Europe: In Armenia, Georgia, and Moldova, the average farm size is small compared to the rest of Europe, reflecting the agrarian structures established during land reforms following the collapse of the Soviet Union in the 1990s. Today, average farm sizes vary from 1.37 hectares in Armenia (Millns, 2013) to 2.5 hectares in Moldova (WB, 2025). In many cases, agricultural land, which was previously managed by large state-owned farms (kolkhozes and sovkhozes), was redistributed to individual households. Efforts to consolidate landholdings across all three countries have been limited, and there is resistance from rural communities due to concerns over losing their primary means of livelihood. Governments and international organizations are exploring ways to improve the sustainability and efficiency of these smaller farming operations, such as encouraging cooperative farming, improving access to credit, and, in some instances, promoting land consolidation programs.

4. Low levels of organic agriculture production and difficultie accessing markets: While organic agricultural production is growing across the three countries, Moldova has the most developed organic sector, with organic farming covering approximately 1.5% of agricultural land (FiBL 2024). Armenia and Georgia's specific statistics are more difficult to obtain, but estimates suggest that organic agriculture covers less than 1% of land. High certification costs and low consumer purchasing power and awareness are key market challenges that prevent farmers and consumers from producing and purchasing organic foods.

5. Poor access to markets and finance Given the small size of many farms in each country, it can be difficult for farmers to access markets (FAO, 2019, WB, 2025). Cooperation between farmers is still relatively limited, although there is some emerging interest in developing farming cooperatives to improve their negotiating position, particularly with larger buyers. Organic and other environmental certification schemes (e.g., ECOGLOBE (ECOGLOBE 2025), Caucascert (Caucascert 2022), Certificat Eco (Certificate, 2025)) which have the potential to improve access to markets and the value of products, face challenges (e.g., can be expensive) and are nascent in these countries and farmers often struggle to meet the quality and safety standards required to access the larger and export markets.

Furthermore, access to finance is a common challenge. Banks and financial institutions often view farming as a high-risk activity, particularly for smallholder farmers with little access to other forms of collateral. A lack of financial training or systems to support farmers with financial advice compounds these challenges. Even when loan or finance programs are available, they do not tend to

focus on climate change mitigation and adaptation—their prime focus is often on productivity improvements.

6. Agriculture and climate education, training, and farmer extension programs: Agricultural education/training and extension programs are critical for improving agricultural productivity, reducing GHG emissions, and supporting rural development. Whilst there is a growing focus and investment in agricultural development across all countries, more informal agrarian development services, particularly regarding farmer training for climate-smart agriculture, are underdeveloped and inaccessible for the smaller farms. Limited resources also hinder the effectiveness and expansion of extension services. Whilst there is some support from international organisations and donors (e.g., USAID, EU, UNDP, World Bank, etc), there are opportunities to increase support for climate-smart agriculture, agroecology, and organic agriculture. Whilst organic and climate-smart-related agriculture research is nascent in the three countries, there are opportunities to include more of these elements within the curricula of research and academic institutions.

7. Post-harvest food loss and waste: Post-harvest food loss and waste (FLW) present significant challenges in Armenia, Georgia, and Moldova. Precise, up-to-date statistics for each country are very limited. Despite this limited data, regional trends suggest that these losses contribute to a lack of proper post-harvest facilities, poor market access (particularly for fresh produce), and limited knowledge of best practices (FAO 2024). The absence of cold storage and processing facilities can also hamper produce quality and shelf life and reduce the amount of food available for the export market (IFAD 2023, Food Systems Summit 2021). Farmers also lack awareness of proper post-harvest handling techniques, leading to physical damage to crops.

8. Food insecurity: While food insecurity varies across Armenia, Georgia, and Moldova and is rising in Moldova, it remains a significant challenge, especially in more rural areas (WFP 2023, FAO 2023). Food insecurity is influenced by factors such as political instability, economic challenges, the impacts of climate change, and regional conflicts. In Georgia and Moldova, migration as a result of from regional disputes (e.g., the war in Ukraine) has added pressure on these countries' food systems. Reduced agricultural output due to climate change can lead to higher food costs, creating barriers for low-income families to access affordable, nutritious diets. All three countries depend on imported foods and key agricultural inputs (e.g., fertilisers), which makes them particularly vulnerable to global market fluctuations and supply chain disruptions.

