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Strategic policies and approaches towards more efficient, inclusive, sustainable and resilient agriculture to improve cropping systems' productivity and natural resource efficiency and sustainability

Executive Summary

Agrifood systems in Europe and Central Asia face substantial challenges, including climate change, environmental degradation, biodiversity loss, geopolitical instability, resource shortages and constraints among small-scale farmers. The emphasis on short-term productivity is jeopardizing ecosystems, food security, nutrition and rural livelihoods, indicating the urgent need for a fundamental shift towards more inclusive, sustainable and resilient crop production practices within the broader agenda of agrifood systems transformation.

This subtopic calls for rebalancing food production with environmental sustainability. It demonstrates how fragmented policies and on-the-ground barriers hinder progress and emphasizes that genuine change requires not only regulations but also policy coherence, effective enforcement and institutional integrity. Achieving an inclusive, sustainable and resilient agrifood system is ultimately a multifaceted challenge, requiring not only a strengthened enabling environment and effective governance with stronger regional cooperation but also a shared vision, locally adapted solutions and the adoption of innovative practices across the value chains.

Guidance sought

Members are invited to review the document, provide their feedback and share examples of their experiences. Members also may examine the recommendation in section 5, as well as the guidance for the future work of FAO, and provide their endorsement. Members also are encouraged to adopt systems-based mechanisms and approaches within their national policies to effectively balance productivity with sustainability in crop production to advance inclusive, sustainable and resilient agrifood systems in the region.

I. Introduction

1. Agriculture is a fundamental pillar of rural livelihoods, food security, nutrition and ecological stewardship in Europe and Central Asia, especially as the region experiences rapid structural and economic changes. It plays a significant role in poverty reduction, particularly in rural areas.

2. However, the current strategies for agricultural development are fragmented and do not effectively address the complex challenges facing agrifood systems. These challenges include low productivity, environmental degradation, weak climate resilience, depletion of natural resources, limited access for small-scale farmers to knowledge and modern technologies, insufficient consumer awareness, food loss and waste, and unequal economic growth. The disconnect between existing strategies, along with a lack of intersectoral coordination and inadequate integration of innovative technologies, significantly hinders the transition to sustainable, inclusive and resilient agrifood systems. This document focuses on cropping systems, emphasizing crop productivity, resource-use efficiency and resilience as critical entry points for agrifood system transformation.

3. This background document is organized into six sections. After the introduction, it outlines in section 2 the transformative challenges that will shape crop production for the future of agrifood systems. In section 3, it presents key principles for improving efficiency and sustainability in crop production. Integrated policies and approaches aimed at enhancing crop productivity, increasing natural resource efficiency and restoring ecological balance are outlined in section 4. The document concludes in section 5 with actionable policy recommendations.

II. Transformative challenges: defining the future of the agrifood system in the region

4. Europa and Central Asia are facing several interlinked challenges that threaten agrifood system transformation, jeopardizing crop production sustainably, food security, nutrition and rural livelihoods.

2.1 Inefficient crop production and dependency on external inputs

5. FAO reports[1] that unsustainable management has degraded soils and weakened ecological functions across Europe, impairing crop efficiency. The European Commission[2] adds that even farming systems in high-income countries face input-related inefficiencies, underscoring the need for better practices. Current crop practices often degrade soil and reduce yields due to monoculture farming, poor resource management, dependence on external inputs, smallholder fragmentation, unaffordable technologies and a lack of collective action. Monoculture weakens soil health, increases pest pressure and lowers climate resilience, while reliance on single crops exposes farmers to market risks.[3] Across Central Asia, countries depend either on wheat or on wheat and cotton, with limited diversification (Table 1). Overall, limited rotation dominates, and this approach is linked to further higher hidden costs.[4]

[1] **FAO.** 2023. *Sustainable use of land and water resources in Europe and Central Asia.* Forty-third Session of the European Commission on Agriculture. Budapest. https://openknowledge.fao.org/server/api/core/bitstreams/1b070f2e-0856-4a85-94fa-bd075bb2de59/content

