Food and Agriculture Organization of the United Nations

Promoting bioeconomy through agriculture practice

in Eastern Europe and Central Asia

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Contents

Boxes, figures and tables

Boxes

Figures

Tables

Abbreviations

BIOEAST	Central-Eastern European Initiative for biobased Agriculture, Aquaculture and Forestry
CIAT	International Center for Tropical Agriculture
CIS	Commonwealth of Independent States
CPF	Country Programming Framework
EECA	Eastern Europe and Central Asia
FAO	Food and Agriculture Organization of the United Nations
GDP	gross domestic product
GEF	Global Environment Facility
HNV	High Nature Value
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
OECD	Organisation for Economic Co-operation and Development
PEFC	Programme for the Endorsement of Forest Certification
SDGs	Sustainable Development Goals
SFM	sustainable forest management
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WFP	World Food Programme

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Background

The Food and Agriculture Organization of the United Nations (FAO) contributes to the promotion and implementation of sustainable and circular bioeconomy as a strategic priority[1] of the FAO Strategic Framework 2022–2031 towards more efficient, inclusive, resilient and sustainable agrifood systems for better production, better nutrition, a better environment and a better life, leaving no one behind.

At the regional level, the FAO Regional Office for Europe and Central Asia promotes this area through its Regional Priority to manage natural resources sustainably and preserve biodiversity in a changing climate. Various objectives of this Priority Programme aim at enhancing knowledge, policies and capacities in climate change and disaster risk reduction (C1), biodiversity, water and soil conservation (C2) and environmental sustainability (C3). They all indirectly contribute to the promotion and implementation of bioeconomy and more; in particular, C3 points towards building awareness of bioeconomy in the region, sustainably managing of agri-chemicals, and reducing soil and water pollution.

This baseline assessment report addresses the objectives of C3 and is a result of the work done under the FAO Regional Office for Europe and Central Asia in Budapest.

In line with the above-mentioned guiding objectives, this report provides a comprehensive overview of agricultural practices in Eastern Europe and Central Asia and identifies which sustainable agriculture approaches contribute to a transition towards a sustainable and circular bioeconomy. It also provides context for understanding the opportunities and limitations related to the growing interest in the implementation of sustainable and circular bioeconomy in various agricultural practices.

Food production is a resource- and energy-intensive activity with high environmental impacts associated with its production and waste disposal. Agrifood systems are highly dependent on land, water, raw materials and fossil-derived energy resources. At the same time, global food demand is growing due to numerous factors, including population growth, prosperity and expanding global trade networks. In this context, critical considerations of the sustainability of food supplies and the ability to meet future demand for food remain a question that needs to be analysed and addressed.

The bioeconomy considerations in this report include the agrifood systems link with the growing demand for raw materials and energy to provide food and other biomaterials and their impact on ecosystems. There is a need to understand how a sustainable and circular bioeconomy can address existing limitations to the sustainable provisioning of food in the context of pressures related to climate change, pollution and waste.

These factors create opportunities and challenges for the agriculture sector. Therefore, to further understand the sustainable and circular bioeconomy principles and to promote their implementation in the Eastern Europe and Central Asia region, this report analyses key benefits of a sustainable and circular bioeconomy and identifies several sustainable agriculture practices that build on the same principles and thus are already implementing bioeconomy-related technologies in the region. The analysis includes value chains and organizational factors as well as policy and institutional factors.

Methods and data sources

The evidence and information reviewed in this report come mainly from desk research, reviews of scientific literature, policy documents, United Nations agencies and the international cooperation information published on their websites, and subject matter knowledge. Additional information has been provided from industry and government information sources and from documented case studies and examples of good practice.

This report provides an overview of a sustainable and circular bioeconomy and recognizes its key benefits in promoting nature-based solutions and ecosystem restoration, reducing dependence on non-renewable materials, revitalizing rural areas, and increasing sustainable production and consumption. The report suggests that the implementation of sustainable agriculture approaches largely contributes to the

[1] The Programme Priority Area BE2, under the aspiration for a better environment, is titled "Bioeconomy for sustainable food and agriculture". The outcome statement is the following: "A bioeconomy that balances economic value and social welfare with environmental sustainability promoted through formulation and implementation of integrated evidence-based policies and practices in micro and macro environments, using technological, organizational and social innovations" (FAO, 2023a).

promotion and implementation of a sustainable and circular bioeconomy in agriculture, based on the logic that many principles on which sustainable agriculture approaches are based are common to a sustainable and circular bioeconomy.

A more extensive examination of the many aspects of bioeconomy and sustainable agriculture mentioned in this report could not be included due to the defined wide-ranging scope of the analysis: mapping and exploring the topic. Therefore, this report focuses mainly on the aspects of food production most relevant to the region. Other agricultural industries – such as the production of biofertilizers, bioplastics and bioenergy and the management of agricultural residues (underutilized resources and waste quantities) and the challenges and opportunities related to them – are only duly mentioned. Broader topics such as rural development, industrialization, income diversification, biotechnology and bioinformatics were not included in the analysis.

An opportunity exists for the preparation of separate studies addressing more detailed data and information on specific topics in a more exhaustive manner, depending on country needs. Therefore, the views presented in this report can be seen as an overview of the many options for follow-up research into the identified trends and areas at national and regional levels.

This report has been unable to present a comprehensive overview of all analysed aspects evenly in all subregions due to limited study resources and English information. Thus, the analysis shows some bias towards countries that have been documented more extensively in English-language scientific literature, and research seems to be more in-depth related to those countries that border the European Union and aim at accession. This may be the result of easier access to research funding and the better documentation of these subregions by the European Union itself.

In addition, the report has been unable to ensure statistical compatibility, as countries have various methods for defining statistical units, and the data provided in tables and figures presented in a comparative manner come from different sources. Nevertheless, the overview presented in this report is among the first attempts to share a perspective on important features of bioeconomy in agriculture in Eastern Europe, the Western Balkans, Central Asia and the Caucasus.

Geographical scope

Some geographical terms related to the analysed region are defined as follows:

Central Asia: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan

Central Asia and the South Caucasus: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan

Commonwealth of Independent States: a regional intergovernmental organization that includes Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Republic of Moldova, Russian Federation, Tajikistan and Uzbekistan

Eastern Europe: Belarus, Republic of Moldova and Ukraine. In principle, the Russian Federation is part of this subregion, but the country is often presented separately to highlight its weight in the subregion. Central and Eastern Europe members of the European Union have been sometimes described in this category but have not been considered the focus of this report.

EECA: Eastern Europe and Central Asia

European Union: the 27 countries of the European Union (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands [Kingdom of the], Poland, Portugal, Romania, Slovakia, Spain and Sweden).

Western Balkans: Albania, Bosnia and Herzegovina,[2] Kosovo,[3] Montenegro, North Macedonia and Serbia. Türkiye is part of this subregion, but the country is often presented separately to highlight its weight in the subregion.

South Caucasus: Armenia, Azerbaijan and Georgia

[2] The country of Bosnia and Herzegovina is comprised of two entities (the Federation of Bosnia and Herzegovina and Republika Srpska) that are occasionally addressed separately.

[3] References to Kosovo shall be understood to be in the context of Security Council resolution 1244 (1999).

1 Understanding bioeconomy and other sustainability concepts

1. Understanding bioeconomy and other sustainability concepts

Sustainable bioeconomy, low-carbon economy, circular economy and biobased economy are complementary concepts within the increasingly widespread trend of sustainability. These concepts, which can be used together to obviate the depletion of natural resources and maintain the planet's ecological balance, are designed to catalyse systemic change and answer economic, societal and environmental challenges faced by countries, economies and local communities, including increasing ecosystem pressure, climate change acceleration and pollution and waste generation (UNECE and FAO, forthcoming).

Although the terms "circular economy" and "bioeconomy" do not appear in the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs), circularity and bioeconomy principles can contribute to achieving several SDGs. A study by Schroeder, Anggraeni and Weber (2019) noted that the strongest relationship among bioeconomy, circular economy and the SDGs exists in SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Production and Consumption) and SDG 15 (Life on Land) (UNECE and FAO, 2021). Therefore, a transition towards a sustainable and circular bioeconomy is often perceived as a way to achieve an economic model that can contribute to the achievement of several SDGs; increase the sustainability of existing systems in the environmental, economic and social dimensions; and, in the long term, reduce worldwide dependence on non-renewable resources and greenhouse gas emissions.

The term "**bioeconomy**" refers to the "production, utilization, conservation and regeneration of biological resources, including related knowledge, science, technology and innovation, to provide sustainable

solutions (information, products, processes and services) within and across all economic sectors and enable a transformation to a sustainable economy" (International Advisory Council on Global Bioeconomy, 2020). It encompasses sectors such as agriculture, fisheries, food industry, forestry, wood manufacturing, and pulp and paper production. It also covers portions of the chemical, biotechnological and energy industries and the manufacturing of bio-based textiles. The vision of bioeconomy includes a system in which food, raw materials, chemicals and energy are based on renewable biological resources that enable the transition away from fossil-based inputs (UNECE and FAO, 2021). This report focuses mainly on the first stage (agricultural and forestry practices for the production and conservation of land-based biological resources for the bioeconomy).

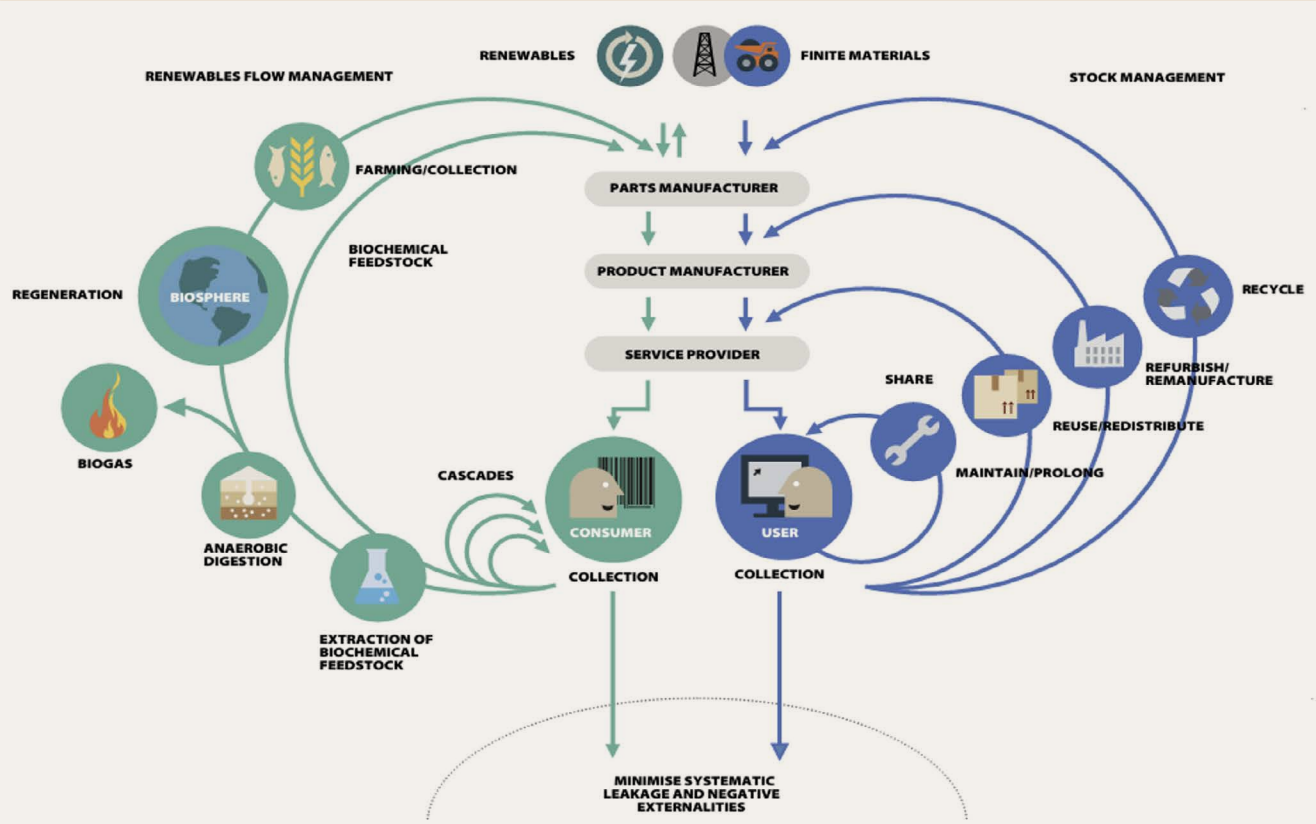
According to FAO, bioeconomy is "based on the sustainable and circular use of biological resources and processes to produce food, feed, bio-based products and services and has major untapped potential to support both climate change mitigation and adaptation" (FAO, 2022a, 2023b).

Although there is no commonly agreed definition of the term "**circular economy**", some definitions are used more often than others. The definition put forward by the Ellen MacArthur Foundation is most commonly used in the international context, describing a circular economy in the language of both material use and a systems perspective. It states that a circular economy is "based on three principles, driven by design: eliminate waste and pollution; circulate products and materials (at their highest value); and regenerate nature" (Ellen MacArthur Foundation, 2023).

The Ellen MacArthur Foundation model shown in Figure 1 distinguishes between technical cycles (shown in blue) and biological cycles (shown in green). Here, circularity involves both materials of biological origin (food and other biomass products, for example) that can return to the biosphere as feedstock and technical materials (such as plastics and metals) that can circulate in closed loops but cannot biodegrade. The model also makes the point that emissions from resource extraction and waste management decrease when resource extraction is reduced.

The synergy between the concepts of bioeconomy and circular economy is expressed by the term of "**circular bioeconomy**" (Figure 2), which can be defined as the sum

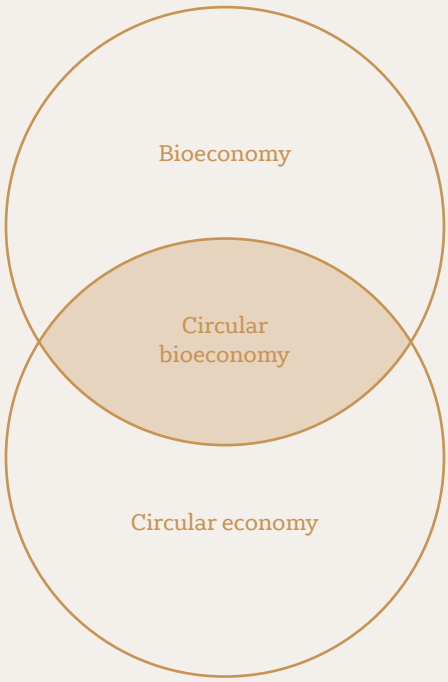
Figure 1. The Ellen MacArthur Foundation circular economy model



Source: Ellen MacArthur Foundation. 2023. What is a circular economy? In: Ellen MacArthur Foundation. [Cited 22 June 2023].

of all activities that transform biomass for use in different product streams, such as materials, chemicals, biofuels and food (UNECE and FAO, 2021).

Figure 2. Circular bioeconomy model



Source: UNECE & FAO. 2023. Reporting on Forests and Sustainable Forest Management in the Caucasus and Central Asia: Focus on Criteria and Indicators. Geneva Timber and Forest Study Papers 53. United Nations and FAO.

A sustainable and circular bioeconomy presents opportunities to improve climate change adaptation and resilience. This can be done through the use of biological resources to replace fossil-based materials as well as by improving of the efficiency of biomass already used. Extended biobased product lifetimes, cascading biomass use and the circularity of value chains contribute to reduced waste and pollution, ecosystem restoration, and soil nutrient and water retention. The resulting increased capacity for the capture and storage of atmospheric carbon in soils, forests, aquatic environments and bioproducts contributes to climate resilience and the overall regeneration of natural systems.

The transition to a sustainable and circular bioeconomy aligns with the climate action strategies from IPCC recommendations, NDCs and adaptation strategies. For example, it contributes to sustainable, balanced and healthy diets, carbon sequestration in agriculture and the reduction of methane and nitrous oxide emissions from fertilizers replaced by biofertilizers. Circularity and increased by-product use contribute to reductions in food loss and waste and enhancements to ecosystem restoration, afforestation and reforestation.

While a sustainable and circular bioeconomy offers myriad potential climate solutions, potential trade-offs from selecting one option over another (land use, food security, human health and safety, for example) should be considered carefully, and measures should be enacted to mitigate those trade-offs (FAO, 2022b).

Consequently, the promotion and implementation of a sustainable and circular bioeconomy (wherever technically possible, socially desirable and economically viable) is a way of reducing the consequences of climate change, land and natural resources depletion and biodiversity loss observed today (UNECE and FAO, forthcoming).

Several intergovernmental initiatives with a likely impact on the agriculture sector in Eastern Europe and Central Asia have been undertaken to enable the transition to a sustainable and circular bioeconomy. These include the European Union's Circular Economy Action Plan (European Commission, 2020a) and the Biodiversity Strategy for 2030 (European Commission, 2020b) within the European Green Deal (European Commission, 2019).

Of particular relevance to the existing intensive agriculture model – building on maximizing agricultural production on a given area of land with inputs such as labour, fertilizer and machinery – the promotion and implementation of a sustainable and circular bioeconomy contributes to the protection of biodiversity and all ecosystem functions. The International Union for Conservation of Nature (IUCN) recently reported on the underexplored relationship between the circular economy and biodiversity and concluded that the agriculture and forestry sectors have the potential to provide significant benefits to nature if they achieve greater circularity (Oberč *et al.*, 2022). Bioeconomy strategies contributing to the application of these benefits include further embedding nature within the core definitions of a circular bioeconomy, utilizing nature-based solutions for achieving desired environmental and economic outcomes, and expanding the natural capital concept and mechanisms for sustainable finance (Oberč *et al.*, 2022).

The United Nations also promotes a transition towards an economy based on renewable resources to contribute to the objectives of the Paris Agreement, the 2030 Agenda for Sustainable Development and the SDGs. When implemented with these prerogatives in mind, a sustainable and circular bioeconomy can represent an important opportunity for the agriculture sector, allowing for the regeneration of nature and biodiversity and consequently contributing to sustainable agrifood systems.

2 Key benefits of a sustainable and circular bioeconomy for agriculture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2. Key benefits of a sustainable and circular bioeconomy for agriculture

In general terms, bioeconomy provides many benefits that can help countries achieve aspirations and objectives (such as the SDGs) from many areas.[4] A sustainable and circular bioeconomy harnesses the responsible use of biomass through bioscience and biotechnology to address the needs of the growing global population while preserving our natural resources. It provides food, feed, wood products and furniture, paper, biobased textiles, biochemicals, bioplastics, biopharmaceuticals and bioenergy (FAO, 2023b). The use of biobased materials according to circularity principles contributes to saving energy and reducing emissions and the pollution of soil, air and water, thus helping prevent damage to natural ecosystems, the climate and agricultural biodiversity.

Most biomass in the world comes from agriculture and the forest sector. Building on the bioeconomy and circular economy principles presented in chapter 1 of this report, an economy that relies on a sustainable and circular use of biomass promotes nature-based solutions, biodiversity and the sustainable provision of ecosystem services.