9. Healthy and sustainable diets: Obesity and other diet-related health issues are rising in all three countries due to increased consumption of highly processed and high-calorie foods. There has been a corresponding reduction in the consumption of healthier and lower-carbon foods, including fruits, vegetables, and whole grains. As a result, micronutrient deficiencies have been rising, including anaemia and vitamin deficiencies, particularly among women and children. Generally, agro biodiversity (crop diversity) has dropped in each country, particularly as more traditional diets (using lentils, beans, nuts, seasonal fruits/vegetables, etc) have lost favour. While governments rarely interfere with peoples' diets, making healthy and sustainable food affordable could increase nutrition security, improve public health, and reduce the climate impacts of food systems.

10. A lack of government or international incentives for promoting climate-friendly and sustainable farming programs: (e.g., subsidies for organic farming or water-saving irrigation) are limited or poorly implemented. International aid often focuses on short-term projects rather than systemic reforms.

11. Governance and strategy: Improving communication, coordination, and synergy between and across ministries can boost progress towards achieving climate-smart food and farming goals. This means looking at food as a whole system, from how food is grown to how it is consumed, engaging all actors (including civil society organisations, farmers, citizens, academics, businesses, etc) with a stake in this process. Scientists and policymakers increasingly agree that making food systems sustainable is not just about new technology; we need systemic changes in food production and consumption. Whilst ministries vary between each of the three countries, they all tend to operate in silos. The Ministries of Agriculture, Environment, Climate, Health, and Labour often develop policies related to food and farming in isolation to align their policies and work together to find practical solutions for shared objectives. Food, agriculture, and climate-related strategies can often be fragmented at best and at worst, they can conflict with one another.

Results and discussions

Examples of Climate Smart Agricultural Policy in Georgia

Agriculture is significant in Georgia's economy, contributing about 7% to the national GDP. 45%, 48% and 7% of Georgia's agricultural production come from animal

husbandry, horticulture and farming services. Roughly, 99% of agricultural holdings are small family-run farms, usually operating on about one hectare of land.

While Georgia has no specific GHG emissions reduction targets for agriculture, its climate action plan (Nationally Determined Contribution) supports 'low carbon development approaches of the agriculture sector through encouraging the climate-smart agriculture and agritourism' (NDC 2021). The Agricultural and Rural Development Strategy for Georgia 2021-2027 (GRDN 2021) is the principal strategic document that guides agricultural development in Georgia. It serves as a roadmap for achieving sustainable economic growth, with key objectives focused on increasing self-sufficiency levels, improving food security, and increasing food exports while protecting the environment.

Acknowledging the significance of horticulture and aiming to lessen dependency on fruit and vegetable imports, the Georgian government initiated the "Plant the Future" program in 2025 (RDA 2025). The scheme encourages the cultivation of high-value crops such as nuts, berries, and fruit trees, and farmers receive grants to cover the costs of seedlings, irrigation, and infrastructure. The scheme particularly encourages farmers to think about how they can adapt to climate change and specifically funds projects that reduce water usage and instal anti-hail initiatives, for example.

A programme to support organic agricultural production, reducing the reliance on fossil fuel-based fertilisers and pesticides, has also been a key priority of the Georgia government over the last five years. For example, in 2022, Georgia launched an Organic Production Support Programme. This initiative aims to boost the production of organic products by providing financial support to potential beneficiaries willing to transition to organic farming practices. Furthermore, the scheme addresses high certification costs, limited access to processing and storage facilities, outdated infrastructure, and knowledge gaps among some farmers.

Examples of Climate Smart Agricultural Policy in Moldova

The agri-food sector in Moldova plays a significant role in the country's economy. It accounts for around 12% of Moldova's Gross Domestic Product and employs over 21% of its labour force. Moldova's main agricultural products, 45% of which are exported, include fruits, nuts, grapes, cereals and livestock (Statista 2023). Most farmers (97.7%) are small-scale, with farm sizes ranging between 0.85 and 10 hectares. The contributions of smallholders and family farms are vital to the sector, as they generate 63% of the country's total agricultural production (REU 2022).

Agriculture is the second most significant contributor to GHG emissions after energy (11.3% and 51.5%, respectively). The country's climate action plan (Nationally Determined Contribution 2022) commits to actively promoting climate-resilient agricultural practices through a wide range of practices, including fertilizer application optimisation, crop diversification, better irrigation, and improvement to soil health. The National Strategy for Agriculture and Rural Development 2023-2030 is the principal piece of legislation.