[2] **European Commission.** 2024. *EU agricultural outlook 2024-35: A resilient sector adapts to climate change, sustainability concerns, and shifting consumer demand.* European Commission. https://agriculture.ec.europa.eu/media/news/eu-agricultural-outlook-2024-35-resilient-sector-adapts-climate-change-sustainability-concerns-and-2024-12-11_en

[3] **Mihrete, T.B. & Mihretu, F.B.** 2025. Crop Diversification for Ensuring Sustainable Agriculture, Risk Management and Food Security. *Global Challenges*, 9 (1), 202400267

[4] **Bilal, M., Mirkasimov, B., Asfaw, E. B., Djanibekov, N., Useinov, A., Rashitova, N., Rajabova, S. & Abduvalieva, N.** 2024. *Potential of crop diversification to address the hidden costs of major crop value chains in*

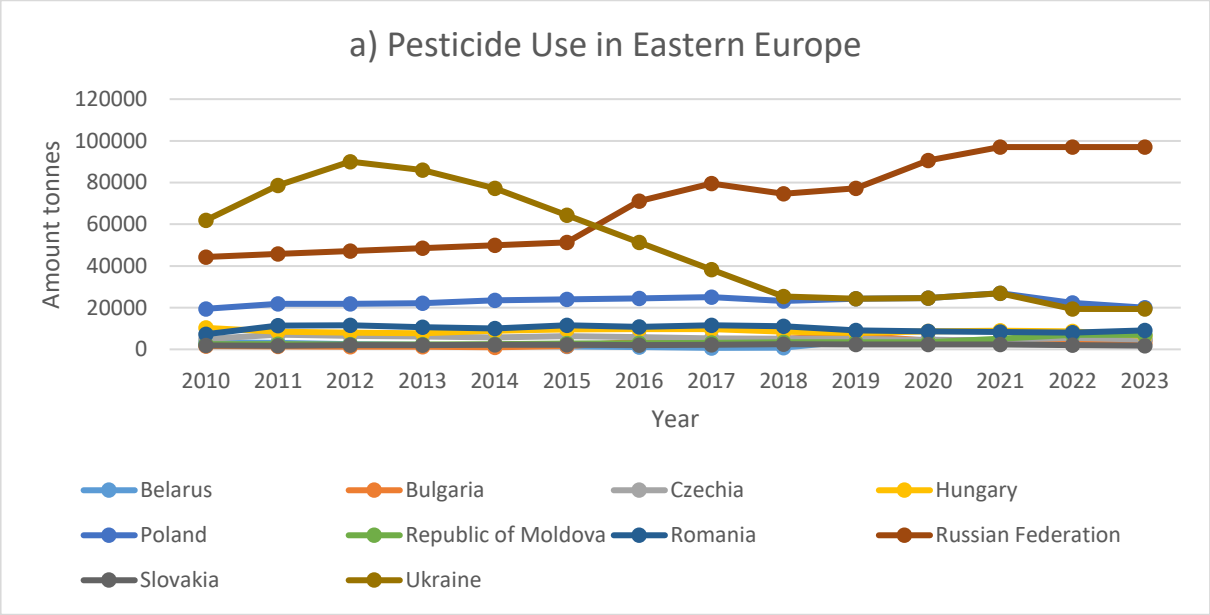
Table. 1: Share of wheat and cotton in Central Asia (% of total harvested land, 2021).

Country	Wheat %	Cotton %	A short description
Kazakhstan	~64	-	Classic monoculture centred on wheat
Kyrgyzstan	~26	-	More mixed, but wheat is still the single largest crop
Tajikistan	~30	~20	Two dominant crops, yet wheat leads
Turkmenistan	~46	~42	Near the "dual monoculture" of wheat and cotton
Uzbekistan	~37	~31	Similar dual focus, though slightly more balanced

Source: Table elaborated based on data from **Bilal, M., Mirkasimov, B., Asfaw, E. B., Djanibekov, N., Useinov, A., Rashitova, N., Rajabova, S. & Abduvalieva, N.** 2024. *Potential of crop diversification to address the hidden costs of major crop value chains in Central Asia.* Background paper for The State of Food and Agriculture 2024. Rome, FAO. https://openknowledge.fao.org/server/api/core/bitstreams/aeed944d-811c-44cf-9bdd-291a291d8340/content

Note: The percentages can vary by year.