The bioeconomy component in particular allows for reducing dependence on non-renewable materials (e.g. fossil energy, agrichemicals and plastics) in agriculture for the effective use of biobased materials according to the cascaded use of biomass, the reintegration of sustainable

[4] FAO's work on sustainability indicators provides technical assistance to countries and stakeholders on identifying indicators to measure benefits and progress towards a sustainable bioeconomy. Learn more at https://www.fao.org/documents/card/en/c/ca6048en.

farming practices and, ultimately, for the revitalization of rural areas. In food processing systems, it promotes the sustainable use of raw materials (including water and energy) and the reduction of food loss and food waste while ensuring food security and increasing safety. In the case of agriculture, some of the most important benefits that a bioeconomy strategy can bring to a country are outlined below.

2.1. Promotion of nature-based solutions and ecosystem restoration

The IUCN defines nature-based solutions as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (IUCN, 2016). The term has roots in work on biomimicry, a concept inspired by the copying of nature for industrial design. In the context of agriculture, nature-based solutions – which imply the effective management of natural resources critical to food production and the restoration of ecosystems – are fundamental to the sustainability of all agrifood value chains.

Indigenous Peoples, small-scale farmers and affiliated social movements comprehend nature-based solutions as those that reflect and reinforce autonomous ways of living and "emphasize regenerative and agroecological approaches that advance food sovereignty situated in economies of care" (Wynberg *et al.*, 2023). According to this interpretation of nature-based solutions, agroecology is a transformative factor of dominant intensive food systems and "seeks to reconnect biologically diverse farms with local and regional markets – linking producers and consumers in relations of proximity and solidarity within and between territories" (Wynberg *et al.*, 2023).

This transformative agroecology "promotes systemic changes based on the redesign and diversification of agroecosystems through ecologically and relationally based diverse cropping, agroforestry" and integrative systems that combine agriculture, sylviculture and pastures (Wynberg *et al.*, 2023). These practices, embraced by at least 75 percent of the world's 1.5 billion smallholders, family farmers and Indigenous Peoples in 2012 (Altieri and Nicholls, 2012; Wynberg *et al.*, 2023), imitate the structure and function of natural ecosystems and allow for the reduction of biodiversity loss and greenhouse gas emissions and for the storing in vegetation and soils of a large amount of carbon (Wynberg *et al.*, 2023).

Bioeconomy and circular economy concepts rely on the sustainable use and conservation of biological resources. Therefore, they promote sustainable farming practices that mitigate climate change, reduce emissions, increase the recycling (cascaded use and regeneration) of natural resources and prioritize local value chains.

Besides promoting ecosystem restoration and the retention in nutrients in soil and water, supporting indigenous and local livelihoods based on biological products and services, the concept of bioeconomy based on agriculture and forestry advances beyond the gradual greening of agrifood systems (FAO, 2022c). It promotes the use of biomass as an alternative to non-renewable materials in a number of innovative applications, including for industry. Therefore, the consideration of the impacts of an increased agriculture biomass supply for production of industrial biobased material, as well as the possible trade-offs between food and industrial production, are of critical importance. Both will need to be balanced with the productive capacities and ecological boundaries of natural systems.

Many of the global challenges impacting ecosystems – such as climate change, pollution, waste and the need to phase out non-renewable materials – create not only threats but also opportunities for the agriculture sector in the context of a transition to a sustainable and circular bioeconomy. Many existing practices protecting ecosystems' ecological boundaries and supporting the full capacity of agrifood systems contribute to a sustainable and circular bioeconomy. Consequently, they can benefit from increased focus and investment in bioeconomy to reinforce ecosystem restoration, address productivity on degraded lands, reduce the loss and waste of raw materials and agricultural produce, and contribute to greater material recovery for non-food applications, including for fertilizers and energy production.

One approach for achieving such positive outcomes is to embrace complexity by promoting the integration of various sectors to create effective solutions and to establish localized approaches that address inequalities and social and economic diversity (Grima *et al.*, 2023; UNECE and FAO, forthcoming). Addressing the aims of the United Nations Decade on Ecosystem Restoration, for example, can also achieve other global goals, such as the Paris Agreement (United Nations, 2015) on climate change, the Post-2020 Global Biodiversity Framework (UNEP, 2022), and land degradation neutrality targets (IUCN, 2015).

It has been agreed that promoting the sustainable use of biodiversity for food and agriculture is integral to efforts to increase agriculture's resilience to climate change, provide rural livelihood alternatives and diversify diets with nutritious foods (United Nations Economic Commission

for Latin America and the Caribbean *et al.*, 2021). This can be done by enhancing ecosystems services, rewarding agroecological practices, promoting crop rotation and sustainable soil and water management practices, and working to recover degraded soils – all aligned with the principles of a sustainable and circular bioeconomy and leading to the regeneration of natural systems (United Nations Economic Commission for Latin America and the Caribbean *et al.*, 2021).

In addition, the circularity aspect of bioeconomy aims at the efficient use of natural resources. In agriculture, it minimizes pollution, food loss and waste along the value chains while increasing production efficiency to reduce input requirements and opening up land for natural ecosystems (Forslund *et al.*, 2022). Regenerative agriculture can help reduce the impacts of agriculture and reverse biodiversity loss in and around cultivated areas via no-till agriculture, crop rotation, polyculture, precision agriculture, organic and agroecology principles and the use of biochar (Forslund *et al.*, 2022).

In forestry, circularity helps improve product lifetimes and encourages the reuse of products and materials, thus lowering the demand for new timber. This diminished demand frees up the land for nature, instead keeping it set aside for forestry. New wood can be extracted from forests managed according to the regenerative principles of sustainable forest management to secure a fuller range of ecosystem services, including by retaining trees that are old, decaying or dead, by keeping native species, and by incorporating various age classes and species – efforts that help ensure co-benefits from forest land while also improving biodiversity outcomes.

In forestry, circularity reduces the demand for new timber by extending product lifetimes. The benefits of increased circularity are not limited to the diversion of waste from environmentally damaging disposal options. Circularity also contributes to the broadening of the raw material base for all forest-based industries; not only are more renewable raw materials available for forest-based products, but also dependence is reduced on virgin wood and fibres. On one hand, virgin material not used in production can be directed to other applications; on the other hand, lower timber demand reduces the land needed for forestry, freeing up land for other ecosystem services. This is done with the recognition that the long-term sustainability of the supply depends on the implementation of sustainable forest management principles to ensure that forest can fulfil its function today and in the future.

In summary, the principles of a sustainable and circular bioeconomy are aligned with various nature-based solutions and provide multiple benefits for the restoration of ecosystems and biodiversity, including through climate change mitigation and reductions in greenhouse gas emissions. However, its implementation requires innovation throughout the entire economy and production systems, beyond agriculture.

2.2. Reducing dependence on non-renewable materials and revitalization of rural areas

Agriculture uses fossil fuels in various ways. Fossil fuels are used to operate farm machinery and vehicles and produce electricity and heat for drying grain and growing glasshouse vegetables. They also often are seen in fertilizers, pesticides and other agrichemical inputs for food production.

Besides the large amounts of fossil fuels required to power farming machinery and provide convenient temperature and humidity conditions for plant growing and animal breeding, other non-renewable materials are largely used in food processing systems. It starts with the transformation of fresh agricultural produce into edible, safe and nutritious food ingredients using refrigeration, transportation, packaging and retail merchandizing and conditioning.

Further, chemical fertilizers require significant amounts of energy, using 1.8 percent of the world's supply, and the production process runs at high temperatures (500 °C) and pressures (Energy & Climate Intelligence Unit, 2022). Fertilizer production also accounts for around 1.8 percent of global greenhouse gases and is one of the four major industries – the others being cement, steel and ethylene – contributing to climate change (Energy & Climate Intelligence Unit, 2022).

Also, plastics are used at various stages of food production, from seedling trays and irrigation tubing to insecticide containers and livestock feed bags (FAO, 2024a). The excessive use of plastics – single-use plastics in particular – has led to environmental impacts that threaten soil condition, water quality and human health.

A FAO report assessed the use of plastics in agricultural value chains (FAO, 2021). In 2019, according to the report, 12.5 million tonnes of plastic products were used in plant and animal production and 37.3 million tonnes in food packaging. According to the report, only most of these plastics are buried or disposed of in landfills, with hardly any being collected and recycled. This negatively impacts ecosystems, biodiversity and human health.

Worse, mulching films – commonly used by farmers as soil cover to help regulate temperatures, conserve moisture and suppress weed growth – can be difficult to retrieve after harvesting, with plastic residues often left in the soil (FAO, 2023c).

These abandoned plastics degrade into smaller particles called microplastics that can accumulate in the soil and harm earthworms, mycorrhizal fungi and other beneficial organisms essential for healthy soils and plant growth and leading to erosion, reduced water infiltration and decreased microbial activity (FAO, 2023c). Microplastics also can transfer to and accumulate in food chains, threatening food safety and human health and necessitating the promotion of more responsible models in agriculture (FAO, 2023c).

Sustainable and circular bioeconomy offers promising solutions to decrease or eliminate the use of plastics in agriculture, including removing plastics in some applications (by employing cover crops and plant residues such as straw instead of plastic mulches, for example) and using bioplastics based on plants, algae, fungi and bacteria instead (FAO, 2023c). These bioplastics, which are fully or partially made from biological resources, are less toxic than their petroleum-based equivalents and have lower carbon and environmental footprints. However, bioplastics do present issues with cost, waste separation, biodegradability and compostability and thus are better used in places where it is impossible to avoid plastics in the first place or where they cannot easily be removed after use or replaced with other materials that are reusable or more durable (FAO, 2023c).

Another bioeconomy application is bioremediation, which either can occur naturally or can be introduced to clean polluted sites via microorganisms that break down environmental pollutants. The process uses biological microorganisms to break down hazardous materials and substances into less toxic or non-toxic products. According to some studies, there are plants and microorganisms that can clean up after oil spills and remove micro- or nanoplastics from soil and water.

Given that much of chemical pollution and plastic waste can be attributed to agrifood systems, bioeconomy is increasingly providing solutions for reducing the use of non-renewable agrichemicals and plastics to decrease soil and water pollution.

In terms of reducing dependence on non-renewable materials, the use of crop residues in different applications is considered a potential strategy to mitigate greenhouse gas emissions and reduce waste. Although crop residues are a by-product of grain production – left in the field after grain harvest – they have great potential. Research has shown the nutrient, erosion and soil carbon benefits of common agricultural waste – crop residues such as corn stover (leftover corn stalks, leaves, husks and cobs), wheat straw, oat straw, barley straw, sorghum stubble and rice straw – that should not be overlooked.

In addition, bioethanol is a renewable liquid biofuel produced from the fermentation of the sugar and starch components of natural materials – usually plant derivatives or agricultural wastes. In agriculture, ethanol can replace fossil fuels by itself or mixed into fuel blends for vehicles. It can also provide a cleaner alternative to household cooking, reducing indoor pollution. A significant benefit of using bioethanol and other liquid biofuels is that they are more sustainable and less harmful to the climate than their fossil fuel counterparts.

However, as general rule, two major considerations need to be taken into account in each case. First, agriculture residues should be used according to the principles of cascaded use (i.e. prioritize more value-added applications). Second, agriculture residues should be promoted as primary feedstocks rather than as biofuel-dedicated crops. Many biofuels use the same feedstock as crops used for human consumption, either directly or indirectly in the form of animal feed. This direct competition for land can result in more land being devoted to agriculture, resulting in more pollution and higher food prices (United States Environmental Protection Agency, 2024). On the other hand, farm-level biogas production from manure is an excellent example of a sustainable bioenergy system based on circularity principles.

2.3. Increasing sustainable production, consumption and food safety

In order to increase their productions and incomes, many agricultural producers have overexploited agricultural ecosystems, reducing or degrading their capacities to regenerate. In some cases, this has also led to the rural exodus phenomena. Therefore, it is important to note that in addition to ecological benefits, the implementation of sustainable and circular bioeconomy principles is a vital enabler of sustainable production and consumption patterns in agricultural practice.

The production and consumption of food has significant impacts on the natural environment, climate change, water consumption and the loss of biodiversity. In this context, the benefits of the circular bioeconomy rely upon the sustainable use of natural resources and the increased recovery of materials and by-products. This can be done

through an enhancement in the number of cycles through which natural resources remain in use and the cascaded use of agricultural residues from production processes. The latter can be effectively recovered and utilized as raw material for non-food applications, including for feed, fertilizers and bioenergy production. In addition to that, agricultural residues also can be used outside the agriculture sector and contribute to sustainability and circularity in other sectors of the economy, for instance by conversion into innovative applications for the production of specialized papers, textiles and bioplastics.

Besides sustainable production and consumption patterns, bioeconomy also addresses the fundamental challenge of reorienting the relationship between food production and nature in order to increase food safety and reduce the use of non-renewable materials harmful to both the environment and human health. It integrates, in a natural manner, sustainable agricultural practices in the form of organic agriculture, which makes available to consumers biofood products that are healthier and more natural than products obtained by intensive agriculture.

According to a 2020 report on the relationship between bioeconomy and food safety and security (Canja, Boeriu and Mazarel, 2020):

> The development of intensive agriculture methods cannot be separated from the major problems, among which the most important are the energy crisis, climate change and environment depletion. Organic agriculture addresses these challenges by using biological resources in soils, seas and forests. It also optimizes the use of organic residues to regenerate biological systems, providing raw materials for food, feed, and industrial and energy production. Consequently, organic agriculture is a convincing alternative to modern intensive farming and plays an important role in providing healthy food for the population, protecting the environment, and preserving the natural balance.

As bioeconomy emphasizes the necessity of food safety in close connection with the health and security of food resources, biotechnology development is another major global driver of bioeconomy, adding value to the agrifood industry while ensuring food safety and security (FAO, 2023d). Biotechnology has a major stake in the future of food safety and environmental stewardship. Beyond the development of alternative proteins, microbiome science is an exciting sector within the bioeconomy, enabled through biotechnology and with untapped potential for improving soil, plant, animal and human health (FAO, 2023d). It exemplifies the FAO One Health approach (FAO, 2023e)

The goal of microbiome science is to sustainably balance and optimize people, animal and ecosystem health. Among the extant knowledge gaps in this field are those related to the effects of residues from agricultural plastics, veterinary drugs, pesticides and fertilizers on the microbiome and overall ecosystem health. In this regard, FAO recently released a review of the literature assessing the scientific evidence regarding the impacts of microplastics, pesticide residues and veterinary drugs on the gut microbiome and their potential connections to adverse health effects (FAO, 2023f, 2023g, 2023h). Microbiome research and innovation are key to achieving One Health and the SDGs (FAO, 2023d).

Overall, there is growing consensus that a sustainable and circular bioeconomy can address challenges related to the existing unsustainable production and consumption patterns in agriculture and to food safety through a more holistic approach – an approach that considers all interrelated elements and actors in the agrifood systems, from production to consumption and beyond. In order to ensure food safety in an environmentally sustainable manner, sustainable agriculture practices need to be promoted to help farmers, fishers and other food chain operators lower their dependence on pesticides and antimicrobials, limit excess fertilization, improve animal welfare, increase organic agriculture and reverse biodiversity loss. On the consumer side, the promotion of organic produce and the elimination of food waste will play a major role.

To achieve these objectives, a sustainable and circular bioeconomy involves a variety of activities that need to be coordinated in a holistic manner along agrifood value chains: precision farming, climate-smart agriculture, sustainable food production and consumption, alternative production technologies and analyses of their safety and life-cycles, voluntary and market-based tools to promote the use of products that are better for the environment, circularity or cascading approaches, eco-innovation such as biomimicry, and the development of markets for secondary raw materials. All of these will serve a paradigm shift of economic growth and intensive agriculture models towards sustainable systems.

The transition to such sustainable agrifood systems needs to be accelerated and facilitated with the participation of all stakeholders to maximize environmental, health and social benefits, with the aim of ensuring fair livelihoods for primary producers, strengthening consumer protection and increasing the resilience of agrifood systems to disasters and emergencies, such as the COVID-19 pandemic.

3 Agriculture in Eastern Europe and Central Asia


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3. Agriculture in Eastern Europe and Central Asia

The countries of Eastern Europe and Central Asia differ widely in their economic development and agricultural systems. Most countries within the region have experienced major economic reforms in the past three decades and were greatly affected by the economic and institutional transformations of the 1990s and 2000s. Among them are substantial differences in the degrees of prior market development and the levels of government commitment; therefore, the rates of transition from planned to market economies have varied greatly (Burkitbayeva, Liefert and Swinnen, 2021). Ultimately, the pace of political reforms and the proximity to the European Union have determined subregions with significant differences in the progress and outcome of these reforms, with the first being Central and Southeastern Europe and the second being the Commonwealth of Independent States (CIS).

Agrifood systems in the region continue to adjust to the effects of globalization and deepening trade integration, both politically and economically. Europe and Central Asia is increasingly engaged in global agrifood trade and the international supply of agricultural commodities and food products. However, most countries in the region have not yet reached their full trade potential and must increase their efforts to implement trade agreements, diversify exports and align regulations with international standards (FAO, 2018). The transition to a sustainable and circular bioeconomy can enhance these efforts and improve the region's competitiveness in global markets.

Box 1. Natural conditions and major farming systems in the region (part 1/2)

Significant differences exist in agroecological conditions and, consequently, the agricultural activities and farming methods in the region. They vary from one of the world's most fertile regions in Southeast Europe to poor, water-scarce regions of Central Asia. This diversity – along with the heterogeneity of political, economic and social conditions in the region – has resulted in the development of a wide variety of farming systems.

The report Farming Systems and Poverty 2001: Improving Farmers' Livelihoods in a Changing World, which mapped major farming systems, is used in this box to explain the agricultural practices most relevant to the implementation of a sustainable and circular bioeconomy in the region.

Irrigated farming system

This system occurs in scattered areas of the southern, central and eastern parts of the region. Medium-to-large irrigated farms of up to 500 ha in size are found throughout the CIS countries and some areas of Romania. All have been affected by the increase in previously subsidized energy prices, as well as the loss of traditional markets for high-value crops such as fruits and vegetables. In the warmer areas of Uzbekistan, Turkmenistan and southwestern Kazakhstan, irrigation is largely used for cotton cultivation, with some rice being grown. With readily available markets, cotton-producing irrigation systems can be maintained, and cotton exports provide capital to farming economies. However, the overuse of water has caused extensive environmental degradation – including the drying out of the Aral Sea, the desertification of the surrounding area and widespread salinization.

Smaller-scale irrigated systems are typical of the Caucasus, the Western Balkans and Türkiye, but they are found in other countries as well. The average farm is in the range of 2 ha to 10 ha in size, owned and operated by a single family, and focused on the production of such crops as wheat, barley, cotton, tobacco, fruits and vegetables. Depending on family size and irrigated area, the farms can provide part- or full-time employment and produce marketable surpluses that are a major source of cash income.

Mixed farming system

This system is widespread in Central European countries within the moist, subhumid agroecological zone. Conditions for agricultural production vary considerably. Most of the crop area is located within intermontane lowland plains and is largely dedicated to wheat, maize, oil crops and barley, combined with smaller areas of fruits and vegetables. Livestock production is dominated by dairy and beef cattle and pigs. Associated hill and mountain areas are used for grazing and forestry.

Forest-based livestock farming system

This system is located in the northwest of the region in a moist, subhumid agroecological zone. Large farms, with holding sizes from 500 ha to 2 000 ha, are typical in Belarus and the northwest part of the Russian Federation. They are characterized by cooperative or corporate ownership, with production focused on fodder, hay, cereals, industrial crops and potatoes. Smaller holdings predominate in the Baltic states.