Given the country's vulnerabilities to climate change impacts, including significant droughts and floods that have affected crop production over the last few years, a National Climate Change Adaptation Programme (UNFCC 2024) was approved in 2023. The programme aims to integrate adaptation measures across various sectors, significantly focusing on agriculture. Key agricultural strategies, for example, include promoting agrobiodiversity and developing drought-resistant crop varieties. These include traditional Moldovan grape varieties, which are noted for their resistance to cold temperatures and drought conditions, making them valuable crops for viticulture in the region.

Furthermore, the Moldovan government places much emphasis on agricultural extension services. It recently established the Agricultural and Rural Advisory Centre, whose mission is to develop consulting services tailored to farmers' needs, facilitating their access to technical, economic, financial, and managerial information, as well as training programs and rural development initiatives. The Centre, for example, runs training programs for farmers focussed on adopting conservation agriculture techniques, micro-irrigation systems, and anti-hail and anti-frost systems. The Centre collaborates with local communities to develop action plans addressing climate change adaptation at the community level. These plans include assessments of climate vulnerabilities and outline specific adaptation actions, contributing to broader climate mitigation efforts.

Examples of Climate Smart Agricultural Practices and Polices in Armenia

The 2020-2030 vision for Armenian agriculture focuses on sustainable development, innovation, and high-value production that respects natural resources, supports biodiversity, and promotes eco-friendly farming. The aim is to create healthy, ecologically clean products

while enhancing the well-being of rural communities. The government is committed to a coordinated approach that emphasizes resource efficiency and partnerships to address key challenges in agriculture and rural areas. The primary goals are to increase agricultural productivity, strengthen food security, adopt modern technologies, and improve income for everyone involved in agriculture: especially smallholder farmers, producer groups, processors, and exporters.

The Government has identified several critical measures to enhance climate resilience and reduce risks in agriculture. These include establishing a national agricultural insurance system, developing and implementing effective anti-hail mechanisms, and promoting climate-resilient technologies such as drought-resistant crop varieties, modern agricultural practices, and localized smart technologies adapted to changing climatic conditions.

The strategy also includes practices that boost biodiversity, soil health, and efficient use of resources, such as crop rotation and organic farming. As a result, new certification procedure introduced in 2024 now requires local certifying organizations to accept national certification standards, which will simplify organic certification and help Armenian products reach broader markets (GoA 2020).

The "GREEN Armenia" Policy Dialogue with European Union, initiated in 2022, highlights the importance of further discussions for technical and infrastructure development to facilitate a successful green transition. Advancing the agriculture sector necessitates additional investments in human capital across various segments and levels of the agricultural market. This involves a comprehensive reform of the educational and vocational training systems to actively involve youth, enhance farmer skills, and train the next generation of Armenian agronomists, agricultural technologists, and entrepreneurs. Additional efforts are required to attract qualified specialists. The primary objective of the GREEN Armenia platform is to consolidate and streamline policies and investment initiatives with the aim of facilitating Armenia's transition to a green economy (GoA 2022).

Climate-Smart Agriculture practices have begun to take root in Armenia, notably through the EU Green Agriculture Initiative in Armenia (EU GAIA), implemented by the Austrian Development Agency, the best "Green and Climate smart agriculture technologies" and "Good agricultural practices" were identified and implemented. There were selected and introduced particularly those technologies and practices that are best suited for the local context that conserve natural resources, reduce GHG emissions, and improve soil quality for healthy food production without depleting natural resources (FAO 2023).

Armenia has set ambitious climate goals, aiming for per capita net emissions of 2.07 tCO2eq by 2050 through economy-wide mitigation measures detailed in its 2021–2030 Nationally Determined Contributions. The Nationally Determined Contributions (NDC) highlight agricultural emissions—such as methane from livestock digestion and nitrous oxide from fertilizer applications—as key areas for mitigation. Complementing this, the National Action Programme for Climate Change Adaptation (2021-2024) aligns sector policies with adaptation efforts, particularly for agriculture, as part of the National Adaptation Plan (NAP). Recent policy actions also reflect Armenia's commitment to sustainable food systems, such as signing the COP28 UAE Declarations on resilient food systems and climate action in December 2023. Despite these prospects, Armenia's agricultural and food systems currently lack updated greenhouse gas (GHG) emissions data. The latest estimate from 2019 attributes 18.8% of GHG emissions to agriculture, largely from cattle-related methane emissions and nitrogen fertilizer practices, with nitrous oxide emissions predominantly linked to manage soil activities (MoE 2023).