6. Furthermore, the region's heavy reliance on external inputs, such as synthetic fertilizers and pesticides, increases its vulnerability to price volatility and supply chain disruptions. Figure 1 presents pesticide use in some Eastern European and Central Asian countries. While most Eastern European countries exhibit stable to moderately rising trends, with notable growth in Belarus and the Russian Federation, Central Asian countries show an increasing trend in pesticide use, indicating a growing dependence on them.



Central Asia. Background paper for The State of Food and Agriculture 2024. Rome, FAO. https://openknowledge.fao.org/server/api/core/bitstreams/aeed944d-811c-44cf-9bdd-291a291d8340/content

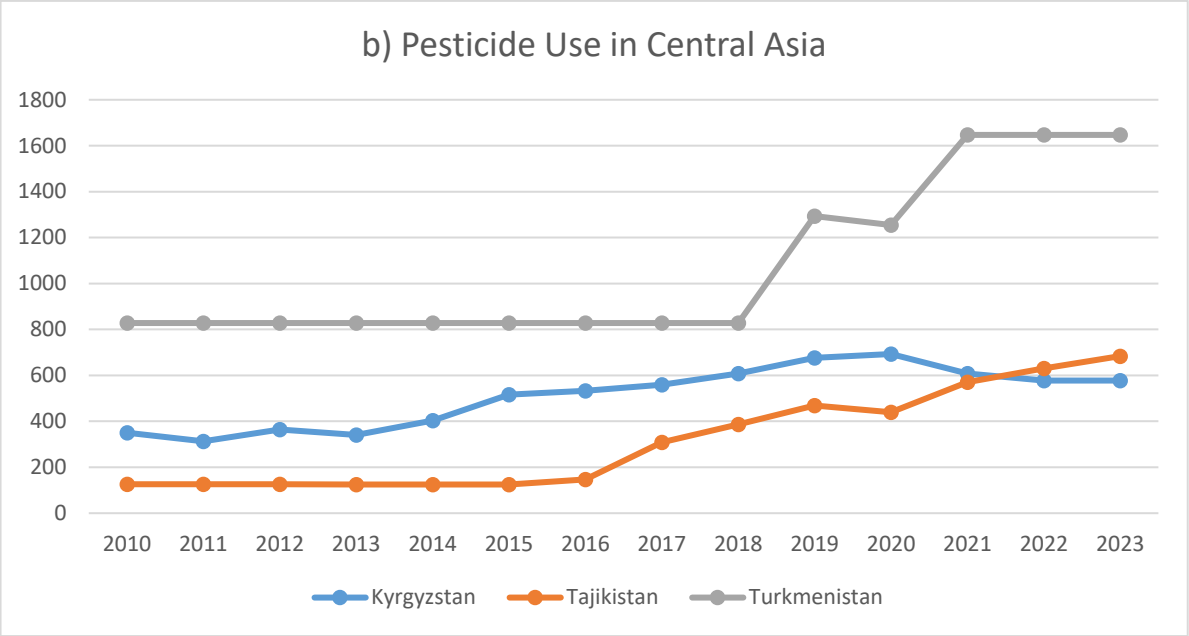


Figure 1. Pesticide use in agriculture in some a) Eastern European and b) Central Asian Countries.