Horticulture mixed farming system

This system is typical of the southern Balkans, northern Türkiye and the Caucasus. The system has an agricultural population scattered primarily on sloping lands in the dry, subhumid agroecological zone characterized by a Mediterranean climate. The average farm is small and has a diversified production pattern, including wheat, maize, oil crops, fruits and vegetables, combined with cattle, sheep and goats.

The cultivation of fruits, nuts and vegetables, partly irrigated or produced in greenhouses or other protective structures, contributes to the value of crop production and household income. In the southern Balkans and the Caucasus, the farms and household plots resulting from privatization are family owned and frequently operated part time, with off-farm employment being common. The production of cereals and oil crops is for subsistence, in many cases, while marketable surpluses of fruits, vegetables and animal products are a major source of cash income.

Large-scale cereal–vegetable farming system

This system is typical of Ukraine, the southwest part of the Russian Federation and the Republic of Moldova. It is principally located in the moist, subhumid agroecological zone. Although the process of land privatization started in the 1990s, most of the farms remain large, ranging from 500 ha to 4 000 ha. The dominant ownership is cooperative or corporate, although private ownership is gradually gaining in importance. Rural populations represent a relatively large proportion of total population in this system and are declining only slowly.

Small-scale cereal–livestock farming system

This system is located in the semi-arid and dry subhumid and mountainous zones of Türkiye, with a growing period of less than 180 days. The land is cultivated by owner-managers or tenants. Private ownership has led to better farm management, intensification of labour use and diversification of production. However, many farms created by land distribution are very small, and some are hardly viable. Tenancy arrangements foster neither short-

Source: Dixon, J., Gulliver, A. & Gibbon, D. 2001. Farming Systems and Poverty 2001: Improving Farmers' Livelihoods in a Changing World. Rome and Washington, D.C., FAO and the World Bank.

Box 1. Natural conditions and major farming systems in the region (part 2/2)

term productivity nor long-term resource management. The main cereals are wheat and barley.

The yields and production of these rainfed crops vary considerably from year to year. Nevertheless, small or subsistence farmers within this system produce most of Türkiye's grain. Farm households consume about half of the wheat crop, with the other half marketed through commercial channels. Barley is almost exclusively used for animal feed or for export. Sheep and goats are the main livestock and play an important role in the system, but some cattle are also raised. There is some crop–livestock integration arising from traditional practices. Animals forage on crop stubble, weeds and grass on fallow land and uncultivable grazing areas. The overgrazing of grasslands, wastelands, forests and mountain meadows is common, with substantial environmental damage and low livestock productivity.

Extensive cereal–livestock farming system

This system is found throughout the semi-arid agroecological zone of the Russian Federation and northern Kazakhstan but also covers substantial areas in southern Kazakhstan, Turkmenistan and Uzbekistan. This is the domain of the steppe, which traditionally was used by transhumant herders until it was converted to cropping in the past few decades. The major outputs are wheat, hay and other fodder crops, combined with cattle and sheep. In the drier parts, with an annual rainfall of just 200 mm to 300 mm, the land is fallowed every two years. Ownership patterns vary from collective and state farms to cooperative or corporate ownership, with an increasing number of smaller family farms.

Pastoral farming system

This system is typical of much of southeastern Central Asia. Rural populations constitute a large proportion of the total population. Most of the pastures are in high mountainous areas or adjacent dry zones. Principal livestock species are sheep, with some cattle. Although the dominant activity is pastoralism, mountain valleys with slightly more favourable conditions are used for the cultivation of cereals, fodder crops and potatoes for subsistence. Herd management is based on spring and autumn grazing of communal pastures close to the villages. Summer grazing is on distant – and often heavily overgrazed – mountain pastures, while stall-feeding predominates in winter. Due to excessive animal populations, poor pasture management and overgrazing, the deterioration of natural vegetation and soil erosion are important issues. Wool production, which was a major output during the Soviet era, has fallen dramatically since the early 1990s, while meat output has increased as farmers have reverted to the sturdy and traditional meat breeds.

Sparse (cold) farming system

This system is found in the Russian Federation, north of the extensive cereal–livestock system, with land cleared for cropping interspersed in the tundra and the taiga forests, mainly in the European part of the country. The taiga remains the world's largest timber reserve. Natural conditions allow only for limited cultivation of rye and oats, as well as of potatoes and some vegetables, supplemented by pig raising. Farming is constrained by the short growing season, very low temperatures and poor soils. The dominant soil type is the podzol, characterized by intense nutrient leaching and acidity. Various groups of Indigenous Peoples, including the Yakut and the Evenk, practice reindeer pastoralism there.

Sparse (arid) farming system

The system is found to the south of the Eurasian steppe, in the southern part of Central Asia, including most of Turkmenistan and Uzbekistan, as well as a large strip of Kazakhstan. The driest parts are used only by nomads. In somewhat more favourable areas, extensive cereal cultivation, complemented by sheep raising, is practised, typically with a harvest every two years followed by a cultivated fallow to conserve soil moisture. Large-scale farms are the dominant production structure. They are heavily indebted and, unless irrigated, not viable now that most subsidies have been withdrawn. There is limited potential for development except where irrigation can be used, but existing water resources are already overexploited. In the most arid parts, reversion to some form of pastoralism is expected.

Urban-based farming system

This system occurs within and surrounding the cities of the region. Although there are no statistical data available on urban agriculture, it is clear that its importance is growing. The land used for farming is mostly private residential land but may also include publicly owned land allocated to local populations. Urban farming produces mainly vegetables, in particular leafy vegetables, but small livestock also are an important component. Like the farmers on small household plots in rural areas, many of the urban farmers produce for their own consumption, with occasional surpluses sold in local markets.

Source: Dixon, J., Gulliver, A. & Gibbon, D. 2001. Farming Systems and Poverty 2001: Improving Farmers' Livelihoods in a Changing World. Rome and Washington, D.C., FAO and the World Bank.

3.1. Subregional overview of production trends

The Eastern Europe, Central Asia and South Caucasus subregions account for an important part of the world's food production, particularly in the dairy and grain sector. Together, they produce 12 percent of the world's milk and 9 percent of the world's grains (including 18 percent of the world's wheat). The region's share in the global agricultural market is 8 percent of the import and 9 percent of the export; 15 percent of the global grain export and, remarkably, 22 percent of the global wheat export come from EECA countries, a sector largely dominated by Kazakhstan, the Russian Federation and Ukraine (Burkitbayeva, Liefert and Swinnen, 2021).

In the aftermath of the Soviet Union collapse, the region, which was previously largely managed as one country, had to undergo a harsh transition towards compartmentalized agricultural systems. This resulted in the loss of about 50–60 million ha of agricultural land during the early 1990s. The following restructuring of the national systems from socialist planned economies to market economies produced varied results in different countries. Subregions such as the South Caucasus and the Western Balkans managed to start their recovery towards pre-collapse productivity already by 1993, whereas the Baltic countries, the Russian Federation and Ukraine kept losing productivity until the turn of the century. Central Asia started recovering by 1996 and managed to improve its productivity, registering a 35 percent growth between 1990 and 2016. On the contrary, Eastern Europe countries registered a 25 percent contraction over the same period. The livestock sector reached output comparable with 1992–1994 by the 2010s.

Some countries such as Bulgaria, Czechia, Hungary, Slovakia, Ukraine and, partly, Kazakhstan recovered productivity by intensifying the activities and raising labour productivity. Other countries – namely Albania, Georgia, Kyrgyzstan and Tajikistan – focused on smallholder agriculture and relied on the improvement of land productivity. Countries such as Armenia, Poland and Romania adopted a hybrid approach.

In most of the Central Asia and South Caucasus countries, medium or large farms are predominant. Smallholders (i.e. farms with less than 2 ha) are the vast majority only in Azerbaijan, where they provide 90 percent of the gross agricultural output, but they are also relevant in Kazakhstan, Kyrgyzstan, the Russian Federation, Tajikistan, and Ukraine (where 35–50 percent of gross agricultural output is provided by smallholders). Smallholder agriculture is predominant in the Western Balkans, where the average farm size is between 2 ha and 3 ha only.

Smallholders are usually associated with lower labour productivity (in terms of income per worker) but also higher land productivity. Integrated systems can provide biomass for a range of products and therefore contribute to the bioeconomy. Nonetheless, their number declined a sharp 60 percent in Eastern Europe between 2000 and 2016, most likely due to competition with other economic actors in the sector, declining food prices, and more demanding regulations and quality standards adopted in the agrifood systems (Burkitbayeva, Liefert and Swinnen, 2021).

Central Asia and the South Caucasus

The area of Central Asia and the South Caucasus encompasses many different climate and terrain types, including desert and steep mountain areas, where agricultural activities are very limited (see the section on physical conditions and major farming systems in the region). Consequently, the percentage of arable land in the countries of Central Asia is relatively low. As of 2016, it was about 25 percent in Azerbaijan, 15 percent in Armenia, around 10 percent in Kazakhstan and Uzbekistan, and 5 percent in Georgia, Kyrgyzstan, Turkmenistan and Tajikistan. Yearly rainfall precipitation in the subregion is relatively low, with an average of 273 mm, but rainfall varies a lot among territories and countries, from 161 mm in arid Turkmenistan to 691 mm in wet Tajikistan (Asian Development Bank, 2019). South Caucasus countries are less prone to water stress. Georgia is the wettest country, with 955 mm of precipitation annually. Armenia has 527 mm of precipitation per year, and Azerbaijan has 444 mm (UNDP, 2011).

The former Soviet countries found themselves deeply affected by the fall of the Soviet Union in the early 1990s, as previously farmland was owned and managed entirely by the state. Following their independence, each country had to reorganize its agricultural system in terms of land tenure, market structure, price policies and access to inputs and labour.

The countries of the South Caucasus implemented the private ownership of land fairly quickly, as did many Eastern European countries. Kyrgyzstan also introduced private ownership in 1998. In Turkmenistan, land can be privately owned but cannot be sold, exchanged or gifted. Kazakhstan formally allows private land ownership to commercial farmers, but the regulatory environment is still very weak, and the vast majority of land is leased from the state on long-term contracts. In Tajikistan and

Uzbekistan, land is still exclusively owned by the state, although farmers can claim user rights.

Countries where land ownership is restricted tend to manage production from the top down in units organized in so-called "agricultural enterprises" that recall Soviet collective establishments. Countries that implemented private land ownership gradually shifted towards individual farming. Tajikistan is an exception, as most arable land is managed individually (65 percent) despite state ownership. More generally, a mix of the two approaches is the most common. Apart from the agricultural enterprises and the individual farms, farmland is composed of household plots, a legacy of the Soviet era that plays a key role in food security throughout Central Asia and the South Caucasus. Despite the relatively low extension, household plots are also quantitatively relevant in terms of livestock and horticulture production.

Wheat is the most farmed crop in the subregion. Countries that dedicate the highest arable land share to its cultivation are Tajikistan (65.4 percent), followed by Kazakhstan (59.7 percent), Uzbekistan (53.9 percent), Kyrgyzstan (32.7 percent) and Turkmenistan (20.4 percent) (FAO, 2024b). Kazakhstan is the main local exporter, providing almost 100 percent of the wheat imports of all the other Central Asian countries. Wheat production in the region peaked in the late 1990s and has gradually declined ever since.

In 2019, Kazakhstan ranked fourteenth on the list of largest wheat producers worldwide, with around 14.3 million tonnes produced. Other countries in the region ranked as follows: Ukraine was eighth, with almost 24.9 million tonnes, and Poland was fifteenth, with almost 12.5 million tonnes. Romania was nineteenth, with 6.8 million tonnes, and Uzbekistan was twenty-third, with 6.2 million tonnes (FAO, 2024b). Wheat exported outside the region is shipped from Black Sea ports and faces high costs and strict competition with Russian exports. Wheat consumption in the region is relatively high; all the countries acquire more than half of their daily calories from wheat products, with the exception of Kazakhstan, where meat protein consumption has overcome wheat intake.

Livestock suffered greatly after the fragmentation that followed the Soviet Union collapse; many breeds have been lost due to indiscriminate breeding and lack of regulations.

Horticulture is dominated by small-scale producers. Uzbekistan is the most prominent local producer of horticulture products thanks to the fertility of the Fergana Valley. The southern parts of Central Asia and the Caucasus have relatively mild climates that allow for a focus on high-value products, such as fruit and nuts (e.g. apples, pomegranates, olives and hazelnuts in Azerbaijan). Fruit and vegetable production has increased in all countries of the subregion except Georgia, where it has been stagnating since the late 2000s.

Several economic integration initiatives have developed in the subregion in recent decades, facilitated by the creation of a common market area among Central Asian countries in 1993. In 2014, the Eurasian Economic Union was established; it originally comprised Belarus, Kazakhstan and the Russian Federation. Although Kyrgyzstan is in the accession process, it can already benefit from preferential tariff rates and labour market access. As of 2018, the Central Asian countries exchange more than 50 percent of their agricultural production with the neighbouring countries and with the Russian Federation. Lately, China has overcome the Russian Federation as the main export partner of the region after the development of the Belt and Road Initiative, which expanded the rail connectivity among China, Kazakhstan and Kyrgyzstan. Water is not an abundant resource in the subregion, and the Central Asian countries are strongly interdependent in water management. The upstream countries Kyrgyzstan and Tajikistan prioritize retaining water in summer to stock energy, while the downstream countries need more water for irrigation.

The development of national agricultural policies in the subregion prioritizes agricultural diversification, the rehabilitation of irrigation systems, a targeted use of subsidies, and the implementation of land-use policies instead of the previous focus on food security, staple food and traditional crops. The diversification was made possible thanks to the expansion of horticulture in the most fertile areas of Azerbaijan, southern Kazakhstan, Kyrgyzstan and Uzbekistan. National agricultural policies also address the transformation of food processing capacities towards added-value products, the expansion of trade, and a reduction in the import of basic foodstuffs. Land degradation processes and inefficient use of water resources are among the most common challenges identified in country strategy documents (Asian Development Bank, 2019).

According to an overview of agriculture research activities, the Central Asia and the South Caucasus subregion is the second largest provider of pastoralism- and nomadism-related research articles (providing 15 percent of the total research efforts in the EECA region between 1992 and 2022, surpassed only by the Mediterranean area, which provided 51 percent). Consequently, it can be concluded that pastoralism and nomadism are important in the local agricultural systems (Bàrberi *et al.*, 2022).

Eastern Europe

The process of economic transformation in the 1990s affected land privatization differently in various countries of Eastern Europe. Belarus had privatized as little as 0.4 percent of its farmland as of 2019, keeping an agricultural system largely dominated by big agricultural enterprises, with just 2 percent of the land managed by individual farmers (Garazha *et al.*, 2023). Bulgaria, on the contrary, has assigned 98 percent of the country farmland to private owners, and production is dominated by large industrial farms and a small percentage of organic producers (Garazha *et al.*, 2023). Hungary has privatized 86 percent of its farmland, and the Republic of Moldova, Romania and Ukraine have allowed private ownership, distributing most of their farmland to farmers (Garazha *et al.*, 2023). Slovakia has returned farmland to the owners who held the land before the collectivization process during the socialistic system or to their heirs, which has resulted in a high fragmentation of land ownership (Garazha *et al.*, 2023). Although the average agriculture innovation level in the subregion is considered low, organic production in Eastern Europe and the Russian Federation is on the rise, with growth of 59 percent between 2009 (1 660 780 ha) and 2018 (2 795 090 ha) (Garazha *et al.*, 2023).

The Eastern Europe subregion is also largely dominated by the production of grains – mostly wheat, corn and barley. Belarus dedicated 91 percent of its arable land to various cereal productions. Ukraine dedicated 53 percent (plus 24 percent dedicated to sunflowers and 6 percent to soy), just like the Republic of Moldova (which dedicated 22 percent of its arable land to sunflowers and 7 percent to grapes). Potatoes also play an important role in Belarus (8 percent of arable land) and Ukraine (5 percent).

Western Balkans

According to an Organisation for Economic Co-operation and Development review (OECD, 2018), the agricultural economies of the non-European Union countries in the Western Balkans (Albania, Bosnia and Herzegovina, Kosovo, North Macedonia, Montenegro and Serbia) are well developed on agrifood system regulation, although they are, to a certain extent, marked by public subsidies. Other than Kosovo, countries and territories in the subregion have developed national strategies for agricultural and rural development. Most of them are aligned with the European Union's Common Agriculture Policy, with the aim to pursue the goal of European Union membership. This particularly results in stricter regulations on the use of natural resources to meet the requirements of the European Union directives on water, nitrates and wild habitats.

Average agricultural production in the subregion did not change significantly from 2000 to 2016. The agrifood sector accounts, on average, for 14 percent of total export and 16 percent of total import. Serbia is the only net exporter of agricultural produce, with 40 percent export growth from 2010 to 2016. In North Macedonia, export volume is at least half the import volume. The main trade partners for the countries in the subregion are the European Union and the other Balkan countries.

The average rural population share in non-European Union Western Balkans countries is much higher than the OECD (20 percent) and the European Union (25 percent), ranging between 40 percent and 45 percent for most countries. Bosnia and Herzegovina stands out with a 60 percent share of the rural population. The average farm size in Albania, Bosnia and Herzegovina and North Macedonia is around 1.5–2 ha. The figures are higher in Kosovo (3.2 ha), Serbia (5.4 ha) and Montenegro (5.8 ha). Smallholders account for 88 percent of farms, operating on 44 percent of the total agricultural land. In Serbia, more than half of the agricultural land is managed by farms larger than 10 ha. In general, in all Western Balkan countries, most of farms are managed as family businesses, regardless of their size.

Grain production (mostly corn and wheat, and secondarily barley) is a priority in the Western Balkans. Serbia dedicates 68 percent of its agricultural land to these crops, plus 9 percent to sunflowers and 8 percent to soy. Bosnia and Herzegovina dedicates 53 percent of its agricultural land to wheat, and North Macedonia 45 percent. North Macedonia also is the most diversified producer, with 14 different crops occupying at least 2 percent of the farmland. Potato and fruit are important secondary crops. Potato occupies 7 percent of land in Bosnia and Herzegovina and 4 percent in North Macedonia. Plum occupies 13 percent of land in Bosnia and Herzegovina and 3 percent in Serbia. Apple cultivation covers 5 percent of the farmland in Bosnia and Herzegovina and 3 percent in North Macedonia, while grape is fairly important in North Macedonia (7 percent) (Diaz-Puente *et al.*, 2022).

The use of commercial fertilizers in the Western Balkans is relatively low. In 2014, Serbia was the only country to use more fertilizers per hectare, including nitrogen and phosphate, than the European Union average. Albania uses more phosphate inputs than the European Union average, while Bosnia and Herzegovina uses a bit more than 50 percent of the European Union average in nitrogen input (OECD, 2018).

Table 1, Table 2 and Table 3 provide key statistical data related to agriculture in selected countries of the region.