The green technologies and good agricultural practices that demonstrate the best sustainable approaches in agriculture address the following main directions: Improved soil management (ISM), improved crop production (ICP), organic Agriculture and post-harvest processing. The establishment of demonstration sites and agribusiness support projects were the main approaches to promote the adoption of green technologies and good agricultural practices at the farm level. In total 16 demo sites were established at beneficiaries' farms. To strengthen the technical capacities of demo sites agricultural production machinery and small agricultural equipment, as well as some smart infrastructural inputs were provided to project beneficiaries (AMPERA 2024).

The current agricultural State Support Programs (SSPs) in Armenia are designed to enhance the sector's competitiveness, sustainability, and export orientation. According to the Ministry of Economy, the primary objectives of state support for the agricultural sector include:

- *Food Security:* As a landlocked country with limited agricultural land, Armenia is particularly vulnerable to food shortages, especially during droughts or other natural disasters. Government involvement is essential in maintaining a secure and dependable food supply chain.
- *Economic Development:* Agriculture is a significant contributor to Armenia's economy, accounting

for approximately 9% of GDP and providing employment for about 30% of the workforce. By supporting the agricultural sector, the government aims to create new jobs, boost incomes in rural areas, and reduce poverty.

• *Climate-Smart Agriculture and Resilience to Climate Change:* Although climate-smart agriculture and resilience to climate change are reflected in Armenia's agricultural development strategy and some SSP descriptions, their emphasis within the programs remains inconsistent. These elements appear sporadically and are not fully aligned with the country's current economic needs or the growing risks posed by climate change.

• *Environmental Protection:* Agriculture has a significant environmental impact. By promoting sustainable agricultural practices, the government seeks to protect natural resources and ensure the long-term viability of the sector.

Organic farming is recognized as an important driver of export growth. The country strategy sets an ambitious goal of achieving more than 5% eco-certified agricultural production by 2029. Increasing stakeholder awareness of global best practices and strengthening collaboration with the Ministry of Environment on conservation issues are essential to achieving these targets. By focusing on sustainable development, Armenia aims to enhance the resilience and competitiveness of its agricultural sector while advancing its green transition and aligning more closely with EU standards. As a consequence of strategy action plan new certification procedure introduced in 2024 now requires local certifying organizations to accept national certification standards, which will simplify organic certification and help Armenian products reach broader markets.

Armenia's green transition also gained momentum with the country's membership in the International Union for the Protection of New Varieties of Plants in 2024. Armenia became the 79th member of the International Union for the Protection of New Varieties of Plants (UPOV), which offers a unique legal framework for plant variety protection. By introducing plant breeders' rights, Armenia opens up opportunities for sector growth and societal benefits, including enhanced breeding practices, access to improved plant varieties, foreign varieties and technologies, increased genetic diversity, and expanded seed and plant material exports. Additionally, this aligns with political commitments, including the CEPA agreement.

Armenia has introduced legislative measures to reduce pollution from mineral fertilizers. As part of its commitments under the Comprehensive and Enhanced Partnership Agreement (CEPA), the country is aligning its laws with EU standards and international guidelines (EU 2018). In terms of water quality and resource management, this includes adherence to five key EU directives: the Water Framework Directive, the Floods Directive, the Urban Waste Water Treatment Directive, the Drinking Water Directive, and the Nitrates Directive. According to Article 32 of the Armenian Water Code: "The Water Resources Management and Protection Authority is responsible for establishing criteria to identify nitrate-sensitive water resource areas and developing strategies to reduce and prevent nitrate pollution caused by agricultural activities."

To address nitrate pollution from agricultural activities, the Armenian government issued Prime Minister's Decision N 1099-A on September 27, 2022. This decision focuses on amendments to the Water Code and the National Water Program of Armenia. The Ministry of Environment of the Republic of Armenia issued a new decree on June 18, 2024. The decree, aligned with Armenia's revised Water Code, sets out criteria for designating nitrate-sensitive areas and outlines actions to limit nitrate pollution. To address the impact of agricultural activities on nitrate pollution, the decree imposes restrictions on the use of nitrogen fertilizers and the storage of livestock manure, considering factors such as soil type, slope, climatic conditions, rainfall, irrigation practices, and agricultural activities. The goal is to strike a balance between the nitrogen requirements of crops and the amount of nitrogen that leaches into soil and water, thereby preventing pollution. The specific measures, tailored to the characteristics of each river basin, will be determined as part of the River Basin Management Plans (Government Decision of RA, 2024).