Source: **FAO.** 2025. *FAOSTAT*. https://www.fao.org/faostat/en/

2.2 Climate change and water scarcity

7. Climate change poses serious region-specific threats to agrifood systems. Rising temperatures, shifting rainfall and more frequent extreme weather events are reducing yields, increasing pests and diseases, and straining traditional farming.[5,6] Significant agricultural losses are projected this century, with higher summer temperatures and less rainfall expected.[7] Southern Europe and Central Asia already face longer droughts, water shortages and rising heat risks.[7,6]

8. The Western Balkans are experiencing worsening droughts, floods and soil loss, while the South Caucasus faces increasing aridity and extreme events, affecting agriculture and biodiversity. Central Asia contends with water scarcity, drought and land degradation. The ND-GAIN[8] scores show Georgia and

[5] **IPCC.** 2023. *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press. https://www.ipcc.ch/report/ar6/syr/

[6] **World Bank.** 2010. *Adaptation to Climate Change in Europe and Central Asia Agriculture.* World Bank Documents and Reports, March 15, 2010. https://documents1.worldbank.org/curated/en/131531484889161438/pdf/111560-WP-PUBLIC-Adaptation-to-Climate-Change-in-Europe-and-Central-Asia-Agriculture.pdf

[7] **IPCC.** 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press. https://www.ipcc.ch/report/ar6/wg2/

[8] ND-GAIN stands for "Notre Dame Global Adaptation Initiative". This is a country index that measures a country's vulnerability to climate change and its readiness to adapt. A country's ND-GAIN score is composed of a vulnerability score (the lower the better) and a readiness score (the higher the better). Countries receive a composite score from 0 (worst) to 100 (best). Here the statement means that Armenia and Georgia are less vulnerable to the negative effects of climate change, whereas Azerbaijan reflects high vulnerability to water stress (a key dimension in the index) and less readiness to adapt, putting it in the "higher-risk" category. For more information, please see https://gain.nd.edu/our-work/country-index/methodology/

Armenia as less vulnerable due to diversified systems, while water-stressed Azerbaijan ranks as high risk. In Central Asia, Uzbekistan is reducing vulnerability, as is Kyrgyzstan, but Kazakhstan remains highly exposed (Figure 2).

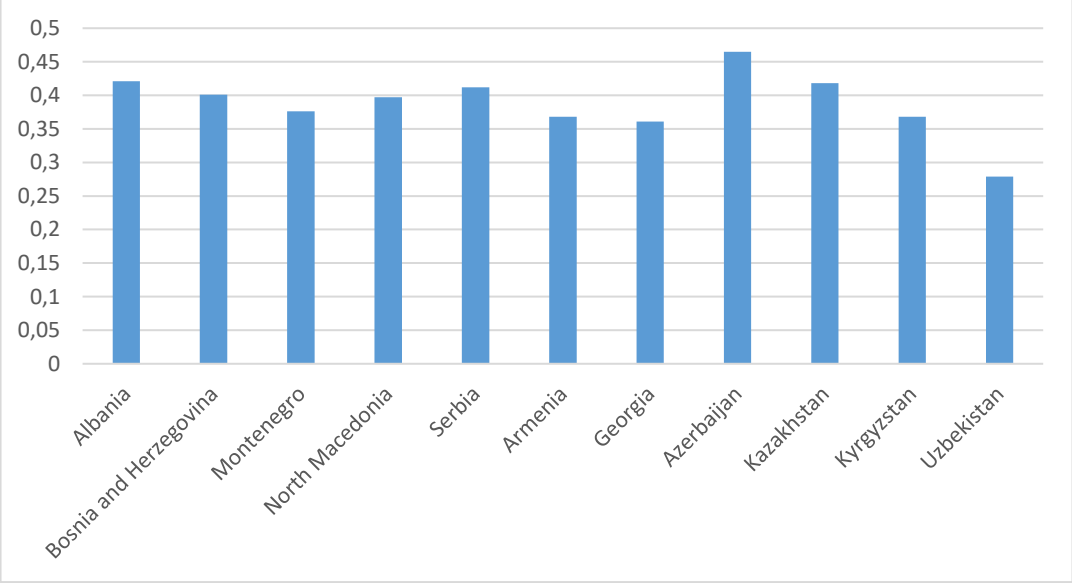


Figure 2. ND-GAIN Food Vulnerability Index for Western Balkans, Caucasus, and Central Asia countries.