Table 1. Key characteristics of agriculture in selected countries of the region

	Agriculture % of GDP 2021 **	Employment % in agriculture 2021 **	Cereal yield kg/ha 2021 *	Labour intensity (ha/person) 2021 ^^	Fertilizer use kg/ha of arable land 2021**	Meat production tonnes 2022 °	Milk production tonnes 2021 °
Armenia	11.34	53.10	2 243	3.60	203.7	103 428.11	654 170
Azerbaijan	5.73	36.28	3 297	2.81	105.6	368 323	2 264 679
Belarus	6.71	11.06	3 143	21.74	169.4	1 220.493	7 887 511
Bosnia and Herzegovina	5.02	13.83	4 422	-	62	88 705.36	615 687
Bulgaria	4.37	6.29	5 950	24.39	131.1	221 739 (2019)	868 600
Georgia	7.23	40.73	2 749	2.36	178.2	74 538.51	598 562.94
Hungary	3.46	4.39	5 920	29.41	161.8	960 508. 90	2 044 900
Kazakhstan	5.03	13.24	1 049	100.00	4.4	1 240 976.40	6 367 029.50
Kyrgyzstan	12.41	25.17	2 335	13.51	22.6	256 840	1 734 691
Republic of Moldova	10.59	56.98	4 948	7.41	50.60	115 781.62	240 400
North Macedonia	7.15	11.23	3 538	-	50.50	23 842	387 967
Romania	4.76	18.47	5 188	6.17	107.4	965 262,30	4 261 900
Serbia	6.29	14.07	5 769	-	75	526 380,06	1 512 107
Slovakia	1.79	3.21	5 977	23.26	134.5	152 396 (2018)	926 980
Tajikistan	23.3 ^	44.34	3 610	3.28	90.40	377 983.10	1 077 337
Turkmenistan	12.7 ^	23.19	2 034	35.71	241.9	359 568.72	2 498 450
Ukraine	10.89	13.82	5 453	12.99	78.50	2 205 514.50	7 767 600
Uzbekistan	24.62	26.54	4 736	7.19	296.8	1 348 460	11 599 137

	Agricultural land % total 2021 **	Arable land % 2021 **	Agricultural land, km² 2021 **	Forest land % total 2020 *	Forest land, km² 2020 *	Pastureland % of total land 2021 °	Agricultural land % in individual farms 2021 ^^
Armenia	58.83	15.6	16 748	11.5	3 285	41.13	99
Azerbaijan	57.84	25.3	47 806	13.7	11 318	29.25	94
Belarus	40.28	27.7	81 740	43.2	87 676	12.09	10
Bosnia and Herzegovina	44.20	19.7	22 630	42.7	21 879	22.40	-
Bulgaria	46.49	32.2	50 466	35.9	38 930	12.87	38
Georgia	34.25	4.5	23 799	40.6	28 224	27.92	72
Hungary	55.27	45.40	50 437	22.5	20 530	8.27	53
Kazakhstan	79.19	11	2 137 959	1.3	34 547	68.15	39
Kyrgyzstan	54.05	6.7	103 661	6.9	13 154	46.93	95
Republic of Moldova	69.00	51.90	22 750	11.8	3 865	10.25	50
North Macedonia	49.96	16.5	12 600	39.7	10 015	31.80	-
Romania	56.85	37.3	130 790	30.1	69 291	17.78	56
Serbia	41.44	31.10	34 850	31.1	27 227	7.92	-
Slovakia	38.60	27.60	18 560	40.1	19 259	10.65	19
Tajikistan	35.43	6	49 170	3.1	4 238	27.92	83
Turkmenistan	72.01	4.1	256 906	8.8	41 270	67.75	93
Ukraine	71.30	56.8	413 110	16.7	96 900	13.00	45
Uzbekistan	58.30	9.1	256 906	8.4	36 897	48.23	98

Sources: * FAO
** World Bank, from theglobaleconomy.com
^ Batmunkh, A., Nugroho, A.D., Fekete-Farkas, M. & Lakner, Z. 2022. *Global Challenges and Responses: Agriculture, Economic Globalization, and Environmental Sustainability in Central Asia*. Sustainability, 14(4): 2455.
^^ Burkitbayeva, S., Liefert, W. & Swinnen, J. 2021. *Agricultural development and food security in Eastern Europe and Central Asia.* Washington, DC, International Food Policy Research Institute.
° FAO, from *ourworldindata.com*

Table 2. Crops covering the greatest surface area and those with the best comparative yield performance in selected countries of Europe and Central Asia

	Crops with the greatest surface area	Best comparative yield performance within Europe and Central Asia (at least 120 percent of the average yield in the region)
Armenia	wheat (32%), barley (24%), potato (10%)	berries, cauliflower, grape, cherry, hazelnut, watermelon, flax, lentils, fig, garlic, plum
Azerbaijan	wheat (42%), barley (23%), cotton (7%)	almond, pistachio, berry, tea, lentils, grape, fig, quince, cherry, nut
Belarus	wheat (21%), triticale (14%), barley (13%)	cherry, garlic, vetch, cabbage, bean, millet
Bosnia and Herzegovina	corn (36%), plum-sloe (13%), wheat (13%)	chickpea, vetch, chilli pepper, berry, anise-coriander, soy
Georgia	corn (23%), grape (19%), wheat (13%)	berries, cauliflower, grape, cherry, hazelnut, watermelon
Kazakhstan	wheat (60%), barley (12%), flax (5%)	garlic, berries, artichokes, almond, tobacco, cauliflower, safflower
Kyrgyzstan	wheat (28%), barley (22%), corn (12%)	almond, flax, nut, garlic, pistachio, buckwheat, millet, safflower, berries
Republic of Moldova	corn (28%), sunflower (22%), wheat (21%)	chickpea, almond
North Macedonia	wheat (22%), barley (13%), corn (10%)	fig, almond, quince, currant, grape, chickpea, anise-fennel, cucumber-pickle, lentils, onion-shallot
Serbia	corn (40%), wheat (24%), sunflower (9%)	vetch, anise-fennel-coriander, sunflower, soy, watermelon, nut, mustard seed, berries
Tajikistan	wheat (32%), cotton (21%), barley (9%)	bean, safflower, corn, lentils, garlic, millet, watermelon, peanut, sunflower, cabbage, sesame, almond, rice
Turkmenistan	wheat (51%), cotton (31%), rice (8%)	plum-sloe, grape, apricot, almond
Ukraine	wheat (25%), sunflower (24%), corn (18%)	nut, gooseberry, cherry, chestnut, plum-sloe, quince, hemp, lentils, tobacco, currant
Uzbekistan	wheat (39%), cotton (32%), grape (3%)	almond, peanut, fig, millet, currant, nut, garlic, artichokes, berries, cherry, quince, chickpea, rye, sorghum, cabbage

Source: **FAO. 2023h.** FAOSTAT. In: *Crops and livestock products*. https://www.fao.org/faostat/en/#data/QCL.

Note: The table shows crops with an average yield performance of at least 120 percent of the average in Europe and Central Asia for 2006–2020.

Table 3. Average fam size in selected countries of the region

	Average farm size	Year	Source
Armenia	1.4 ha	2022	**International Trade Administration. 2023.** Agriculture. In: *Armenia - Country Commercial Guide*.
Azerbaijan	2 ha	2015	**van Berkum, S. 2017.** *Market and competitiveness analysis of the Azerbaijan agricultural sector: an overview*. Wageningen Economic Research and Delphy.
Belarus	55 ha	2014	**FAO. 2014.** *Belarus: FAO Country Programming Framework (CPF) in the Republic of Belarus 2014-2016*.
Bosnia and Herzegovina	2.6 ha	2018-2020	**UNDP. 2024.** *EU4AGRI – Modernizing Agri-Food Sector in Bosnia and Herzegovina: For Thriving Rural Areas*. In: Bosnia and Herzegovina.
Bulgaria	33 ha	2020	**USDA. 2021.** *Bulgaria: 2020 Agricultural Census Confirms Farm Consolidation and Growth*. Sofia, United States Department of Agriculture Foreign Agricultural Service.
Georgia	0.7 ha	2007	**USAID. 2010.** Georgia. In: *LandLinks*.
Hungary	7.6 ha	2016	**Bojnec, Š., Fertő, I. & Podruzsik, S. 2022.** *What drives family farm size growth in Hungary?* Heliyon, 8(11): e11890.
Kazakhstan	~325 ha	2013	**Oshakbayev, D., Taitukova, R., Petrick, M. & Djanibekov, N. 2018.** *Kazakhstan's cotton sector reforms since independence*. Working Paper. 172. Discussion Paper.
Kosovo			
Kyrgyzstan	~220 ha	2007-2009	**USAID. 2011.** Kyrgyzstan. In: *LandLinks*.
Republic of Moldova	2.5 ha	2017	**JICA. 2017.** *Data Collection Survey on Agriculture Sector in Moldova*.
North Macedonia	1.85 ha	2013	**FAO. 2024a.** The former Yugoslav Republic of Macedonia. In: Family Farming Knowledge Platform. https://www.fao.org/family-farming/countries/mkd/en/
Romania	4.42 ha	2022	**International Trade Administration. 2024.** Agricultural Products. In: *Romania - Country Commercial Guide*.
Serbia	5.4 ha	2012	**Jurjević, Ž., Zekić, S., Matkovski, B. & Đokić, D. 2022.** *Sustainability of Small Farms in Serbia: A Comparative Analysis with the European Union*. Agronomy, 12(11): 2726.
Tajikistan	0.32 ha	2007	**FAO. 2024b.** Europe & Central Asia » Tajikistan. In: Family Farming Knowledge Platform. [Cited 7 May 2024]. https://www.fao.org/family-farming/data-sources/dataportrait/country-details/en/?cnt=TJK
Turkmenistan	2.5 ha	2014	**Hays, J. 2016.** Agriculture in Turkmenistan. In: *Facts and Details*.
Ukraine	Agricultural enterprises 1.000+ ha Private land 4.2 ha	2013-2015	**USAID. 2017.** Ukraine. In: *LandLinks*.
Uzbekistan	81.7 ha	2013	**Abdullaevich, F.M. 2015.** Characteristics of agriculture in Uzbekistan in the years of independence. European science review, 3–4: 67–69.

Note: No other sources of information for Turkmenistan were found.

4 Regional implementation of sustainable and circular bioeconomy through sustainable agriculture approaches

4. Regional implementation of sustainable and circular bioeconomy through sustainable agriculture approaches

After the identification of key concepts and approaches related to a sustainable and circular bioeconomy presented in **chapter 1** of this report and an understanding of the overall benefits for agriculture resulting from their implementation identified in **chapter 2**, this chapter will analyse various sustainable agriculture approaches in the region. This will be done with the purpose of demonstrating that these practices rely on the same or very similar principles as bioeconomy and, by consequence, effectively support the implementation of a sustainable and circular bioeconomy in the region.

In addition, the overview of natural conditions, corresponding major farming systems, and existing agricultural production trends in the region presented in **chapter 3** of this report serve as a background for the understanding of the current sectoral context and the evaluation of the potential for the promotion and implementation of a sustainable and circular bioeconomy in the region.

In **chapter 4**, sustainable agriculture approaches in the region will be presented. This will be followed by a detailed analysis of the status of implementation of sustainable agriculture approaches in the region. Finally, some examples of bioeconomy initiatives in the region will be revealed.

This logical flow will allow for adequate consideration and understanding of how sustainable agriculture approaches can enhance the promotion and implementation of a sustainable and circular bioeconomy in the agriculture sector in the region, thus providing conclusions that address the objective of this report.

In addition, the questionnaire approach shared in the Annex of this report can be applied as a ready-to-use screening method for further analysis of the status of implementation of a sustainable and circular bioeconomy through sustainable agriculture approaches at the national level. The method can be summarized as follows:

- **Background**
  - Natural conditions
  - Sectoral context in agriculture
- **Bioeconomy analysis**

  Step 1: enabling policy regulations and bioeconomy initiatives

  Step 2: existing sustainable agriculture approaches that support sustainable and circular bioeconomy objectives

  Step 3: identification of the development potential and existing limitations for selected priority approaches and technologies
- **Conclusions**

The suggested method can be used as a tool proposed by FAO to help analyse the implementation of a sustainable and circular bioeconomy. It aims to provide countries with information needed to design policies, build capacities and create other enabling conditions for the promotion and implementation of a sustainable and circular bioeconomy in their agriculture sectors.

Besides this simplified approach, FAO's commitment to promoting a sustainable bioeconomy has been demonstrated through the development of other more overarching tools to support the development of sustainable and circular bioeconomy strategies and policies at the national level. These tools include, for instance, the "Towards Sustainable Bioeconomy Guidelines" (FAO, 2018) and "The bioeconomy toolbox" (Gomez San Juan, 2024).

4.1. Sustainable agriculture approaches

Besides sharing the objectives of conventional agriculture related to food security and profitable farm income, sustainable agriculture approaches share the common goal of striving for sustainability, environmental protection, and natural resource base and soil fertility preservation. These approaches also share characteristics with the principles of a sustainable and circular bioeconomy, including crop rotation, mixed intercropping, synthetic pesticide and mineral fertilizer use reduction, decreased livestock densities, managed and free-range grazing, crop diversification, mixed farming and forestry, mixed crop and animal farming, and the recovery and reuse of by-products for agriculture and industrial use. Because they make up the largest share of the bioeconomy – from an economic and value-added perspective – and can boost discovery and innovation, agrifood systems are integral to the shift towards sustainable and circular production and consumption patterns (FAO, 2021).

A Oberč and Arroyo Schnell study (2020) is used as reference in this section to help visualize the main characteristics of sustainable agriculture approaches in the region. Building on that, the following sections provide more detailed information on the implementation of selected sustainable agriculture approaches in the region that can contribute to the implementation of a sustainable and circular bioeconomy.

Many other sustainable agriculture approaches exist but were not included due to the defined scope of this report.

Agroecology

FAO's Agroecology Knowledge Hub online defines the term "agroecology" this way (FAO, 2023i):

> Agroecology is a holistic and integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of sustainable agriculture and food systems. It seeks to optimize the interactions among plants, animals, humans and the environment while also addressing the need for socially equitable food systems within which people can exercise choice over what they eat and how and where it is produced.

Nature-positive production in agriculture

Nature-positive production is based on agroecology, permaculture and nature-based solutions principles and considers the agricultural system as an agroecosystem, with a particular focus on sustainability (Ferri and Arnés García, 2023). Integrating food production and natural capital to enable agriculture and nature reinforce each other, nature-positive agriculture aims to boost food production by optimizing ecological processes and overcoming the divide between nature and agriculture (Patidar, 2022).

Permaculture

Permaculture is an approach to agricultural design that focuses on whole systems thinking and the use or simulation of patterns and interactions from nature. It is seen as a form of agriculture that seeks inspiration in nature to develop farming systems aimed at maintaining the balance between crop productivity and ecosystem regeneration.

Organic agriculture

According to FAO, organic agriculture is a "production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved" (Auerbach, Rundgren and Scialabba, 2013).

According to the Codex Alimentarius collection of international food standards, organic agriculture is "a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity" (Codex Alimentarius Commission, 1999).

Climate-smart agriculture

Launched by FAO in 2010, climate-smart agriculture helps guide the transformation of agrifood systems towards practices that are green and climate resilient. It supports efforts to accomplish the SDGs, the Paris Agreement and other international goals through sustainably increasing agricultural productivity and incomes, adapting to climate change and building resilience, and reducing or removing greenhouse gas emissions (FAO, 2023j).

Circular agriculture

Circular agriculture aims to minimize the use of external inputs, close nutrients loops, regenerate soils and reduce environmental impacts (United Nations Department of Economic and Social Affairs, 2021). In a circular bioeconomy, the material reuse and recycling are among the choices made during production and use (Helgason, Iversen and Julca, 2021).

As defined by Wageningen University (Wageningen University & Research, 2023), circular agriculture is based on the optimization of biomass use. One supply chain's waste can be used as raw materials for another (animals can be fed from food waste, manure can be used as organic fertilizer, and wastewater can be used in irrigation). Thus, a circular agriculture system of this type requires the integration of plant- and animal-based value chains (Wageningen University & Research, 2023).

Agroforestry

Agroforestry considers the farm as a system and analyses how its various components work together to enhance the land's ecosystem functions. According to FAO, the term "agroforestry" describes "land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence" (FAO, 2023k).

Agroforestry systems include both ecological and economical interactions.

Agroforestry is "a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels" (FAO, 2023k). It is crucial, according to FAO, to smallholder farmers and others living in rural areas "because it can enhance their food supply, income and health" (FAO, 2023k). Agroforestry systems can provide many economic, sociocultural and environmental benefits (FAO, 2023k).

Agroforestry includes three primary types of systems (FAO, 2023k):

- Agrisilvicultural systems combine crops and trees (via alley cropping or home gardens, for example).
- Silvopastoral systems combine forestry with pasture, rangeland or farm grazing.
- Agrosylvopastoral systems integrate trees, animals and crops. A common example is a home garden that includes animals, croplands used for grazing after crops are harvested, and scattered trees.

In these systems, animal waste from one area can become resources for another area, such as organic fertilizer for home gardens (FAO, 2023k).

Pastoralism and free-range animal husbandry

In pastoralism and animal husbandry, livestock (goats, chickens, yaks, camels, sheep, cattle, etc.) are handled via several methods:

- nomadic, in which humans move along with their herds in search of grasslands to grade;
- herder systems, where herds migrate seasonally in search of new pastures; and

- transhumance, where herders move seasonally between higher and lower pastures.

Both pasture-based and free-range farming aim to address demands for lower environmental impact (such as efforts in pasture-based farming to reduce greenhouse gas emissions) for greater animal welfare and less intensive production, as opposed to raising animals in enclosed spaces. These systems allow animals to roam and move freely, creating a renewable cycle in which one system's wastes can meet the needs of another.

Sustainable forest management

According to FAO, the aim of sustainable forest management (SFM) is to "ensure that forests supply goods and services to meet both present-day and future needs and contribute to the sustainable development of communities" (FAO, 2023l). The United Nations General Assembly recognized SFM as a "dynamic and evolving concept that aims to maintain and enhance the economic, social and environmental values of all types of forests for the benefit of present and future generations" considering seven thematic elements: "extent of forest resources; forest biodiversity; forest health and vitality; productive functions of forest resources; protective functions of forest resources; socioeconomic functions of forests; and legal, policy and institutional framework" (FAO, 2023l).

Approaching the issue holistically, SFM aims to ensure that forest ecosystems "deliver social, environmental and economic benefits, balance competing needs and maintain and enhance forest functions now and in the future" (PEFC, 2023).

High Nature Value farming

The concept of High Nature Value (HNV) farming was developed by the European Environmental Agency to address those extensive agricultural systems that are connected to seminatural areas and that consequently play a role in biodiversity conservation. HNV farmland, according to Erling Anderson (cited in Pointereau et al., 2007, p. 2) "comprises those areas in Europe where agriculture is a major (usually the dominant) land use and where agriculture supports or is associated with either a high diversity of species and habitat, the presence of species of European conservation concern or both".

Ecotourism and agritourism

According to the United Nations World Tourism Organization, the term "ecotourism" refers to nature-based forms of tourism undertaken for the purpose of observing and appreciating nature and traditional cultures (UN Tourism, 2024).

Agritourism, meanwhile, is a form of ecotourism in which tourists experience farm life or explore the countryside via farms or agricultural villages. Agritourism connects tourism with agricultural production and processing on farms, ranches and other agricultural business to generate income while entertaining and educating visitors (National Agricultural Law Center, 2024).

Bioenergy

Biomass waste from agricultural production is considered an alternative energy source that lowers greenhouse gas emissions, as agricultural residues from each step of agricultural production can be used in bioenergy production (Kumar et al., 2023). In addition, animal waste can be turned into biogas and act as a source of heat and power. The three primary categories of bioenergy provided by agriculture are biogas, biodiesel and bioethanol, with each having grown dramatically in recent years (Yavuz and Tümenbatur, 2022).