A crucial regulatory framework on reducing the environmental impact of food systems in the Republic of Armenia is the 'Forestry Code of the Republic of Armenia.' This code establishes the competencies of authorized state administration bodies in the field of sustainable forest management and control, and plays a key role in ensuring that forest practices contribute to environmental protection and climate goals. The Forestry Code, which states the responsibilities of authorized state administration bodies, includes 42 key points, two of which, No. 27 and No. 40, are specifically devoted to agroforestry. These points are essential in regulating and supporting various aspects of agroforestry, such as the restoration and afforestation of forests, the management of seed systems, and the promotion of sustainable forest practices (Forestry Code of RA 2024).

The agritech sector in Armenia shows great potential for growth and transformation. Agriculture remains a key pillar of the nation's economy, and the development of

agritech is seen as a way to modernize traditional farming practices, boost productivity, and enhance sustainability in response to challenges such as climate change, water scarcity, and a rapidly changing global marketplace.

Conclusion

Policy opportunities for climate-smart agriculture and food systems in Armenia.

Overall, the green transition within Armenia's agricultural and food sectors is crucial for ensuring the country's long-term sustainability and resilience. The consequences of not achieving a green transition in Armenia's agricultural and food processing sectors are significant, posing risks to the environment, economy, and long-term food security. Given Armenia's dependence on agriculture to meet food demands, any disruption in agricultural production threatens the country's food security.

There are significant opportunities to address these challenges in the food system in Armenia, Georgia, and Moldova. In Armenia specifically, drawing on lessons from Georgia and Moldova, we identified the following:

1. Modernizing irrigation systems: Improving Armenia's irrigation systems (e.g., drip and precision irrigation systems) is key to increased agricultural productivity and climate resilience, particularly given how Armenia is increasingly subject to droughts and water scarcity. Providing financial assistance and tax incentives for purchasing and installing modern irrigation equipment and planting a greater diversity of drought-resistant crops is also key. The protected cropping (greenhouse) sector is also an economically promising area for expansion in Armenia with export growth potential – supporting water and energy-efficient greenhouses using renewable energy technologies holds promise with dual benefits for climate and the economy.

2. Promotion of climate-smart practices such as organic agriculture, agroecological practices, and agroforestry: Armenia has a significant opportunity to significantly expand organic farming and agroecological practices due to its rich agricultural and food heritage, fertile soils, and increasing demand, particularly from urban customers, for organic products. Using digital tools such as precision agriculture, remote sensing, and more accurate monitoring systems (e.g., weather, pests, and diseases) can also reduce the reliance on fossil fuels and pesticides whilst reducing costs and risks. The Armenian government could develop policies to support the further subsidisation and expansion of organic production, and organic certification and provide more technical training (formal and informal) for farmers.

3. Crop diversification programs and strategies: Given the benefits of crop diversification in terms of drought resilience, enhancing soil fertility, and improving biodiversity, there are significant opportunities to scale up production and research in a wider variety of traditional, wild, or underutilised crops. However, farmers often lack awareness or technical knowledge about the benefits and methods of diversification. Policies and funding can also favour monoculture cropping systems rather than supporting crop diversification and mixed or intercropping systems.

4. Supporting on-farm renewable energy technologies (on-farm solar and biogas): Solar energy is one of Armenian farmers' most promising renewable energy sources, given the country's favourable geographic location and abundant sunshine. Solar could particularly help power horticulture and greenhouse production but also be used to power irrigation pumps and cold stores. Furthermore, biogas has significant potential in Armenia, particularly in the agricultural sector. The country has abundant agricultural waste from the livestock and dairy sectors, such as straw, crop residues, and animal manure. This can be converted into biogas, fertilizers, or solid biomass for heating and electricity generation.

5. Growth in climate-smart food processing: Armenia's food processing sector is also experiencing rapid growth. While this can come with challenges (more highly processed foods with high levels of fats, sugars, and salts), it also offers significant export market growth, driven by healthy and environmentally friendly 'green products', using, for example, organic ingredients and manufacturing technologies using low-carbon sources of energy.