Source: University of Notre Dame. 2025. Country Index. In: *ND-GAIN.* https://gain.nd.edu/our-work/country-index/

Note: The higher the score, the more vulnerable the country.

9. Water scarcity, intensified by climate change and inefficient practices, limits crop yields, restricts agricultural expansion and increases competition across sectors. In Europe overall, 60 percent of surface waters are in poor ecological status. Central Asia already faces severe scarcity from rising demand, inefficient irrigation, unreliable supply and weak infrastructure.[9,10] By 2030, nearly all countries in Central Asia and the Caucasus except Georgia are projected to face "high" or "extremely high" water stress, along with parts of Southeastern Europe, the European Union and other Eastern European countries[11].

2.3 Soil and land degradation

10. Land degradation is a major challenge across Europe and Central Asia. Unsustainable farming, deforestation and extreme weather drive soil erosion, salinization, fertility loss and desertification, reducing land productivity. A FAO report[1] notes that 60 to 70 percent of European Union soils are degraded due to poor management, weakening their ecological function. The Forty-third Session of the European

[9] **Hermans, K., Djanibekov, N., Abdullaev, I., Abduvalieva, N., Assubayeva, A., Blondin, S., Bobojonov, I., Conrad, C. *et al.*** 2024. Future research directions for understanding the interconnections between climate change, water scarcity, and mobility in rural Central Asia. *Climate and Development*, 1–10. https://doi.org/10.1080/17565529.2024.2436090

[10] **Biswas, A., Sarkar, S., Das, S., Dutta, S., Choudhury, M.R., Giri, A., Bera, B., *et al.*** 2025. Water scarcity: A global hindrance to sustainable development and agricultural production – A critical review of the impacts and adaptation strategies. *Cambridge Prisms: Water*, 3:e4. https://doi.org/10.1017/wat.2024.16

[11] **Van 't Wout, T., Celikyilmaz, G. and Arguello, C**. 2021. Policy analysis of Nationally Determined Contributions in the Europe and Central Asia region
2021. Budapest, FAO. https://doi.org/10.4060/cb7745en

Commission o Agriculture also identified land degradation and soil salinity as key threats to sustainable land use (FAO, 2023). In Central Asia, over 80 percent of agricultural land is degraded,[12] with 40 to 60 percent of irrigated land salt affected or waterlogged.[13]

2.4 Biodiversity loss and genetic resource erosion

11. Biodiversity loss and genetic resource erosion threaten agrifood systems in the region. Monocultures and dependence on a few high-yield crops and breeds reduce genetic diversity and resilience to climate change, pests and disease.[14] Moreover, dependence on imported seeds weakens local seed production, which is the cornerstone for sustainable and resilient agriculture. FAO warns[15] that while over 80 percent of food comes from plants, just nine crops provide more than 60 percent of production, exposing systemic fragility.

2.5 Policy fragmentation

12. Current agricultural strategies in many countries are fragmented, with weak coordination among the water, environment, agricultural and rural development sectors. Climate risks, biodiversity loss, water scarcity and land degradation are poorly integrated and embedded in agricultural policy. Smallholders and traditional knowledge often are excluded, while consumer awareness and market incentives for sustainability remain limited. The lack of strong policy instruments and financial incentives hinders the adoption of climate-smart and sustainable agricultural practices. Addressing these policy gaps requires integrated and inclusive approaches for agrifood system transition.

2.6 Sociodemographic shifts and urbanization

13. Demographic forces increasingly shape the sustainability of agrifood systems. Generational and gender gaps, together with rapid urban migration, now weigh as heavily on future output as soil and climate pressures, among other factors. In the European Union, just 12 percent of farms are run by managers younger than 40, and women make up a mere 3 percent of that cohort.[16]

14. Across wider Europe and Central Asia, the demographic tide is even stronger; by 2050, more than 80 percent of people are expected to live in urban areas.[17] For rural women, this means reduced access to land, credit and stable work, reinforcing poverty traps.[18] FAO warns that unmanaged rural-to-urban shifts