4.2. Analysis of sustainable agriculture approaches implementing bioeconomy in the region

The implementation of sustainable agriculture approaches largely contributes to the promotion and implementation of a sustainable and circular bioeconomy because many sustainable agriculture approaches are based on the same principles as the sustainable and circular bioeconomy.

This section provides an overview of various sustainable agriculture approaches implemented in the region. These approaches adapt naturally to existing geographical conditions, natural systems capacities and prevailing agricultural practice and build on local experience, tradition and cultures that have been in place for centuries.

Organic agriculture

Organic agriculture has been experiencing a stable growing trend in the entire Eastern Europe, Caucasus and Central Asia region. The trend is more advanced in Eastern Europe and the Western Balkans subregion due to the encouragement of

this concept by the European Union and by the aspirations of these countries to join the community. Organic agriculture in these countries covers 3.58 percent of the land, compared with 9.63 percent in European Union Member States.

The region does excel in some areas of organic agriculture.

The region contains important areas for the cultivation of organic cereals, including in Czechia, Hungary, Kazakhstan, the Republic of Moldova, Romania, the Russian Federation and Ukraine, where organic cereals cover a large area compared to the country's small territory (Willer, Schlatter and Trávníček, 2023). Dry pulse cultures are significant in Bulgaria, Czechia, Poland, Romania and the Russian Federation. Bulgaria, Hungary, Poland and Romania are the most important producers of tempered fruit, while Romania, the Russian Federation and Ukraine produce oilseeds (Willer, Schlatter and Trávníček, 2023).

In Belarus, the main organic products are cereals (oats, spring barley), oilseeds, fodder crops, vegetables, berries (cranberries, blueberries) and fruits. The country also exports birch juice, wild berries and mushrooms. The organic agriculture sector was first regulated by a 2015 law and implemented by a 2018 law. Five foreign certification companies are active in the country.

In Ukraine, organic agriculture is mostly oriented to export, and the European Union is the main landing market (82 percent of export share in 2021), according to *The World of Organic Agriculture 2023* (Willer, Schlatter and Trávníček, 2023). The main export products are corn, soybeans, wheat (including spelt), sunflower cake, rapeseed, sunflower oil, frozen blueberries, sunflower seeds, millet and frozen elderberries (Willer, Schlatter and Trávníček, 2023). From 2021 to 2022, the export volume to the European Union and Switzerland increased by 13 percent (Willer, Schlatter and Trávníček, 2023). Organic agriculture is a national priority in Ukraine as a strategy for rural development and the implementation of the 2030 Agenda for Sustainable Development. The sector has been officially regulated since 2019. In 2021, it was included in the National Economic Strategy, with the objectives of increasing organic area up to 3 percent of total agricultural land (it was around 1 percent in 2021) and to reach USD 1 billion in exports by 2030 (this figure was USD 222 million as of 2021) (Willer, Schlatter and Trávníček, 2023).

In 2021, Eastern Europe and the Western Balkans were the two subregions with the highest relative growth in organic production. Most notably, North Macedonia (109.1 percent growth), Bosnia and Herzegovina (47.5 percent), Kosovo (24.1 percent), Romania (23.4 percent), Serbia (21.8 percent) and Croatia (12.3 percent). Table 4 presents an overview of organic land in the region.

Table 4. Organic land area in selected countries of Eastern Europe and Central Asia

	Organic land (ha)	Organic land as a percentage of total agricultural land	Number of producers
Armenia	583	<0.1	27
Azerbaijan	38 080	0.8	446
Belarus	6 725	0.1	19
Bosnia and Herzegovina	2 495	0.1	90
Bulgaria	86 310	1.7	5 942
Georgia	4 278	0.2	729
Hungary	293 597	5.9	5 129
Kazakhstan	113 247	0.1	281
Kosovo	1 990	0.5	56
Kyrgyzstan	30 259	0.3	1 144
Republic of Moldova	28 368	1.3	151
North Macedonia	7 794	0.6	887
Romania	578 718	4.3	11 562
Serbia	23 527	0.7	458
Slovakia	222 896	11.7	716
Tajikistan	22 292	0.5	166
Ukraine	422 299	1.0	418
Uzbekistan	4 925	<0.1	26

Source: **Willer, H., Schlatter, B. & Trávníček, J., eds. 2023.** *The World of Organic Agriculture 2023: statistics & emerging trends*. FiBL.

In the Western Balkans, a Regional Expert Advisory Working Group on Organic Production was established in the context of a regional strategy to advance the European Union accession. The group consists of representatives of the national ministries and related institutions and national and local experts. The initiative is supported by the Federal Ministry of Food and Agriculture of Germany. Countries that already established regulatory bodies for organic agriculture in line with the European Union standards are Albania, Kosovo and North Macedonia. Bosnia and Herzegovina and Serbia are in the process, and Montenegro still needs to harmonize its entire approach.

The organic land share in the subregion is increasing, with a growth of 30.3 percent from 2018 to 2020 (from 29 000 ha to 37 800 ha), yet the relative share in the total utilized agricultural area is still below 1 percent – with the exception of Montenegro, which dedicates 1.7 percent of its farmland to organic agriculture.

The organic production of the Western Balkans focuses mostly on cereals (36 percent), followed by fruits (including grapes), industrial plants and fodder crops.

Serbia has developed a national plan for supporting organic agriculture and a national research agenda, two documents that stress the importance of both organic food production and biodiversity conservation (Aksoy, Nurbekov and Muminjanov, 2018). A law on organic agriculture was promulgated in 2010, followed in 2011 by a rulebook on the control and certification of organic production and integrated in 2013 by further regulation of organic products exported to the European Union. The certification companies are national, but the producers often have to rely on imported inputs, as the national market is not sufficient (Aksoy, Nurbekov and Muminjanov, 2018).

Box 2. Harmonization of organic agriculture regulations in the region with the European Union regulations

Albania has fully harmonized its regulations. It had an action plan for organic agriculture in 2007–2013, and its implementation in the 2021–2027 period was still being discussed as of 2022. Organic agriculture in Albania is dominated by wild gathering and forest areas, which account for 377 716 ha, whereas farmland accounts for 897 ha.

The Federation of Bosnia and Herzegovina in **Bosnia and Herzegovina** does not have harmonized regulation. There are no specific public strategies or policies dedicated to expanding organic agriculture. Awareness raising is done voluntarily by sectoral associations. As of 2017, organic land was dominated by wild gathering (150 604 ha), with just 1 273 ha of farmland.

Republika Srpska in Bosnia and Herzegovina, on the other hand, has partially harmonized regulation. There is no national strategy on organic agriculture, but organic production is cited in the Strategy for the Development of Agriculture and Rural Areas, both for its role in the protection and sustainable use of natural resources and in improving agricultural production. There are 1 013 ha of organic farmland and small populations of livestock and bees. A sectoral association will be operative in the near future.

Kosovo has a fully harmonized regulation. Organic agriculture is mostly dedicated to growing medicinal and aromatic plants (560 ha) and to collecting non-timber forest products (373 488 ha). Two sectoral associations are operative in Kosovo.

North Macedonia has a fully harmonized regulation. There is no national strategy on organic agriculture. The share of organic agriculture saw a strong decline from 2011 to 2014, followed by a partial recovery in the following years. There are 2 337 ha of organic farmland (more than a third of which is dedicated to cereal crops, followed by fruit and fodder crops), 81 465 heads of organically grown livestock (71 933 of which sheep) and 6 034 beehives. There is a national association and three local organic agriculture organizations.

Montenegro has a partially harmonized regulation. There is no national strategy dedicated to organic agriculture, but it is cited both in the Strategy for the Development of Agriculture and Rural Areas and in the National Strategy of Biodiversity. There are 307 ha of arable land, 564 ha of perennial crops, 3 952 ha of pasture and meadows, 2 062 heads of livestock (1 369 sheep) and 3 381 beehives. A national association of organic agriculture producers is no longer operative.

Serbia has a partially harmonized regulation and no dedicated national strategy, but the development of organic agriculture is one of the main axes of its rural development programme. There are 15 915 ha of organic arable land (half of which is either fruit or cereal crops) and 5 349 ha of pasture and meadows. There are no organic agriculture associations, but the system is based on local cooperatives.

Source: 2022 IAMO, 2020 data

In Central Asia, the organic sector is the less developed, mostly due to incomplete legislative processes and weak institutional support and coordination. The development of internationally aligned certification is hindered by national legislations that often provide definitions of key concepts related to organic production that differ from international rules and definitions. A production rules registry of organic producers have not been sufficiently developed.

Kyrgyzstan adopted its first Law on Organic Agricultural Production in 2017. This law was amended and updated in 2022 to meet the international standards set by the Codex Alimentarius and IFOAM - Organics International. The new law set the creation of a national organic strategy with the objective of creating a favourable legal environment for organic agriculture. The certification regulation was revised, and participatory guarantee systems for the domestic market were implemented.

The organic sector in the country has been promoted since 2012 by the Federation of Organic Development Bio-KG, which supports the national strategy implementation and raises awareness on the topic through organic fairs and the National Forum of Organic Farmers. The government supports biological control through the large-scale application of biological control agents and the provision of training to farmers on how to effectively use them.

Also, advances were made to improve collaboration and regulation harmonization among the Eurasian Economic Union. The main destinations for organic export are the other Central Asian countries and the Russian Federation, but also Germany for cotton production. The main export products are cotton, tobacco, vegetables and fruit (Willer, Schlatter and Trávníček, 2023).

In Georgia, organic production was regulated nationally in 2013 with the resolution "On bio-production" 198/2013, and the "Bio-Agro Production" department was established in the National Agriculture Research Centre. The sector focuses mostly on cereals and vegetables but also approaches animal productions, fodder and aquaculture. Organic production is concentrated in the mountainous areas where the land is free from intense chemical inputs.

Organic agriculture strategies adopted in Georgia include the creation of a 100 percent organic region in Mtskheta-Mtianeti and the creation of the Biofarmer programme for training organic farmers, recently approved by the Ministry of Education.

Azerbaijan implemented an organic agriculture law in 2008, but neither a functional mechanism for its implementation nor a standardized certification system is in place. Government support has focused mostly on subsidizing organic fertilizers; hence, the sector's growth is mainly led by private initiatives. The main organic products include fruits, vegetables, hazelnuts and wild berries.

Kazakhstan has promulgated a national law on the regulation of organic agriculture, however but the sector's development has been slow. The main crops include cereals, oilseeds, legumes and medicinal herbs.

In Tajikistan, national regulation is under development. The European Union is the main export market. Cotton production is by far the most relevant, followed by fodder, apricots and peanuts (Aksoy, Nurbekov and Muminjanov, 2018).

Cotton production in Central Asia was historically concentrated in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, where it was grown on irrigated soils. However, extensive irrigation projects diverting water into farmland from local rivers have caused desertification in the region and the disappearance of the Aral Sea. Uzbekistan remains the largest cotton producer in the region, and organic cotton is grown in Kazakhstan, Kyrgyzstan and Tajikistan. These countries are major players in the sector, accounting for 17 percent of the global production, with Kyrgyzstan at 9 percent and Kazakhstan and Tajikistan at 4 percent each. Only India (38 percent), Türkiye (24 percent) and China (10 percent) have larger production volumes. In Tajikistan, the production is projected to almost double, once the producers currently undergoing conversion obtain the full organic certification (Willer, Schlatter and Trávníček, 2023).

Climate-smart agriculture

Many countries in the Western Balkans, Central Asia and the South Caucasus are prone to droughts. Western Balkan countries, Türkiye and Hungary also participated in the development of the Drought Management Centre for Southeastern Europe, which was established to improve drought preparedness and reduce drought impacts. In addition, most of governments in the region have promulgated laws that address climate change and implement climate-smart agriculture policies with the development or rehabilitation of irrigation systems as the focus area. Table 5 provides examples of laws and measures introduced in the Western Balkans in response to climate change with particular mention of agriculture.

The Republic of Moldova adopted its National Climate Change Adaptation Strategy with the following goals for agriculture: i) upscale conservation agriculture practices; ii) adopt better-adapted genetic varieties of plants and animals; and iii) improve plant protection and environmental risk management techniques. In addition, the National Low-Emissions Development Strategy (2013–2020) stressed the importance of upscaling conservation agriculture, shifting to more adapted plant and animal species, using organic fertilizers, and managing manure from agropastoral systems. A 2016 World Bank study showed a satisfactory level of implementation (greater than 60 percent) of the following climate-smart agriculture practices: i) anti-hail nets (apple groves in the central north region); ii) drip irrigation with grass cover between rows (apple groves and vineyards in the central north region); and iii) drip irrigation in open and closed fields (tomato fields in the central region) (World Bank and CIAT, 2016).

Georgia set its priorities for climate-smart agriculture advances with its Technology Action Plans for Climate Change Mitigation (2012) and the Fourth National Communication to the United Nations Framework

Table 5. Western Balkans laws and measures in response to climate change

	Laws	Agriculture
Albania	The Law on Climate Change has been adopted, representing the legal basis for the adoption of the National Energy and Climate Plan (NECP) from 2021 to 2030	Afforestation and barriers to protect arable land from erosion are crucial. Introduction of drip irrigation systems and modernization of existing systems
Bosnia and Herzegovina	The 2020–2030 Climate Change Adaptation and Low Emission Development Strategy for Bosnia and Herzegovina is prepared in 2021	High priority investments with a goal of rehabilitation and modernization of irrigation systems
Montenegro	In December 2019, Montenegro adopted the Law on Protection from the Negative Impacts of Climate Change	Development of a drought adaptation plan in conditions of increased climate variability. Establishment of a national network within agrometeorological observations
North Macedonia	The Republic of North Macedonia has approved an Energy Development Strategy until 2040, making it the first country in the Western Balkans to consider abolishing coal by 2030	Harmonization of agrarian policy with climate change and strengthening of agricultural institutions. In addition, it is necessary to invest in infrastructure and greater support for agricultural farms
Serbia	The Law on Climate Change was adopted	Rehabilitation of drainage and irrigation infrastructure. Flood risk reduction and water resources management

Source: **Županić, F.Ž., Radić, D. & Podbregar, I. 2021.** *Climate change and agriculture management: Western Balkan region analysis*. Energy, Sustainability and Society, 11(1): 51.

Convention on Climate Change (2021). The priorities include: i) increasing irrigated land; ii) studying degraded soils to recover soil fertility and water retention capacity; iii) creating a legal framework for windbreaks; iv) updating legislation on the protection of biodiversity; v) supporting sustainable forestry management; vi) extending the hydro-meteorological surveillance network; vii) improving the atmospheric air, water and soil quality monitoring system; viii) transitioning to integrated water resource management; and ix) improving waste and chemical substance management.

Agriculture is also included as one of the seven key sectors for climate change mitigation in the 2030 National Climate Change Strategy, which proposes two objectives: implement sustainable land management in farmland and pastures and develop capacities to improve climate-smart agriculture in the country. Among the many practices adopted, conservation agriculture in wheat growing (crop rotation, organic mulching and no tillage) reached a satisfying adoption rate of more than 60 percent.

A USD 31 million project implemented in 2015–2021 by the International Fund for Agricultural Development (IFAD), titled "Agriculture Modernization, Market Access and Resilience AMMAR", resulted in 3 135 ha of land brought being under climate-smart agriculture practices, as well as 14 300 ha benefiting from renovated irrigation infrastructures. As a result, the legislation of windbreaks was advanced and 50 specialists were trained in climate-smart agriculture practices.

Kyrgyzstan adopted a National Development Strategy 2018–2040, with a National Development Plan 2021–2026 that aims at advancing towards the implementation of the SDGs. The vulnerability of the country to climate change is deemed high, with the frequency of extreme weather events such as heatwaves, floods and droughts having increased by 150 percent since 2010 (World Food Programme, 2022)

In November 2022, the country and the World Food Programme (WFP) developed a strategic plan for 2023–2027 with the aim of increasing food security, employment and human capital development and building the capacity to withstand the impacts of climate variability. Under the plan, the WFP will provide training and resources to strengthen the "community capacity to use improved agriculture practices, post-harvest loss reduction measures, sustainable natural resource management and climate risk information" (World Food Programme, 2022). Another GEF project "Sustainable Management of Mountainous Forest and Land Resources under Climate Change Conditions" promoted climate-smart agriculture practices in mountain forestry and in the management of rangeland from 2014 to 2022.

A review of climate-smart agriculture implementation in the country by the International Center for Tropical Agriculture (CIAT and World Bank, 2018) showed that most of the climate-smart agriculture practices had an intermediate rate of implementation (30–60 percent) and crop rotation in maize fields in Talas and Jalal-Abad areas had a satisfactory implementation rate (greater than 60 percent).

While climate-smart agriculture seldom appears directly in the countries' policies and plans, building adaptive capacity and resilience to climate change is quite often among the top strategic priorities of agricultural policies. The United Nations and the international cooperation organizations have initiated a number of projects to implement climate-smart agriculture measures in the region. Box 3 (see next page) includes some examples.

Circular agriculture

A number of countries in the region have initiated the implementation of circular agriculture strategies.

In the Western Balkans, a performance indicator-based review by Vasa, Angeloska and Trendov (2017) highlighted how the region has good conditions for the transition from a linear to a circular agriculture. Despite the actual focus on unsustainable farming practices, the region has diversified landscapes, climate conditions, traditional products and practices. North Macedonia is leading the way in the implementation of information and communications technologies in agriculture. Organic agriculture is advancing steadily in Serbia, and Albania performs well in predominant smallholder farming with a fairly low use of inputs, although it could do better in research and development.

A review on circular agriculture advances in Kazakhstan and Uzbekistan (Kuldosheva, 2021) has shown that the sector is still in the early development stage, with advances only in waste management and energy consumption, despite agriculture often being addressed as a priority sector. The city of Almaty published a research document with a thoroughly defined strategy to implement circularity in its urban surroundings (Hoogzaad *et al.*, 2019). Urban agriculture and food processing are at the centre of the strategy, with an emphasis on closing the cycle of renewable materials and connecting the urban agriculture with rural systems.

In 2022, the Ministry of Economic Development and Poverty Reduction in Uzbekistan and the World Bank hosted an event aimed at developing a circular economy

Box 3. Examples of international cooperation projects supporting the development of climate-smart agriculture in Eastern Europe, the Western Balkans, the Caucasus and Central Asia

Eastern Europe and the South Caucasus. Between 2012 and 2017, the "Clima East – Shifting Ground" project was implemented in Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova, Russian Federation and Ukraine. It was financed by the European Union and supported by UNDP. Through the implementation of different pilot projects, the project achieved the reduction of greenhouse gas emissions by:

- replacing fossil fuels with biomass (Belarus);
- restoring peatlands (1 600 ha in the Russian Federation and Ukraine) and pastureland (30 700 ha in Armenia, Azerbaijan, Georgia and Republic of Moldova), improving the protection status of globally important ecosystems (Belarus, Georgia, Republic of Moldova, Russian Federation and Ukraine);
- improving sustainable land use practices and improving incomes for sheepherders to ease the pressure on pastures (Georgia); and
- advancing research on permafrost melting and how to slow it (Russian Federation).

The total implementation area summed up almost 72 000 ha, with around 92 000 people benefitting from the enhanced ecosystem functioning and climate resilience.