6. Tackling post-harvest food waste: Overall, there needs to be more analysis and monitoring to quantify food losses across the supply chain and identify hotspots for intervention. In general, financial support through subsidies, grants, and loans is needed to help farmers and cooperatives build on-site storage and infrastructure that enables timely delivery of food to important markets. Low-carbon cold storage infrastructure solutions must ensure fresh produce is delivered to markets before it perishes. There are also opportunities to support the development of processing units for drying, canning, or freezing surplus to extend life.

7. Agriculture extension services: Given Armenia's vulnerability to climate change and the need for the

transition to climate-smart technologies and techniques, there is an opportunity to provide agricultural extension services that can focus on educating farmers about climate-smart farming practices, such as drought-resistant crops, water conservation techniques, and alternative pest management systems. There are also opportunities to foster partnerships with the private sector, academic partners, and farmer cooperatives, supporting farmers in accessing better markets, inputs, and financial services (e.g. micro-finance).

8. Digitalization for better governance, transparency and enforcement: Achieving sustainable and effective governance in the agri-food sector requires updating and harmonising national laws, policies, and regulations to align with best practices and standards. Integrating digitisation into this process can significantly enhance efficiency and transparency by creating centralized electronic platforms for legal documentation, compliance tracking, and reporting. Advanced digital tools can also support real-time monitoring and enforcement, ensuring consistent application of standards and reducing gaps in compliance. Furthermore, digitized systems promote accessibility, enabling stakeholders to access updated regulations and submit necessary documentation online, fostering greater accountability and participation.

References

1. AMPERA, "Value Chain Analysis of Apricot, Peaches, Raspberry and Walnut", Final Report, 2024.
2. AND NUTRITION Available at: https://openknowledge.fao.org/server/api/core/bitstreams/a6f6da71-3efd-40a7-aedd-9a726e0ab2f8/content.
3. Armenia (2021). NDC of Republic of Armenia 2021-2030.pdf. [online] Google Docs. Available at: https://drive.google.com/file/d/1BwCO0HJHjtM92O7hGw7QvXD9Rxalixc/view [Accessed 16 Apr. 2025].
4. ARMENIA CLIMATE RISK COUNTRY PROFILE. (n.d.). Available at: https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15765-WB_Armenia%20Country%20Profile-WEB_0.pdf.
5. Boakes, E.H., Dalin, C., Etard, A. and Newbold, T. (2024). Impacts of the global food system on terrestrial biodiversity from land use and climate change. Nature Communications, [online] 15(1), p.5750. https://doi.org/10.1038/s41467-024-49999-z.
6. Caucascert. (2022). Home - Caucascert. [online] Available at: http://caucascert.ge/en/home [Accessed 16 Apr. 2025].
7. Certificat. (2025) Available at: https://certificat-eco.md/ [Accessed 16 Apr. 2025].
8. Circle (n.d.). National Statistics Office of Georgia. [online] www.geostat.ge. Available at: https://www.geostat.ge/en.
9. Climate-Smart Agriculture (Food and Agriculture Organization of the United Nations (fao.org)).
10. Comprehensive and Enhanced Partnership Agreement between the European Union and the European Atomic Energy Community and their Member States, of the one part, and the Republic of Armenia, of the other part. (2018), available at: https://eurlex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:22018A0126(01).
11. Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F.N. and Leip, A. (2021). Food Systems Are Responsible for a Third of Global Anthropogenic GHG Emissions. Nature Food, [online] 2(3), pp.198–209. https://doi.org/10.1038/s43016-021-00225-9.
12. Dept, I.M.F.F.A. (2022). Armenia: Technical Assistance Report-Quantifying Fiscal Risks from Climate Change. IMF Staff Country Reports, [online] 2022(329). https://doi.org/10.5089/9798400224140.002.A001.
13. Ebrdgeff.com. (2025). Climate change and sustainability in the Armenian agricultural sector – GEFF in Armenia. [online] Available at: https://ebrdgeff.com/armenia/climate-change-and-sustainability-in-the-armenian-agricultural-sector/ [Accessed 16 Apr. 2025].
14. ECOGLOBE. (n.d.). ECOGLOBE | INTERNATIONAL ORGANIC CERTIFICATION BODY | Yerevan. [online] Available at: https://www.ecoglobe.com/ [Accessed 16 Apr. 2025].
15. European Commission (2020). Farm to Fork Strategy. [online] food.ec.europa.eu. Available at: https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en (accessed 16.4.25).
16. European Commission (2021). The European Green Deal. [online] European Commission. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.
17. FAO (2019) SMALLHOLDERS AND FAMILY FARMS IN ARMENIA. Available at: https://openknowledge.fao.org/server/api/core/bitstreams/e72612b1-14fd-4f29-889d-55510c1ae896/content.