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[12] **Qushimov, B., Ibragimov, G., Rustamova, B., Khaitov, R., & Islam, R.** 2007. *Land Degradation Caused by Agricultural Activities in Central Asia*. In: R. Lal, M. Sulaimenov, B. Stewart, D. Hansen, & P. Doraiswamy (Eds.), Climate Change and Terrestrial C Sequestration in Central Asia. Taylor and Francis, New York. https://www.researchgate.net/publication/277131529_Land_degradation_by_agricultural_activities_in_Central_Asia_In_Climate_Change_and_Terrestrial_C_Sequestration_in_Central_Asia

[13] **FAO.** 2020. Capacity development program in Central Asia on Soil salinity mapping and soil fertility restoration. In: *Global Soil Partnership*. [Cited 15 July 2025]. https://www.fao.org/global-soil-partnership/resources/highlights/detail/en/c/1306719/

[14] **FAO.** 2020. *FAO Strategy on Mainstreaming Biodiversity across Agricultural Sectors.* Rome. https://doi.org/10.4060/ca7722en

[15] **FAO.** 2025. *The Third Report on the State of the World's Plant Genetic Resources for Food and Agriculture.* https://openknowledge.fao.org/server/api/core/bitstreams/14a2bc63-fbdd-4a78-b974-e5b008cbdf7a/content

[16] **European Commission.** 2025. Young people in agriculture and rural areas. In: *Agriculture and rural development.* https://agriculture.ec.europa.eu/overview-vision-agriculture-food/young-people-agriculture-and-rural-areas_en

[17] **ESSRG.** 2024. Transforming Urban Food Systems in Europe and Central Asia. In: *ESSRG.* https://www.essrg.hu/en/transforming-urban-food-systems-in-europe-and-central-asia/

[18] **FAO.** 2025. Rural women are the backbone of agrifood systems across Europe and Central Asia. In: *FAO Regional Office for Europe and Central Asia.* https://www.fao.org/europe/news/detail/rural-women-are-the-backbone-of-agrifood-systems-across-europe-and-central-asia/en

can lock food systems into long, emission-heavy supply chains and nutrient-poor diets.[19] As city boundaries advance, peri-urban farmland is squeezed, and production is pushed deeper into remote zones, converting new land and adding cost and risk to rural livelihoods.[20]

15. Across all these challenges, smallholders remain the most vulnerable group. Limited access to land, water, finance, inputs, trainings, technology and infrastructure[21] reduced their ability to adapt to climate change, diversify production and benefit from sustainable incentives. These constraints are further challenged by weak knowledge transfer systems, inefficient extension services and limited access to innovation and technology. Unless these barriers are addressed in a systematic way, smallholders will continue to face declining productivity and rising risks, undermining progress toward resilient, inclusive and sustainable agrifood systems in the region.

III. Key principles for enhancing efficiency and sustainability in crop production

16. The following key principles are essential for boosting productivity, conserving resources and reducing environmental impacts and greenhouse gas emissions. A monitoring system and governance mechanism are vital for the long-term viability of farmers and ecosystems.

3.1 Water-energy use efficiency in crop production

17. Building sustainable and resilient agrifood systems in Europe and Central Asia depends on improving water and energy efficiency in crop production. This includes precision irrigation, renewable energy integration, and energy-efficient technologies – key for reducing costs and environmental impact amid climate stress and growing demand.[22]

18. Precision irrigation is central to water efficiency. Applying water at optimal times and amounts matches crop needs, reducing waste.[23] Soil moisture sensors, remote sensing and delivery systems such as drip, micro-sprinkler and subsurface irrigation reduce water loss. Even moderate stress can improve crop quality.[24]

19. Water use in the region could drop 30 to 70 percent while boosting yields.[1] Through rotations and intercropping, diversified cropping systems improve soil health, reducing irrigation needs.[25] Recycled

[19] **FAO, IFAD, UNICEF, WFP & WHO.** 2023. *The State of Food Security and Nutrition in the World 2023: Urbanization, agrifood-systems transformation and healthy diets across the rural–urban continuum.* https://doi.org/10.4060/cc3017en