Central Asia and Türkiye. Climate-smart agriculture is also an important component of the CACILM-2 project "Integrated natural resources management in drought-phone and salt-affected agricultural production landscapes in Central Asia and Türkiye", which has been implemented in the Central Asia region since 2015 by FAO, with GEF co-funding. Among other things, the project aims at:

- upscaling a proactive drought risk management mechanism;
- upscaling innovative drought mitigation technologies and implementing drought-tolerant species; and
- enhancing skills on the adoption of salinity mitigation approaches and technologies.

Black Sea basin. The European Union funded the AGREEN "Cross-Border Alliance for Climate-Smart and Green Agriculture in The Black Sea Basin" project in the context of the Black Sea Cross-Border Cooperation. The project brings together partners from Armenia, Bulgaria, Georgia, Greece, Romania and Türkiye. In 2014–2020, the project aimed to create a network of knowledge exchange among the participating countries and develop marketing and operational tools to support climate-smart agriculture in the region (including a climate-smart brand and an internet platform).

North Macedonia. The Ministry of Agriculture, Forestry and Water Economy and FAO have proposed a project to be co-funded by the Adaptation Fund with almost USD 10 million. The project, titled "Building Climate Resilience of the Agricultural System in Radovish Region through Improved Irrigation, Land and Water Management", aims at:

- raising awareness, generating evidence and building capacity on climate change-related issues in the country and the region;
- climate-proofing the irrigation system of the Radovish valley; and
- implementing climate-resilient agricultural practices.

Turkmenistan. The project "Supporting Climate Resilient Livelihoods in Agricultural Communities in Drought-prone Areas" was implemented in Turkmenistan, a water stressed country, by UNDP with USD 24 million in GEF co-funding. The project aimed at:

- implementing community-based climate adaptation solutions in the territories of Lebap and Dashoguz Velayats;
- mainstreaming climate adaptation measures in the strategies and policies of both agricultural and water development; and
- strengthening the national capacity to plan, implement and monitor climate change adaptation.

Uzbekistan. Climate adaptation is a priority in Uzbekistan, where warming trends have been recorded to be twice as fast as the global average, causing water stress and increasing aridity and the frequency of extreme events. The UNDP project "Climate resilient livelihoods of horticultural producers in Fergana valley in Uzbekistan" in 2022–2023 provided ten agro-meteo stations to one of the country's agriculture hotspots. The programme was financed with USD 1 million and benefited 3 percent of Uzbekistan's rural population.

Source: 2022 IAMO, 2020 data


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for the agricultural value chain.[5] Serbia is engaged in a similar process in the framework of the UNDP project "Circular Economy Platform for Sustainable Development in Serbia", which resulted in the drafting of a national road map that identified four priority sectors, one of which is agriculture and food processing.

Kyrgyzstan, after promulgating national policies to advance in the green transition (Climate Investment Programme 2018, Sustainable Development Strategy in Industry 2019–2023, and Green Economy Development Programme 2019–2023), is on its way to adopting the National Action Plan on Sustainable Consumption and Production, which is expected to have a focus on bioeconomy in the agrifood sector (European Commission, 2021).

Azerbaijan has been selected for the implementation of the Visegrád Fund project "Circular Farm Impact Lab V4 for AZ", which aims to share know-how on agri-resource management from Visegrád countries (Czechia, Hungary, Poland and Slovakia) with young farmers in Azerbaijan.

A European Union-funded circular economy project "Knowing Circular Economy in the Black Sea Basin" (also known as the "BSB-CIRCLECON") has been activated with partnerships in Bulgaria, Georgia, Greece, Türkiye and Ukraine, although it mostly focuses on industrial processes, without a specific focus on agriculture and food.

Agroforestry

In the countries of Central and Eastern Europe, agroforestry has not been a central activity since the collapse of the Soviet Union. When that happened, according to Worms (2021), it became important to quickly adapt to the European Union regulatory and legislative environment to ease membership. Agroforestry practices that considered

[5] For more information on this event, please visit https://mineconomy.gov.uz/en/news/view/4300.

traditional farming systems became disused, despite their resilience during the Soviet period, enabling farmers to continue practising old management techniques such as the forest grazing systems in Hungary.

Windbreaks are a widespread infrastructure in Ukraine, where they occupy 446 000 ha and protect around 13 million ha of arable land. Water shelterbelts, which have the function of conveying runoff waters, also are popular in the country (European Agroforestry Federation, 2023).

The neighbouring country Republic of Moldova also has a rich heritage of small windbreak forests. Through the Moldova Agriculture Competitiveness Project,[6] the government rehabilitated 2 200 ha of shelterbelts in the south of the country between 2012 and 2017 (World Bank, 2020). The Republic of Moldova has 30 700 ha of shelterbelts in total, with almost all of them managed at the state or municipal level. Besides their role in protecting plants and soil from the winds (one shelterbelt hectare protects 12–20 ha of farmland), they also provide food (38 percent of shelterbelts are made of walnut trees), firewood, fodder, and other non-timber forest products (36 percent are made of acacia trees and 9 percent of oak trees).

In Central Asia and the South Caucasus, considering the subregion's exposure to soil degradation and dry spell phenomena, trees in farmland are used to prevent soil erosion, replenish soil fertility, and improve the microclimate and soil moisture. Some of the most common and relevant agroforestry practices in Central Asia and the South Caucasus include (Djanibekov *et al.*, 2015):

- managed walnut woodland for non-timber forest products (firewood, fruit, nuts, berries, mushroom, etc.) associated with hay harvesting, typical of southern Kyrgyzstan;
- silvopasture and forest grazing, where fodder trees are associated to livestock;
- tree windbreaks to contain soil erosion, save water and improve yields, occasionally made with fruit trees such as apricots, apple trees or mulberry trees;
- fruit trees associated with home gardens as a means of self-subsistence as well as income diversification, occasionally associated with wheat intercropping and widely spread in Uzbekistan;
- alley cropping, where crops are grown between tree lines – particularly used in Tajikistan mountains, with apple trees that tolerate rainfed conditions, but also in Uzbekistan, where mulberry trees for silk production are associated with wheat crops and where tree rows also work as windbreaks; and
- riverbanks to provide wildlife habitats and protect banks from erosion and waters from the leaching of agricultural inputs.

Due to low institutional recognition, agroforestry practices in the subregion remain remnants of traditional practices. The policy environment does not contribute to the promotion of agroforestry practices for two reasons: i) the preferential subsidization of certain crops prevents the association with other crops; and ii) since most land is state-owned and lent to farmers, it often is not possible to change the designated land use to a mixed system. This standardization of land use for legal or regulatory purposes is a major obstacle for agroforestry not only in this subregion but also all over the world.

However, more attention is given to the role of windbreaks in Central Asia, where the winds can be more erosive and where forest cover is scarce. An assessment study (Thevs *et al.*, 2022) revealed that expanding windbreaks in Uzbekistan by just 26 percent of their maximum possible extension would generate more wood resources than those that are produced and imported in the country. Therefore, agroforestry appears to have remarkable potential for expanding sustainable and circular bioeconomy value chains.

Agroforestry also can contribute to landscape restoration objectives. The planned "Kazakhstan Resilient Landscapes Restoration Project" is being implemented with USD 4 million in funding from the World Bank and the Global Partnership for Sustainable and Resilient Landscapes. The three objectives of the project include: i) improving biodiversity conservation capacities and monitoring in southern Kazakhstan; ii) implementing pilot agroforestry projects in the proximity of protected areas; and iii) enriching the collection of preserved unique plants in the Kazakh Scientific Research Institute of Forestry.

This project is expected to build upon the results of the previous World Bank/GEF-funded "Kazakhstan RESILAND Resilient Landscapes Restoration Project", which kicked off in 2021 and is expected to run until 2025 with an allocated amount of USD 4.34 million. RESILAND focuses on piloting community-centred dryland agroforestry practices and improving the governance of protected areas through integrated management and landscape restoration.

Agroforestry is one of the four main components of a third GEF-funded project in the country, the "Kazakhstan Resilient Agroforestry and Rangeland Project", which also

[6] More information on this project is available at https://projects.worldbank.org/en/projects-operations/project-detail/P118518.


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started in 2021 with USD 2 million in funding. This project is more dedicated to the management and restoration of dryland pastures.

The Central Asia region also hosts two other projects implemented by the Centre for International Forestry Research and World Agroforestry (CIFOR-ICRAF) and the Eberswalde University of Sustainable Development, thanks to funding from the German Federal Ministry of Economic Cooperation and Development. From 2017 to 2019, the project "Agroforestry Systems in Irrigated Agriculture in Central Asia for Building Resilience Against Water Stress and Climate Change" was implemented in Kyrgyzstan and Kazakhstan, with the objectives of: i) assessing the positive effects of various windbreak types on tree and crop water consumption; and ii) investigating the costs and benefits of various windbreak types and the income they can potentially generate. In 2019–2021, the project "Poplars in Agroforestry in Central Asia – from Planting Material to Utilization" investigated the identification of new poplar clones that can contribute to farm income or energy, either as agroforestry or small plantation systems. The project identified possible alternative wood products that can be made from poplar biomass. Study sites were set up in seven different areas of Kyrgyzstan, Kazakhstan, Tajikistan and Uzbekistan.

Pastoralism and free-range animal husbandry

Pastoralism has historically been, and partly still is, a relevant activity in the region, particularly in Central Asia and the Caucasus. Rangelands and pastures are the most relevant land uses in Central Asia and the South Caucasus, occupying 56 percent of the total land area and 78 percent of the agricultural land (Neudert, 2021). Central Asia and the South Caucasus contain 22 percent of the world's grasslands.

In Central Asia and the Caucasus, the processes of national rearrangement that followed the independency declarations of 1991 deeply affected pastoralist communities, eventually leading to the reorganization of pastoral groups, land management and access under renewed market and accessibility conditions. In the Soviet era, land and livestock were both owned by the state, and cross-border movement was not problematic.

The effective governance of rangelands and pastures is crucial in preventing overgrazing and land degradation, which affect many territories in Central Asia and the South Caucasus. Varied traditions and post-socialist trajectories have produced differentiated forms of pastoralism and stationary livestock management (ranching) in the subregion. The main axis of pastoralism variability is between horizontal movement (nomadism in lowlands or plateaus, without permanent housing), or

vertical movement (transhumance in mountain areas, with permanent housing and only seasonal movement).

Nomadism was historically more practised in the steppes between China, Kazakhstan and Mongolia, but the modern integration of pastoralist communities into state structures has led to compulsory settlement and reduced mobility. A general trend towards shorter migration and the predominance of transhumance reflect the process of urban drift among former nomadic culture groups. On one hand, this reduced migration hampers access to natural resources and the sustainable use of biodiversity, but on the other hand, it can bring new industrialization opportunities using traditional knowledge in modern technology.

In Central Asia, the shift towards a market economy and the rapid privatization of land have entailed a decrease in the maintenance of public infrastructures, leading to the failure of large irrigation systems and the abandonment of transport routes in the most remote areas. Important livestock assets were sold to foreign farmers due to the lack of regulation in the 1990s, resulting in an impoverishment of local genetic resources.

Today, livestock ownership is polarized between the few households that own large commercial herds and the many smallholders who own a few animals for self-subsistence. Pastoralist communities have largely been omitted from national policies. This led to the Hustai declaration, a document signed in 2015 by the pastoralist organizations of India, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, Uzbekistan and the Altai Republic of the Russian Federation. The declaration recognized the inadequate recognition of pastoralist activities vis-à-vis the important benefits they provide at socioeconomic, environmental and cultural levels – benefits recognized by United Nations organizations such as FAO, UNDP, the United Nations Environment Programme (UNEP) and IUCN. The pastoralist organizations called for inclusion in the decision-making processes that affect their livelihood, for recognition of their lifestyles and better support for their activities.

Assessing the exact extent of pastoralist activities is difficult due to a lack of proper data sets, yet a general overview can be drawn. When it comes to rangeland management, four main models can be applied: private management, community-based management, public institution management (at communal, district or state scales) and open access (which implies almost no access control).

In Georgia, mountain transhumance is predominant. Rangelands governance models have changed often,

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resulting in a mix of overgrazed land and underutilized land where forests have expanded. The country is set on the path of privatizing the pastureland, having allocated up to 15–25 percent of pastures to farmers. International development organizations have supported this approach as well as community-based management.

In Armenia, mountain transhumance is predominant, and degradation is affecting as much as half the pastureland due to overgrazing. The country has gradually shifted its approach from state control to moderate privatization and community-based management.

Azerbaijan has a mix of steep gradient mountain transhumance and gentler transhumance in agropastoral landscapes. Pastureland remains in state ownership, with remote pastures leased out for 25 years through an auction mechanism. Village pastures are managed by village communities themselves (known as "*Belediyye*" in Azerbaijan). Despite the state ownership, pastures are managed similarly to privatized land in remote areas, and with a community focus around the villages. Overgrazing appears to be affecting village pastures more often.

Turkmenistan is characterized by a mix of seminomadic and transhumant pastoralism. Herd movement patterns are radial, centred on water infrastructures (wells), where summer camps are built. Pastureland, wells and livestock are mainly owned by the state and managed by herders, who receive a share of the offspring and products if they meet production targets. Community access to pastures was regulated only in 2015. Privately owned livestock is on the rise, but the system is still largely dominated by the state, allowing high flexibility to herders and resembling an open-access system. The state of rangelands is currently undetermined, as various studies provide contrasting results.

In Kazakhstan, the ancient tradition of long-distance pastoralism almost ceased at the end of the 1990s, and livestock activities remained concentrated around villages; the state attempted to lease out the land without much success. Between 2003 and 2016, the law was changed to allow only for direct purchase. The process was then the object of a moratorium until 2021 due to grassroots movement protests. Today, land governance in the country is a mix of privatized, state-managed and community-based systems. Around settlements, pastures are affected by overgrazing, while in remote areas, they are underused (Kerven *et al*., 2016).

Uzbekistan is dominated by horizontal nomadism, despite some transhumance being present in the mountain areas. No rangeland privatization is allowed. Pastures are under district governments in semi-arid areas and under the control of agricultural cooperatives in dry areas. Pastures under district governance are de facto open access, as livestock is owned by families. In 2019, a new law proposed the creation of "pasture user associations", and consequently the country adopted a mixed approach based on public control and community-based management. The state of pastures in the country appears to be fairly degraded, mostly due to open access and the lack of maintenance of water infrastructure.

Mountain transhumance is predominant in Kyrgyzstan, where rangelands cover 80 percent of the country's land. While livestock was privatized, pastures remained under state ownership. In 2009, the country was the first to shift to a community-based management model, after the failure of the lease approach. The process initially resulted in the elite capture of rangeland, but with positive equitability outcomes after 2009. The governance of pasture user committees is reportedly still somewhat inefficient in matching pasture availability with demand and facilitating mobility.

Similar to Kyrgyzstan, Tajikistan is dominated by mountain transhumance, but with a larger predominance of agropastoral systems. The country's pastures were unregulated – with de facto open access – until 2013, when a reform was promulgated following the model of state ownership and community-based management of Kyrgyzstan. The reform was only partially adopted, and pasture access is regulated both for user associations and individual leases, leading to a mixture of private and community governance. The system is not enforced by regulation, which has led to a certain concentration of wealth in the hands of a minority. As in other countries in Central Asia and the South Caucasus, rangelands are affected by overgrazing around the settlements (Neudert, 2021; Nori, 2022).

In the Western Balkans, pastures and meadows cover roughly 20–30 percent of the land; however, grassland is connected to 70 percent of the Important Plant Areas[7] in the subregion. This highlights the role that these ecosystems play in supporting biodiversity – and, consequently, the threat of biodiversity loss that is linked with the disappearance of the pastoral activities that maintain these ecosystems. HNV systems[8] may

[7] Important Plant Areas are those sites with "exceptional botanical richness"; that contain plant species that are considered rare, threatened and socioeconomically valuable; and that encompass rare and threatened habitats (Plantlife, 2024).

[8] HNV farming, according to FAO's Family Farming Knowledge Platform, has been developed since the early 1990s "as a policy tool to describe those farming systems in Europe which are of greatest biodiversity value" (FAO, 2016). The HNV concept doesn't just focus on maintaining rare and endangered species and habitats on protected sites, but it also recognizes that conserving biodiversity in the European Union "also depends to a great extent upon the continuation of specific farming systems and practices across much wider areas of the countryside" (FAO, 2016).

vary considerably among countries, but transhumance, nomadic herding, common grazing and forest grazing are some of the common features. The Western Balkans are particularly rich in local breeds, the result of centuries-old breeding practices. Serbia alone accounts for more than 30 breeds and landraces with breeding lines recorded by breeding associations. North Macedonia supports autochthonous – though low-productivity – breeds in its national strategy for rural development.

Similar to Central Asia and the South Caucasus, herding mobility in the Western Balkans has been deeply affected by changing borders, the recent phenomena of migration and the lack of generational renewal in rural areas. This has resulted in the overgrazing and degradation of lowland village pastures, another feature common in Central Asia and the South Caucasus. Land abandonment is a widespread phenomenon, although it is hard to measure due to the lack of systemic data.

In Albania, both transhumance and nomadism can be found, but they are usually practised over short distances within a single district. Less than 10 percent of the pastureland is private. Around 60 percent is owned by the municipalities, and the rest is owned by the state. Livestock owners are mostly allowed to access the communal or state forests (for a fee), where as much as 60 percent of forage needs are met.

Bulgarian pastures are mostly owned by municipalities, which used to grant use to local herders informally. Traditional management was based on the diversification of animal species and assigned pastures at different climates (goats at higher altitudes, cattle at lower altitudes). After the European Union accession, the country reformed its policy framework to formally assign pasture management to user associations and individual farmers in case some spare land was still available. The process is ongoing, and the regulatory framework has been amended several times.

Pastures in North Macedonia are mostly owned by the state and assigned via five-year contracts subject to the payment of a fee. However, the deterioration of infrastructure (roads, water structures and shelters) is reported throughout the country.

Box 4. Examples of pastoralism or sustainable livestock projects implemented in Eastern Europe and Central Asia

Ukraine: UNDP 2021–2026, "Promoting Sustainable Livestock Management and Ecosystem conservation in Northern Ukraine"

Kyrgyzstan: IFAD 2021–2026, "Regional Resilient Pastoral Communities Project"; IFAD 2013–2021, "Livestock and Market Development Programme II"; and World Bank 2014–2019 "Pasture Management Improvement Project", all aimed at improving community-based pasture management in Kyrgyzstan.

Kazakhstan: GEF/FAO 2021–2025, "Kazakhstan Resilient Agroforestry and Rangeland Project" and World Bank 2020–2025, "Kazakhstan Sustainable Livestock Development Program". Originally a big USD 500 million project, it was downscaled by the Kazakhstan Government in 2022.

Sustainable forest management

Countries in Eastern Europe, the Caucasus and Central Asia are facing many challenges in forest management. UNECE and FAO (2007) identified several key factors affecting forest management in region, including:

- the reorganization of state assets in the forest sector, comprising the privatization and restitution of forest land to private forest owners, the sale of forest enterprises to national and international investors, and the restructuring of remaining state assets (for example, the decentralization of forest management and the outsourcing of state forest management to commercial entities);
- the development of a private forest sector, comprising increased private-sector investment, the development of private forest management institutions (e.g. forest owners' associations), and the development of forest management and marketing skills in the private sector;
- the increasing need for social and environmental services from forest management and the appearance of specialized policies and institutions;
- changes in policy and legislation to reflect greater private-sector involvement in the forest sector and the changing role of the state from the control of all forestry activities to the design and implementation of forestry policy;
- changes in forest management to reflect a greater interest in economic objectives (i.e. profitability) among private forest owners and state forest enterprises; and
- the transition to market economies, which has led to the increased integration of these economies into the global economy (i.e. increased foreign trade and investment) and greater public awareness and influence on activities in the sector.