18. FAO. (2023). EUROPE AND CENTRAL ASIA REGIONAL OVERVIEW OF FOOD SECURITY.

19. FAO. (2024) THIRTY-FOURTH SESSION CHIŞINĂU, THE REPUBLIC OF MOLDOVA, 14–17 MAY 2024.

20. Forestry Code of Republic of Armenia No ՀO-365-Ն, Adopted on January 01, 2024, Republic of Armenia

21. Forschungsinstitut für biologischen Landbau FiBL (2024). FiBL - Praxispublikationen. [online] Fibl. org. Available at: https://www.fibl.org/de/shop/1747-organic-world-2024.

22. GEORGIA CLIMATE RISK COUNTRY PROFILE. (n.d.). Available at: https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15836-WB_Georgia%20Country%20Profile-WEB.pdf.

23. GEORGIA'S UPDATED 2021 Nationally Determined Contribution (NDC). (2021) Available at: https://unfccc.int/sites/default/files/NDC/2022-06/NDC%20Georgia_ENG%20WEB-approved.pdf.

24. Government Decision No. N 219-Ն, Adopted on June 18, 2024, Republic of Armenia, https://www.arlis.am/DocumentView.aspx?docid=194277.

25. Government of Armenia, 2022 Official News: The first policy dialogue of "GREEN Armenia" joint platform took place Available at: https://www.gov.am/en/news/item/10142/.

26. Government of the Republic of Moldova Updated Nationally Determined Contribution of the Republic of Moldova. (n.d.). Available at: https://unfccc.int/sites/default/files/NDC/2022-06/MD_Updated_NDC_final_version_EN.pdf.

27. Grdn.ge. (2021). Improving Rural Life | Rural Development Policy. [online] Available at: https://grdn.ge/en/rural-development-policy/87 [Accessed 16 Apr. 2025].

28. Group, W.B. (2021). Armenian Grasslands – How Sustainable Livestock Practices Can Boost Incomes While Protecting the Environment. [online] World Bank. Available at: https://www.worldbank.org/en/news/feature/2021/05/12/armenian-grasslands-how-sustainable-livestock-practices-can-boost-incomes-while-protecting-the-environment?utm_source=chatgpt.com [Accessed 16 Apr. 2025].

29. Handbook for Saline soil management Eurasian Center for Food Security. (n.d.). Available at: https://openknowledge.fao.org/server/api/core/bitstreams/1b8b05e9-a7dc-4883-a631-f5299f273d4e/content.

30. HOW TO FIGHT AGAINST FOOD LOSS AND WASTE. Available at: https://openknowledge.fao.org/server/api/core/bitstreams/8e0d5794-11aa-4aae-bc3b-8ae6127f17b2/content? [Accessed 16 Apr. 2025].

31. https://www.armyupress.army.mil/Portals/7/military-review/Archives/English/Online-Exclusive/2023/Ferreira-Critelli/Ferreira-Food%20Resiliency%20in%20Moldova-UA.pdf [Accessed 16 Apr. 2025].

32. IBID

33. IFAD. (2023). FOOD RESILIENCY IN MOLDOVA ASSESSMENT AND LESSONS FROM UKRAINE

34. Leah, Tamara (2015). "Agriculture and Soils of the Republic of Moldova: Assessment, Findings, Solutions" (PDF). Agrarian Economy and Rural Development - Realities and Perspectives for Romania. (6th Edition of the International Symposium ed.): 330–336.

35. LONG-TERM LOW GREENHOUSE GAS EMISSION DEVELOPMENT STRATEGY OF THE REPUBLIC OF ARMENIA (UNTIL 2050). (n.d.). Available at: https://unfccc.int/sites/default/files/resource/UNDP%20LT_LEDS_ARMENIA.pdf.

36. Millns, J. (2013). FAO Regional Office for Europe and Central Asia Policy Studies on Rural Transition No. 2013-2 Agriculture and Rural Cooperation Examples from Armenia, Georgia and Moldova. [online] Available at: https://www.fao.org/4/ar424e/ar424e.pdf?utm_source=chatgpt.com [Accessed 16 Apr. 2025].