[20] **FAO, IFAD, UNICEF, WFP & WHO.** 2024. *The State of Food Security and Nutrition in the World 2024 – Financing to end hunger, food insecurity and malnutrition in all its forms.* Rome. https://doi.org/10.4060/cd1254en

[21] **FAO.** 2022. *Territorial approaches and community development to drive local change and prevent all forms of malnutrition.* Forty-second Session of the European Commission on Agriculture. https://openknowledge.fao.org/server/api/core/bitstreams/f7376dfd-3f7d-40f1-8730-fcff3ecb3cac/content

[22] **Francisco, É.C., Ignácio, P.S. de A., Piolli, A.L. & Dal Poz, M.E.S.** 2023. Food-energy-water (FEW) nexus: Sustainable food production governance through system dynamics modeling. *Journal of Cleaner Production*, 386, 135825. https://doi.org/10.1016/j.jclepro.2022.135825

[23] **European Commission.** 2025. *European Water Resilience Strategy.* Brussels, European Commission. https://environment.ec.europa.eu/publications/european-water-resilience-strategy_en

[24] **Gruda, N.S., Gallegos-Cedillo, V.M., Nájera, C., Catalina, E.G., Ochoa, J. & Fernández, J.A.** 2025. Advancing Protected Cultivation: A Pathway for Nutrient-Rich Vegetables. *Critical Reviews in Plant Sciences*, 44(2), 88–116. https://doi.org/10.1080/07352689.2025.2515801

[25] **European Commission.** 2025. Sustainable agricultural practices and methods. In: *Agriculture and rural development.* https://agriculture.ec.europa.eu/cap-my-country/sustainability/environmental-sustainability/sustainable-agricultural-practices-and-methods_en

wastewater and rainwater also ease freshwater pressure. Efficient irrigation reduces energy needs, and solar-powered systems support pumping and climate control.[26]

20. Across the region, agrifood systems depend heavily on fossil-based electricity and fuels, driving greenhouse gas emissions, while rural areas often lack decentralized and renewable solutions, despite significant potential. In 2023, the 27 countries of the European Union sourced 44.7 percent of their electricity from renewable sources (primarily wind, hydro and solar), including hydropower in Norway and wind in the United Kingdom of Great Britain and Northern Ireland. The Western Balkans remain dependent on coal. Georgia relies on hydropower; Armenia on gas, nuclear and hydropower (with solar plans); and Azerbaijan on gas. Central Asia mixes hydropower with fossil fuels but is expanding solar and wind. Türkiye is increasing its renewable energy sources but still relies on coal and gas.

21. On-farm renewables enhance self-sufficiency and cut emissions. The European Union's Common Agricultural Policy supports renewables through eco-schemes and strategic plans.[27] Biogas and wind power are expanding, backed by Central Asian investments.[28,29]

22. The conservation tillage cuts fuel use and compaction. Electric tractors and clean fuels such as hydrogen and biomethane are gaining ground in Europe, though still emerging in Central Asia, the Western Balkans and the Caucasus.[30,31]

3.2 Improve soil health and reduce external input dependence

23. Improving soil health and reducing external inputs are essential for sustainable and resilient agrifood system. The European Union Agricultural Outlook 2024–2035 highlights that precision farming and sustainable practices, including shifts to pulses, can lower emissions and nutrient surpluses by 2035.[2] Raising soil organic matter enhances nutrient cycling, water retention and microbial life. Practices such as cover cropping, residue retention, composting and reduced tillage improve fertility and reduce dependence on synthetic inputs. Organic farming can reduce nitrate leaching by 28 to 39 percent and increase organic matter by 35 percent, enhancing water retention, soil health, drought tolerance and yields.[32] Soil carbon

[26] **Dhonde, M., Sahu, K. & Murty, V.V.S.** 2022. The application of solar-driven technologies for the sustainable development of agriculture farming: a comprehensive review. *Reviews in Environmental Science and Bio/Technology*, 21, 139–167. https://doi.org/10.1007/s11157-022-09611-6