Among the countries of Eastern Europe, Belarus is implementing the state programme Belarusian Forests 2021–2025, which aims to: i) expand the current forest cover area; ii) increase the timber harvest; iii) increase timber harvest per surface unit; iv) create new forest roads; v) ensure moose, red deer and roe deer species growth; and vi) increase the production of several transformed products, such as paper, cardboard and furniture. The project also aims at improving information and digital infrastructures, the seed selection process, felling procedures, firefighting, and fire detection equipment.

In the Western Balkans, the average forest cover is around 41 percent of the national territories (highest in Bosnia and Herzegovina, with 63 percent, and lowest in Serbia, with 29 percent). The share of privately owned forests is lowest in Albania (3 percent) and increases from there to North Macedonia (11 percent), Republika Srpska (23 percent), Federation of Bosnia and Herzegovina (32 percent), Kosovo (38 percent), Serbia (47 percent) and Montenegro (48 percent).

All countries in the subregion have developed national forest sector strategies (with the exception of one Bosnian entity, the Federation of Bosnia and Herzegovina, which developed a national Forestry Stewardship Council standard for SFM). Most of these strategies were drafted in the 2000s and may need to be updated with regard to climate change, bioeconomy and forest biodiversity conservation goals. The potential for afforestation has not been analysed yet. Due to the relatively high share of privately owned forests, their management and control has led to conflicts due to urbanization processes, ownership issues and usurpation phenomena. Further weaknesses for the implementation of SFM in the region are the lack of a sufficiently widespread informative system and the low level of coordination and cooperation among forest stakeholders.

Several SFM projects have been implemented in the subregion with cooperation and funding from the World Bank, GEF, the International Bank for Reconstruction and Development, the Swedish International Development Cooperation Agency, the European Union Instrument for Pre-Accession Assistance and others. The projects have aimed at further developing strategic, legal and institutional frameworks and national forest inventories. Albania, Serbia and Kosovo also worked on projects that established Forestry Information Systems. An ongoing campaign "Developing national forest certification systems in the Balkans" from the Programme for the Endorsement of Forest Certification is working towards developing national schemes for SFM as well as harmonizing the SFM approach at the regional scale (Petrovic, 2023).

In Central Asia, forest cover is much lower than in the Western Balkans. In Uzbekistan, it is around 10 percent, while in Turkmenistan, Kazakhstan and Kyrgyzstan it ranges from 5 percent to 9 percent. In Tajikistan, it is less than 5 percent. This is the result of a large-scale deforestation. However, the region is recognized as a global biodiversity centre and one of the major centres of crop origin and domestication, with more than 300 species of wild fruits and nuts. The deforestation process was also historically paired with a process of land degradation, which resulted in the large-scale extension of agriculture in a fragile environment. The main degradation processes are soil erosion in rainfed farmland and mountains, secondary salinization in irrigated lands and desertification in a wide range of land covers.

South Caucasus countries have a larger percentage of land covered by forests – almost 40 percent in Georgia and 10–12 percent in Armenia and Azerbaijan. Forests are used by local communities primarily to harvest fuelwood. This, together with illegal logging, has led to a significant forest degradation.

Forests in the subregion provide key functions against erosion and desertification, particularly present due to dry climates and strong winds. A significative amount of forest area is owned and managed by the state and is dedicated to the protection of biodiversity, although wood and non-wood forest resources also contribute to the livelihoods of rural people. The forest sector in the subregion is negatively affected by a shortage of qualified staff, limited resources, scarce coordination with other sectors and a general lack of awareness of forestry issues (UNECE and FAO, 2023).

The development and the regular tracking of criteria and indicators for SFM is a recognized prerequisite to the implementation of SFM strategies. As reviewed by FAO and UNECE (2023), the forestry sector in Central Asia and the South Caucasus has seen only little development towards SFM, as none of the countries, except for Georgia, has established its own set of criteria and indicators, rendering the monitoring of forest status difficult to implement. Balanced and reliable data reporting from the region is not available.

Despite limited resources, Georgia participates in Forest Europe's regional initiative for criteria and indicators for SFM and reports indicator-based data to FAO/UNECE, the United Nations Framework Convention on Climate Change and other United Nations institutions. As a result of a United Nations Development Account project implemented by FAO and UNECE between 2016 and 2020, five pilot countries (Armenia, Georgia, Kazakhstan, Kyrgyzstan and Uzbekistan) have now established their national sets of criteria and indicators for SFM, though their actual implementation outside of Georgia is still pending.

Another overview of the region by UNECE and FAO (2019) stressed the lack of financial and human resources

in the sector and insufficient data gathering, which hinders policymaking. The main threats to forests in Central Asia and the South Caucasus are represented by illegal logging (often caused by the high demand for fuelwood) and overgrazing. The review calls for a better integration of SFM objectives in national intersectoral strategies and for the strengthening of cooperation attempts and regulation efforts.

Kyrgyzstan developed a Concept of Development of the Forestry Sector with FAO assistance, looking at the 2040 target. The main objectives of the national policy document include: i) develop a forest inventory with ecological and economic data; ii) create the conditions for improving the economic sustainability of forestry activities; iii) improve the value-added chain for forest resources; and iv) ensure that the recreational use of forests is done sustainably.

Box 5 includes examples of forest management projects implemented in the region.

Box 5. Examples of forest management projects implemented in the region

EUROPAID 2021–2023, "Improvement of forest management in Serbia as a contribution to climate change adaptation and mitigation"

Green Climate Fund 2020–2029, "Forest resilience of Armenia, enhancing adaptation and rural green growth via mitigation"

FAO/GEF 2018–2023, "Sustainable Management of Forests in Mountain and Valley Areas" in Uzbekistan

UNDP 2018–2023, "Conservation and sustainable management of key globally important ecosystems for multiple benefits" in Kazakhstan

FAO/GEF 2016–2020, "Conservation-oriented management of forests and wetlands to achieve multiple benefits" in Belarus

UNDP 2016–2019, "Mainstreaming Sustainable Land and Forest Management in Mountain Landscapes of North-Eastern Armenia"

Bioenergy

The traditional use of bioenergy in the region includes burning wood and charcoal, a practice widely used in rural areas. It is a strategic alternative in the process of replacing fossil fuel sources, as it is adaptable to existing infrastructures such as gas pipelines and heat engines. More advanced bioenergy uses entail the processing of raw materials into solid, liquid or gaseous energy matter.

As of 2019, the Republic of Moldova had among the highest rates of bioenergy in the region under analysis, with the energy source accounting for 25 percent of the country's total energy supply (International Energy Agency, 2022a). This is the result of cooperation with the European Union and the Government of Japan, which invested in solid biofuels infrastructure in the country for heating purposes. In 2022, the installed capacity of biomass boilers in public institutions reached 70 MW (UNDP Moldova, 2022).

The bioenergy share in the energy mix of other countries was between 5 percent and 10 percent. Armenia, Belarus, Georgia, the Russian Federation and Ukraine had around 3–5 percent share of bioenergy use. Other countries had less than that. Bioenergy production accounts for almost all renewable energy shares in Belarus, the Republic of Moldova and Ukraine (International Energy Agency, 2022a, 2022b).

Ukraine included the scaling up of bioenergy use in its 2017 Energy Strategy and its 2014 National Renewable Energy Action Plan, where it aimed at satisfying 40 percent of the country's heating energy consumption with bioenergy by 2035 (from 2 million tonnes of oil equivalent in 2020 to 11 million tonnes). The country aims to replace 3 billion m^3 of natural gas with biomass for district heating and to increase the biomass electricity production from 24 MW to 950 MW in the long term; a secondary objective involves the replacement of natural gas with sunflower seed husks in lime production (an important input for the production of iron and steel) (International Energy Agency, 2022c).

The European Union and the International Energy Agency (IEA) have been implementing a structural programme in Eastern Partnership countries (Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova and Ukraine) since 2016. The first phase, which ended in 2022, also involved the five Central Asia countries. The EU4Energy programme focuses on improving energy data capabilities, enhancing data collection, monitoring, and providing assistance for the design of energy policies in the partner countries.

In Ukraine, the USD 56 million project "Sustainable Bioenergy Value Chain Innovation", co-financed by the GEF and implemented by the European Bank for Reconstruction and Development, was launched in 2019 and expected to last four years. The national government, the private sector and the Bioenergy Association of Ukraine work together to implement four components: i) develop the regulatory and legislative framework for bioenergy; ii) provide technical assistance to support the value chains; iii) deploy investments to support projects in the sector; and iv) develop knowledge management and awareness.

In Serbia, the bioeconomy project "Sustainable Land, Livelihoods and Energy Initiative" is currently being implemented by E3 International and CIFOR-ICRAF, with

support from the Austrian Development Agency and biomass energy companies. The expected activities include: i) the development of pilot business models that implement short rotation plantations of fast-growing trees and reed species for the production of woody biomass and biogas, respectively, to be implemented in degraded or abandoned farmland; ii) a strategy to scale up these short-rotation plantation businesses and restore 4 000 ha of permanent forest to be exploited for non-timber products (honey, fruit, medicine and fodder); and iii) the setting up of a multistakeholder enabling environment that can support farmer outreach, training, logistics, financing and funding options.

4.3. Examples of bioeconomy initiatives in the region

The institutional interest and relevance given to bioeconomy in the region appears to be very differentiated. Most countries in Eastern Europe and the Western Balkans are working towards a national strategy or have already finalized one. In Central Asia and the South Caucasus, the subject is less present in the institutional initiatives and on political agendas. One of the key drivers behind this differentiation is encouragement by the European Union, which is very active in promoting the concept through its 2012 European Bioeconomy Strategy[9] and funding projects in neighbouring countries to find a continental alignment.

The European Union adopted its strategy for bioeconomy in 2012 and revised it in 2018 to better suit the 2030 Agenda and the SDGs. The Eastern European and Balkans Member Countries that initiated the development of their national bioeconomy strategies were Croatia, Czechia, Hungary, Poland and Slovakia (European Commission, 2022). Romania and Bulgaria are less advanced in this aspect, but they participate along with other countries of the subregion in BIOEAST, the Central-Eastern European Initiative for biobased Agriculture, Aquaculture and Forestry.

The BIOEAST initiative,[10] initiated 2015 by the governments of the Visegrád Group (Poland, Czechia, Hungary and Slovakia), is co-founded by the European Union. The main objective of BIOEAST is to develop an intersectoral approach to develop national bioeconomy strategies and a regional strategy for Central and Eastern Europe. The initiative is also meant to boost cooperation among countries and provide a space to develop a multistakeholder network.

Other European Union co-funded bioeconomy projects in the region include:

- CELEBio,[11] the Central European Leaders of Bioeconomy Network, facilitates the creation and expansion of industrial bio-based activities via information, action plans and networking. Participating countries include Bulgaria, Croatia, Czechia, Hungary, Poland, Slovakia and Slovenia.
- BIOREGIO[12] aimed to improve knowledge related to the circular economy of biological materials to increase their recycling rates. The project also shares expertise on such technologies as biorefinery, biogas production and relevant cooperation models (ecosystems, networks and administrative cooperation). The project promoted possibilities for closing the loops of biological streams, such as using materials as fertilizers and biofuels instead of disposing of them. Activities ended in 2022.
- BE-RURAL[13] supported the development of bio-based strategies and road maps for rural and regional development in the European Union. The project established five thematic Open Innovation Platforms with regional scope in five Eastern European countries: Stara Zagora, Bulgaria (essential oils and herbal plants in the cosmetics and pharmaceutical industry); Vidzeme and Kurzeme, Latvia (by-products of forest management); Strumica, North Macedonia (agricultural residues); Szczecin Lagoon and Vistula Lagoon, Poland (small-scale fishing of undervalue species); and Covasna, Romania (underused biomass valorization). Activities ended in 2022.

The involvement of South Caucasus and Central Asia countries in European Union-promoted initiatives on bioeconomy is low.

The TRANSECT project, funded by the German Federal Ministry of Education and Research and led by the Eberswalde University of Sustainable Development together with a consortium of universities in China, Kazakhstan, Pakistan and Tajikistan, seeks to analyse the context of Central Asia (including Afghanistan and Pakistan) and evaluate potential pathways for bioeconomy development in the agrarian sector.

[9] For more information on the 2012 European Bioeconomy Strategy, please visit https://op.europa.eu/en/publication-detail/-/publication/edace3e3-e189-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-149755478.

[10] More information on this initiative can be found at https://bioeast.eu/.

[11] Please visit https://celebio.eu/ for more information on this network.

[12] More information on this project can be found at https://projects2014-2020.interregeurope.eu/bioregio/.

[13] More information on this project can be found at https://be-rural.eu/.

Conclusions

The development of this report is based on three interrelated considerations.

First, it draws attention to the fact that existing agricultural practices generate increased land and water use and demand for raw materials and agrichemicals, on one hand, and unprecedented waste generation and food loss on the other. At the same time, ecosystems are under several natural pressures related to the consequences of climate change and natural disasters. It is necessary to balance the provisioning of food, feed and other agricultural produce with the full range of ecosystem services and benefits they offer. Therefore, the report draws attention to the key benefits of a sustainable and circular bioeconomy that can address this objectives, including the promotion of nature-based solutions and ecosystem restoration, reduced dependence on non-renewable materials, the revitalization of rural areas, and increased sustainable production, consumption and food safety.

Second, this report demonstrates that the implementation of sustainable agriculture approaches largely contributes to the promotion and implementation of a sustainable and circular bioeconomy in agriculture, because many principles on which sustainable agriculture approaches are based are common to sustainable and circular bioeconomy as well.

The third consideration of this report is the analysis of the state of the art in specific sustainable agriculture approaches in the region and how they naturally adapt to existing geographical conditions and ecosystem capacities and build on local experience and tradition, contributing to a sustainable and circular bioeconomy. This is done with the aim of identifying existing limitations and the development potential for selected priority approaches and of providing countries with the information they need to design policies and build capacities and other enabling conditions for the promotion and implementation of a sustainable and circular bioeconomy in their agriculture sectors.

This report presents an overview of bioeconomy-related concepts and the benefits of their implementation in agriculture and provides information on the agriculture production trends, bioeconomy initiatives and sustainable agriculture approaches across the region. In this way, it presents a canvas for the consideration of potential policies and initiatives that would further support the development of specific sustainable agriculture approaches adapted to each country and that would promote the implementation of a sustainable and circular bioeconomy in agriculture practice in the region. It opens the way for further analysis and research of considered topics at national levels, depending on countries' specific needs.

Some examples of policies and initiatives have been presented as a menu of options throughout the chapters of this report, including flagship policies focused on establishing national bioeconomy strategies and plans that include interventions in the agriculture sector and dedicated institutional bodies to address the agrifood sector.

Information analysed in this report suggests that to support these, improved national and regional infrastructures will be required to collect, monitor and utilize data on progress. This should be underpinned by a central data repository enabling the coordination and comparison of information and the coordination of strategies at national and regional levels.

The report also demonstrates the important role of international cooperation initiatives led by the United Nations and other international organizations as well as the advantages of substantial regional integration efforts and support to national reforms directed and funded by the European Union.

Beyond these cross-cutting considerations, the detailed analysis of agricultural production trends provided in this report points to the conclusion that the development of national agrifood systems in the region prioritizes diversifying agriculture, restoring irrigation systems and implementing land-use and climate adaptation policies, much more than the previous focus on food security and production growth. National agricultural policies also address the transformation of food processing capacities towards value-added products, the expansion of trade, and the reduction in imports of basic foodstuffs. Addressing land degradation and boosting the efficient use of water and other natural resources are among the priorities most identified in national strategies.

When analysing specific sustainable agriculture approaches, the report demonstrates that organic agriculture is well developed in the region, especially in subregions within the geographic vicinity of the European Union, which actively promotes this topic and represents the key outlet for organic produce. Climate-


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smart agriculture and circular agriculture are gaining ground due to the increasing global emergency in addressing challenges such as droughts and resource scarcity. SFM practices and the use of bioenergy in the region represent untapped potential among sustainable agriculture approaches and can be effectively advanced with the increased support of relevant guidelines and institutional and capacity-building measures.

Agroforestry and pastoralism, on the other hand, appear to be distinctly underrated and overlooked in most national policies and do not benefit enough from institutional support. This particularly missed opportunity to address biodiversity issues for a long-term sustainable and circular bioeconomy should be addressed presently. As these traditional practices build on native traditions and the knowledge of local populations, they do not require major investments in technology and skills and can therefore be enhanced relatively smoothly through the development of policy and institutional capacities that address existing land ownership and management limitations.

In conclusion, it is essential that agrifood systems in Eastern Europe and Central Asia become more efficient in their use of resources, with minimal food loss and waste, and that they operate within natural planetary boundaries and a sustainable and circular bioeconomy framework.

To achieve this, the development of national bioeconomy strategies in the countries of the region could provide suitable policy vehicles that integrate a variety of approaches in a holistic manner along the agrifood systems. Beyond including sustainable agriculture objectives, they would combine sustainable food production and consumption strategies with food safety and eco-innovation outside of food production to improve the economic competitiveness of the sector and reduce food loss and waste. All of them would serve a paradigm shift from economic growth and intensive agriculture towards sustainable and circular bioeconomy models.

References

Aksoy, U., Nurbekov, A. & Muminjanov, H. 2018. *Development of Organic Agriculture in Central Asia*. FAO. https://www.fao.org/family-farming/detail/en/c/1133081/

Altieri, M.A. & Nicholls, C.I. 2012. Agroecology Scaling Up for Food Sovereignty and Resiliency. In: E. Lichtfouse, ed. *Sustainable Agriculture Reviews*. pp. 1–29. Vol. 11. Sustainable Agriculture Reviews. Dordrecht, Springer Netherlands. https://doi.org/10.1007/978-94-007-5449-2_1

Asian Development Bank. 2019. *Agriculture Development in the Central Asia Regional Economic Cooperation Program Member Countries: Review of Trends, Challenges, and Opportunities*. Manila, Philippines, Asian Development Bank. https://doi.org/10.22617/TCS190607-2

Auerbach, R., Rundgren, G. & Scialabba, N.E.-H. 2013. *Organic agriculture: African experiences in resilience and sustainability*. Rome, FAO.

Bàrberi, P., Carlesi, S., Leoni, F., Mantino, A., Marini, S., Moonen, A.-C. & Primucci, D. 2022. *Green agriculture in Europe and Central Asia*. Pisa, Italy, Scuola Superiore Sant'Anna.

Burkitbayeva, S., Liefert, W. & Swinnen, J. 2021. *Agricultural development and food security in Eastern Europe and Central Asia*. Washington, DC, International Food Policy Research Institute. https://doi.org/10.2499/9780896293830_07

Canja, C., Boeriu, A. & Mazarel, A. 2020. Bioeconomy and Food Safety Security. https://www.researchgate.net/publication/341462274_BIOECONOMY_AND_FOOD_SAFETY_SECURITY

CIAT & World Bank. 2018. *Climate-Smart Agriculture for the Kyrgyz Republic*. CSA Country Profiles for Asia Series. Washington, D.C., International Center for Tropical Agriculture (CIAT) and World Bank. https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA%20_Profile_The%20Kyrgyz%20Republic.pdf

Codex Alimentarius Commission. 1999. *Guidelines for the production, processing, labelling and marketing of organically produced foods*. FAO. https://www.fao.org/input/download/standards/360/cxg_032e.pdf

Diaz-Puente, J.M., Martin-Fernandez, S., Garcia-Montero, L.G. & Bettoni, M. 2022. *Position paper on science and innovation in green agriculture in Europe and Central Asia*. FAO and Universidad Politecnica de Madrid.