37. Ministry of Economy of the Republic of Armenia. The Strategy of the Main Directions Ensuring Economic Development in Agricultural Sector of the Republic of Armenia for 2020-2030, available at: https://mineconomy.am/en/page/1467.

38. National Greenhouse Gas Inventory Report of Armenia 1990-2019 Submission of the Ministry of Environment of the Republic of Armenia under United Nations Framework Convention on Climate Change, 2023, http://env.am/storage/files/nir-2019-eng.pdfseries/smallholders-and-family-farms-in-the-republic-of-moldova/ [Accessed 16 Apr. 2025].

39. NATIONAL PATHWAY FOR FOOD SYSTEMS TRANSFORMATION IN SUPPORT OF THE 2030 AGENDA THE REPUBLIC OF ARMENIA. (2020). Available at: https://summitdialogues.org/wp-content/uploads/2021/09/Armenia_National-Pathway_2021_En.pdf.

40. PHYSICAL MAP OF THE REPUBLIC OF

ARMENIA ФИЗИЧЕСКАЯ КАРТА РЕСПУБЛИКИ АРМЕНИЯ. (n.d.). Available at: https://www.armstat.am/file/doc/99541043.pdf [Accessed 16 Apr. 2025].

41. Rda.gov.ge. (2025). Plant The Future. [online] Available at: https://rda.gov.ge/en/programs/572746-plant-the-future/ca9c173d-887a-4ce8-a891-7988e9311c88 [Accessed 16 Apr. 2025].
42. REPUBLIC OF MOLDOVA THE NATIONAL CLIMATE CHANGE ADAPTATION PROGRAMME UNTIL 2030 (n.d) Available at: https://unfccc.int/sites/default/files/resource/NAP_Moldova_2024.pdf.
43. REU. (2022). Smallholders and family farms in the Republic of Moldova. [online] Available at: https://www.fao.org/europe/resources/empowering-smallholders-and-family-farms-series/smallholders-and-family-farms-in-the-republic-of-moldova/ [Accessed 16 Apr. 2025].
44. SEI. (n.d.). Green Agenda for Armenia, Georgia, Moldova and Ukraine. [online] Available at: https://www.sei.org/projects/green-agenda/ (accessed 16.4.25)
45. Statista. (2023). Moldova - export of commodities in 2023 | Statista. [online] Available at: https://www.statista.com/statistics/823004/export-of-commodities-from-moldova/ [Accessed 16 Apr. 2025].
46. Strategic Dialogue on the Future of EU Agriculture A shared prospect for farming and food in Europe. (n.d.). Available at: https://agriculture.ec.europa.eu/document/download/171329ff-0f50-4fa5-946f-aea11032172e_en?filename=strategic-dialogue-report-2024_en.pdf.
47. UNFCCC. (2024). REPUBLIC OF MOLDOVA: THE NATIONAL CLIMATE CHANGE ADAPTATION PROGRAMME UNTIL 2030. Available at: https://unfccc.int/sites/default/files/resource/NAP_Moldova_2024.pdf.
48. WFP. (2023) POVERTY AND FOOD SECURITY: A SNAPSHOT OF INTERLINKAGES. Available at: https://docs.wfp.org/api/documents/WFP-0000147506/download/?_ga=2.70116374.780460327.1736418546-317502233.1736418546.
49. Worldbank.org. (2025). 4[online] Available at: https://documents1.worldbank.org/curated/pt/778601467989461212/pdf/103997-REPF-Moldova-Trade-Study-Competitiveness-in-Moldovas-Agricultural-Sector.pdf? [Accessed 16 Apr. 2025].
50. Worldbank.org. (2025). Available at: https://documents1.worldbank.org/curated/pt/778601467989461212/pdf/103997-REPF-Moldova-Trade-Study-Competitiveness-in-Moldovas-Agricultural-Sector.pdf [Accessed 16 Apr. 2025].
51. ԶԲԱՂՎԱԾՈՒԹՅՈՒՆ-EMPLOYMENT 175. (n.d.). Available at: https://www.armstat.am/file/article/labmarket_2023_4.2.pdf [Accessed 16 Apr. 2025].

Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article

Received on 23.05.2025
Revised on 20.06.2025
Accepted on 12.09.2025