Djanibekov, U., Dzhakypbekova, K., Chamberlain, J., Weyerhaeuser, H., Zomer, R., Villamor, G. & Xu, J. 2015. Agroforestry for landscape restoration and livelihood development in Central Asia. *CRAF Working Paper 186. World Agroforestry Centre East and Central Asia, Kunming, China*, 2015: 1–31.

Ellen MacArthur Foundation. 2023. What is a circular economy? In: *Ellen MacArthur Foundation*. [Cited 22 June 2023]. https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

Energy & Climate Intelligence Unit. 2022. Farming, fertiliser, and fossil fuels. In: *Energy & Climate Intelligence Unit*. https://eciu.net/analysis/reports/2022/farming-fertiliser-and-fossil-fuels

European Agroforestry Federation. 2023. Ukraine. In: *EURAF*. https://euraf.isa.utl.pt/countries/ukraine

European Commission. 2019. *The European Green Deal*. Brussels, European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

European Commission. 2020a. *A new circular economy action plan for a cleaner and more competitive Europe*. Brussels, European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF

European Commission. 2020b. *EU Biodiversity Strategy for 2030: Bringing nature back into our lives*. Brussels, European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF

European Commission. 2021. Green and circular growth: A uniting vision for the Kyrgyz Republic. European Commission. https://www.switchtogreen.eu/green-and-circular-growth-a-uniting-vision-for-the-kyrgyz-republic/

European Commission. 2022. *Report COM/2022/283: EU Bioeconomy Strategy Progress Report - European Bioeconomy policy: stocktaking and future developments*. https://knowledge4policy.ec.europa.eu/publication/report-com2022283-eu-bioeconomy-strategy-progress-report-european-bioeconomy-policy_en

FAO. 2016. Sustainable High Nature Value (HNV) farming. In: *Family Farming Knowledge Platform*. [Cited 21 October 2024]. https://www.fao.org/family-farming/detail/en/c/391091/

FAO. 2018. *Towards sustainable bioeconomy guidelines*. FAO. https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1156377/

FAO. 2021. *Assessment of agricultural plastics and their sustainability: A call for action*. Rome, FAO. https://doi.org/10.4060/cb7856en

FAO. 2022a. *Sustainable bioeconomy and FAO*. Rome, FAO. https://openknowledge.fao.org/handle/20.500.14283/cb7445en

FAO. 2022b. *Sustainable and circular bioeconomy in the climate agenda: Opportunities to transform agrifood systems*. FAO. https://doi.org/10.4060/cc2668en

FAO. 2022c. FAO hosts brainstorming event with the International Sustainable Bioeconomy Work Group. In: *Sustainable and circular bioeconomy for food systems transformation*. https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/resources/news/details/es/c/1475449/

FAO. 2023a. *The Director-General's Medium Term Plan (Reviewed) 2022-25 and Programme of Work and Budget 2024-25*. Rome. https://openknowledge.fao.org/server/api/core/bitstreams/237eaea9-46f1-423f-979a-41635d0e14d7/content

FAO. 2023b. Sustainable and circular bioeconomy for food systems transformation. In: *Food and Agriculture Organization of the United Nations*. [Cited 22 June 2023]. https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/en/

FAO. 2023c. Breaking the plastic cycle in agriculture. In: *Newsroom*. [Cited 19 November 2024]. https://www.fao.org/newsroom/story/Breaking-the-plastic-cycle-in-agriculture/

FAO. 2023d. Bioeconomy has a major stake in the future of food safety and environmental stewardship. In: *Sustainable and circular bioeconomy for food systems transformation*. [Cited 22 June 2023]. https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/resources/news/details/en/c/1477147/

FAO. 2023e. One Health. In: *Food and Agriculture Organization of the United Nations*. [Cited 23 June 2023]. https://www.fao.org/one-health/en

FAO. 2023f. *The impact of veterinary drug residues on the gut microbiome and human health*. Food Safety and Quality Series 20. Rome, FAO. https://doi.org/10.4060/cc5301en

FAO. 2023g. *The impact of pesticide residues on the gut microbiome and human health*. Food Safety and Quality Series 19. Rome, FAO. https://doi.org/10.4060/cc5306en

FAO. 2023h. *The impact of microplastics on the gut microbiome and health*. Food Safety and Quality Series 21. Rome, FAO. https://doi.org/10.4060/cc5294en

FAO. 2023i. Overview. In: *Agroecology Knowledge Hub*. [Cited 28 June 2023]. http://www.fao.org/agroecology/overview/en/

FAO. 2023j. Climate-Smart Agriculture. In: *Food and Agriculture Organization of the United Nations*. [Cited 28 June 2023]. https://www.fao.org/climate-smart-agriculture/en/

FAO. 2023k. Agroforestry. In: *Food and Agriculture Organization of the United Nations*. [Cited 28 June 2023]. https://www.fao.org/forestry-fao/agroforestry/80338/en/

FAO. 2023l. Sustainable forest management. In: *Food and Agriculture Organization of the United Nations*. http://www.fao.org/sustainable-forests-management/en/

FAO. 2024a. Sustainable use and management of plastics in agriculture. In: *Climate Change*. [Cited 21 October 2024]. https://www.fao.org/climate-change/areas-of-work/plastics-in-agriculture/en

FAO. 2024b. FAOSTAT. https://www.fao.org/faostat/en/#home

Forslund, T., Gorst, A., Briggs, C., Azevedo, D. & Smale, R. 2022. *Tackling root causes: Halting biodiversity loss through the circular economy*. Sitra Studies 205. https://www.sitra.fi/app/uploads/2022/05/sitra-tackling-root-causes-1.pdf

Garazha, O., Cherneha, I., Ulanchuk, V., Skus, O. & Nepochatenko, O. 2023. Agricultural Production in Eastern Europe: History, Current Status, and Prospects of the Development for Innovation. *Science and Innovation*, 19(2): 83–98. https://doi.org/10.15407/scine19.02.083

Gomez San Juan, M. 2024. *The bioeconomy toolbox*. Environment and Natural Resources Management Working Paper 99. Rome, FAO. https://doi.org/10.4060/cc8856en

Grima, N., Moeini-Meybodi, H., Scott, T., Zuzhang, X., Biao, J., Daniels, C., Gianvenuti, A., Salvemini, D. & Walter, S. 2023. *Issue Brief: Forests, Energy, and Livelihoods*. https://openknowledge.fao.org/server/api/core/bitstreams/ddb90965-0be6-4c86-9503-9d9f70a973fe/content

Helgason, K.Sv., Iversen, K. & Julca, A. 2021. *Circular agriculture for sustainable rural development | Department of Economic and Social Affairs*. UNDESA Policy Brief 105. UNDESA. https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-105-circular-agriculture-for-sustainable-rural-development/

Hoogzaad, J., Zikrina, Z., Urazayeva, F., Vinnikova, N., Fraser, M., Douma, A., Raspail, N. *et al.* 2019. Circular Economy Opportunities in Almaty. Shifting Paradigms. https://www.circle-economy.com/resources/circular-economy-opportunities-in-almaty

International Advisory Council on Global Bioeconomy. 2020. Expanding the Sustainable Bioeconomy: Vision and Way Forward. Communiqué of the Global Bioeconomy Summit 2020. https://gbs2020.net/wp-content/uploads/2020/11/GBS2020_IACGB-Communique.pdf

International Energy Agency. 2022a. Moldova 2022: Energy policy review. IEA. https://iea.blob.core.windows.net/assets/dc881e93-9f82-4072-b8b4-a0d00a487f59/Moldova2022.pdf

International Energy Agency. 2022b. Tajikistan 2022: Energy sector review. IEA. https://iea.blob.core.windows.net/assets/ab8f5f01-4b54-4636-b2e8-7818e2ed55a8/Tajikistan2022.pdf

International Energy Agency. 2022c. Ukraine Energy Profile. IEA. https://iea.blob.core.windows.net/assets/ac51678f-5069-4495-9551-87040cb0c99d/UkraineEnergyProfile.pdf

IUCN. 2015. *Land Degradation Neutrality: implications and opportunities for conservation*. Technical Brief 2nd Edition. Nairobi, IUCN.

IUCN. 2016. WCC 2016 Res 069. In: *IUCN*. [Cited 30 June 2023]. https://portals.iucn.org/library/node/46486

Kerven, C., Robinson, S., Behnke, R., Kushenov, K. & Milner-Gulland, E. 2016. Horseflies, wolves and wells: Biophysical and socio-economic factors influencing livestock distribution in Kazakhstan's rangelands. *Land Use Policy*, 52: 392–409. https://doi.org/10.1016/j.landusepol.2015.12.030

Kuldosheva, G. 2021. Circular economy: How close are the Central Asian Republics to transition to a circular economy? https://www.researchgate.net/publication/355061406_Circular_economy_How_close_are_the_Central_Asian_Republics_to_transition_to_a_circular_economy

Kumar, J.A., Sathish, S., Prabu, D., Renita, A.A., Saravanan, A., Deivayanai, V.C., Anish, M. *et al.* 2023. Agricultural waste biomass for sustainable bioenergy production: Feedstock, characterization and pre-treatment methodologies. *Chemosphere*, 331: 138680. https://doi.org/10.1016/j.chemosphere.2023.138680

National Agricultural Law Center. 2024. Agritourism Overview. In: *National Agricultural Law Center*. [Cited 21 October 2024]. https://nationalaglawcenter.org/overview/agritourism/

Neudert, R. 2021. Combating pasture degradation in Central Asia and the Caucasus – a review of approaches. In: V. Beckmann, ed. *Transitioning to Sustainable Life on Land*. MDPI - Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/books978-3-03897-879-4

Nori, M. 2022. *Assessing the policy framework in pastoral areas of Asia*. EUI RSC PP 2022/04. European University Institute. https://hdl.handle.net/1814/74316

Oberč, B.P. & Arroyo Schnell, A. 2020. *Approaches to sustainable agriculture*. Brussels, IUCN. https://doi.org/10.2305/IUCN.CH.2020.07.en

Oberč, B.P., de Jong, R., Demozzi, T. & Battioni Romanelli, B. 2022. *Towards a circular economy that begins and ends in nature*. Gland, Switzerland, IUCN. https://doi.org/10.2305/IUCN.CH.2022.13.en

OECD. 2018. *Competitiveness in South East Europe: A Policy Outlook 2018*. Paris, Organisation for Economic Co-operation and Development. https://doi.org/10.1787/9789264298576-en

Patidar, A. 2022. Nature-Inclusive Agriculture: A New Approach towards Sustainability. *Just Agriculture Multidisciplinary e-Newsletter*(9). https://justagriculture.in/files/newsletter/2022/may/19.%20Nature-Inclusive%20Agriculture%20-%20%20A%20New%20Approach%20towards%20Sustainability.pdf

PEFC. 2023. What is sustainable forest management? In: *PEFC*. [Cited 28 June 2023]. https://www.pefc.org/what-we-do/our-approach/what-is-sustainable-forest-management

Petrovic, N. 2023. *Sustainable forest management in the Western Balkan region*. Skopje, Standing working group for regional rural development. https://seerural.org/wp-content/uploads/2022/12/Sustainable-forest-management-in-the-western-balkan-region.pdf

Plantlife. 2024. Important Plant Areas (IPA). In: *Plantlife*. [Cited 21 October 2024]. https://www.plantlife.org.uk/protecting-plants-fungi/important-plant-areas/

Pointereau, P., Paracchini, M.L., Terres, J.-M. & European Commission, eds. 2007. *Identification of High Nature Value farmland in France through statistical information and farm practice surveys*. Luxembourg, Publications Office.

Schroeder, P., Anggraeni, K. & Weber, U. 2019. The Relevance of Circular Economy Practices to the Sustainable Development Goals. *Journal of Industrial Ecology*, 23(1): 77–95. https://doi.org/10.1111/jiec.12732

Thevs, N., Aliev, K., Emileva, B., Yuldasheva, D., Eshchanova, G. & Welp, M. 2022. Potential of Agroforestry to Provide Wood Resources to Central Asia. *Forests*, 13(8): 1193. https://doi.org/10.3390/f13081193

UN Tourism. 2024. Ecotourism and Protected areas. In: *UN Tourism*. [Cited 21 October 2024]. https://www.unwto.org/sustainable-development/ecotourism-and-protected-areas

UNDP Moldova. 2022. By using biomass boilers in public institutions, the gas consumption may be reduced by up to 20 million m3 of gas a year. In: *UNDP*. https://www.undp.org/moldova/press-releases/using-biomass-boilers-public-institutions-gas-consumption-may-be-reduced-20-million-m3-gas-year

UNDP. 2011. *Regional Climate Change Impacts Study for the South Caucasus Region*. Tbilisi, Georgia, UNDP. https://www.undp.org/sites/g/files/zskgke326/files/migration/ge/GE_SC-CC-2011.pdf

UNECE & FAO. forthcoming. *Sustainable and circular bioeconomy in forest-based industries: How to get there*. Geneva, UNECE. https://unece.org/sites/default/files/2023-11/ECE_TIM_2023_Inf.4_FAO_EFC_2023_Inf.4.pdf

UNECE & FAO. 2007. *Strategy for FAO and UNECE forestry activities in Eastern Europe and Central Asia*. https://unece.org/fileadmin/DAM/timber/other/eecca-strategy-2007.pdf

UNECE & FAO. 2019. *State of Forests of the Caucasus and Central Asia: Overview of forests and sustainable forest management in the Caucasus and Central Asia region*. Geneva Timber and Forest Study Papers 47. New York and Geneva, United Nations. https://unece.org/DAM/timber/publications/sp-47-soccaf-en.pdf

UNECE & FAO. 2021. *Circularity concepts in forest-based industries*. Geneva Timber and Forest Study Papers 49. Geneva, UNECE and FAO. https://unece.org/sites/default/files/2022-05/Circularity%20concepts%20in%20forest-based%20industries%20ECE_TIM_SP_49.pdf

UNECE & FAO. 2023. *Reporting on Forests and Sustainable Forest Management in the Caucasus and Central Asia: Focus on Criteria and Indicators*. Geneva Timber and Forest Study Papers 53. United Nations and FAO. https://doi.org/10.18356/9789210023825

UNEP. 2022. *Post-2020 Global Biodiversity Framework. Draft recommendations submitted by the co-chairs.* Nairobi. https://www.cbd.int/doc/c/079d/0d26/91af171843b6d4e9bee25086/wg2020-04-l-02-annex-en.pdf

United Nations Department of Economic and Social Affairs. 2021. UN/DESA Policy Brief #105: Circular agriculture for sustainable rural development. In: *Department of Economic and Social Affairs Economic Analysis*. [Cited 21 October 2024]. https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-105-circular-agriculture-for-sustainable-rural-development/

United Nations Economic Commission for Latin America and the Caribbean, UNESCO Regional Bureau for Science in Latin America and the Caribbean, UNESCO/UNITWIN Chair on Biotechnology and SDGs & Center for Sustainable Development Goals for Latin America and the Caribbean. 2021. *Highlights from the side event: Bioeconomy for a biodiversity-and-science-based sustainable development of food systems in Latin America and the Caribbean*. 6 July 2021. https://sc-fss2021.org/wp-content/uploads/2021/07/005_Bioeconomy_0607_1600_HL.pdf

United Nations. 2015. Paris Agreement. United Nations. https://unfccc.int/sites/default/files/english_paris_agreement.pdf

United States Environmental Protection Agency. 2024. Economics of Biofuels. In: *EPA*. [Cited 18 November 2024]. https://www.epa.gov/environmental-economics/economics-biofuels

Vasa, L., Angeloska, A. & Trendov, N.M. 2017. Comparative analysis of circular agriculture development in selected Western Balkan countries based on sustainable performance indicators. *Economic Annals-XXI*, 168(11–12): 44–47. https://doi.org/10.21003/ea.V168-09

Wageningen University & Research. 2023. Circular agrofood system. In: *Wageningen University & Research*. [Cited 28 June 2023]. https://www.wur.nl/en/research-results/dossiers/file/circular-agrofood-system.htm

Willer, H., Schlatter, B. & Trávníček, J., eds. 2023. *The World of Organic Agriculture 2023: statistics & emerging trends*. FiBL. https://www.fibl.org/en/shop-en/1254-organic-world-2023

World Bank & CIAT. 2016. *Climate-Smart Agriculture in Moldova*. CSA Country Profiles for Africa, Asia, Europe and Latin America and the Caribbean Series. Washington, D.C., The World Bank Group. https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA%20Moldova.pdf

World Bank. 2020. *Combined Project Information Documents / Integrated Safeguards Datasheet (PID/ISDS)*. Fourth Additional Financing for the Agriculture Competitiveness Project (P170853). The World Bank. https://documents1.worldbank.org/curated/en/934351605124754620/pdf/Project-Information-Document-Integrated-Safeguards-Data-Sheet-Additional-Financing-for-the-Agriculture-Competitiveness-Project-P170853.pdf

World Food Programme. 2022. Kyrgyz Republic Country Strategic Plan (2023–2027). In: *World Food Programme*. https://www.wfp.org/operations/kg02-kyrgyz-republic-country-strategic-plan-2023-2027

Worms, P. 2021. Agroforestry: The Age-Old Future of Europe's Agriculture. In: *Revolve*. https://revolve.media/features/agroforestry-the-age-old-future-of-europes-agriculture

Wynberg, R., Pimbert, M., Moeller, N., McAllister, G., Kerr, R.B., Singh, J., Belay, M. & Ngcoya, M. 2023. Nature-Based Solutions and Agroecology: Business as Usual or an Opportunity for Transformative Change? *Environment: Science and Policy for Sustainable Development*, 65(1): 15–22. https://doi.org/10.1080/00139157.2023.2146944

Yavuz, T. & Tümenbatur, A. 2022. Sustainable Supply Chains for Bioeconomy: A Survey on Projects and Literature on Agro-Biomass. *Toros Üniversitesi İİSBF Sosyal Bilimler Dergisi*. https://doi.org/10.54709/iisbf.1175356

Annex: Survey questions - National bioeconomy context

COUNTRY NAME	
Background	
What is the agricultural land area in your country (in surface area and in the percentage of total land)?	
What are the natural conditions and major farming systems in different areas of your country? (See chapter 2.1.)	
What is the average farm size in your country? What is the most common farm size in the country?	
What are the percentages of state-owned farms, private ownership, local authorities' farms and cooperatives? Do private farmers and/or cooperatives lease state-own land?	
What are the common agricultural activities (crops, pastures, horticulture, fisheries, etc.)? What is the percent of their contribution to the sector?	
Bioeconomy analysis	
What are the international and national regulations impacting the agriculture sector in your country?	
What bioeconomy related policies, strategies, plans, laws and initiatives are present in your country?	
What sustainable agriculture approaches supporting bioeconomy are present in your country? (See chapter 4.1.)	
Please describe the sustainable approaches from the previous point with the highest development potential (no more than two). Please identify key limitations hindering their further development.	
Please describe what types of assistance are needed from FAO (data, technology, innovation, enabling environment, etc.) to address these limitations.	
Please provide any additional comments or questions.	

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