[27] **European Commission.** 2025. CAP at a glance. In: *Agriculture and rural development.* https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en

[28] **REN21.** 2025. *Renewables 2025 global status report.* https://www.ren21.net/gsr-2025/downloads/pdf/go/GSR_2025_GO_2025_Full_Report.pdf

[29] **Modern Diplomacy.** 2025. Central Asia's Renewable Energy Drive: A Strategic Pivot Towards Sustainability. In: *Modern Diplomacy.* https://moderndiplomacy.eu/2025/06/23/central-asias-renewable-energy-drive-a-strategic-pivot-towards-sustainability/

[30] **GlobeNewswire.** 2025. Europe Electric Tractor Market Industry Report 2025-2030: Germany, France, Italy, U.K. and Netherlands are Emerging as Key Markets Spearheading the Transition to Greener Agricultural Practices. In: *GlobeNewswire.* [Cited 30 June 2025]. https://www.globenewswire.com/news-release/2025/04/09/3058608/28124/en/Europe-Electric-Tractor-Market-Industry-Report-2025-2030-Germany-France-Italy-U-K-and-Netherlands-are-Emerging-as-Key-Markets-Spearheading-the-Transition-to-Greener-Agricultural-Pr.html

[31] **BusinessWire.** 2025. Germany Tractors Market Report 2025-2030, with Key Company Profiles for AGCO, CNH Industrial, Deere & Company, Kubota, CLAAS KGaA and SDF. In: *BusinessWire.* [Cited 30 June 2025]. https://www.businesswire.com/news/home/20250630914066/en/Germany-Tractors-Market-Report-2025-2030-with-Key-Company-Profiles-for-AGCO-CNH-Industrial-Deere-Company-Kubota-CLAAS-KGaA-and-SDF---ResearchAndMarkets.com

[32] **IFOAM Organics Europe.** 2025. *Executive Summary - Organic farming as a solution to the water crisis.* https://www.organicseurope.bio/content/uploads/2025/03/IFOAMEU_policy__water-resilience_briefing_FINAL_20250325.pdf

sequestration boosts productivity and climate mitigation,[33] while large-scale restoration enhances resilience.[34]

24. Integrated nutrient management supports microbial health, balances soil nutrients, and strengthens crop resilience to climate stress.[35] It also stabilizes yields, reduces costly fertilizers and lowers pollution.[36] The Green Deal targets 25 percent organic farmland by 2030,[37] but in the Western Balkans, organic farming covers just 2.56 percent of agricultural land.[38]

3.3 Enhance biodiversity for food and agriculture

25. The Caucasus and Central Asia, historically part of Vavilov's centres of origin, are renowned for fruit, nut, and vegetable agrobiodiversity.[39] The conservation and sustainable use of biodiversity is key for regional food production and crucial for an ecosystem's resilience to disturbances. FAO emphasizes integrating biodiversity into policies and practices, including the national biodiversity strategies and action plans and their alignment with the Kunming-Montreal Global Biodiversity Framework. The European Union Biodiversity Strategy for 2030 promotes crop diversification and rotations to restore soil health and biodiversity.

26. Diversified cropping enhances soil fertility by raising carbon and nitrogen levels and boosting microbial activity, especially among nitrogen fixers and ammonia oxidizers.[40]

27. Locally adapted, genetically diverse and climate-resilient crops and landraces are increasingly valued for improved nutrition, reduced emissions and diversified production. Climate-smart crops such as quinoa, sesame, lupine, lentils[41] and millets offer resilience under harsh growing conditions.

3.4 Education and capacity building for sustainable and resilient agrifood system

28. Empowering smallholders, youth and women farmers and advisers with knowledge in sustainable and resilient agricultural practices – e.g. agroecology, regenerative agriculture and precision farming – and

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[33] **Lal, R.** 2004. Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. *Science* 304, 1623, doi: 10.1126/science.1097396

[34] **Bossio, D.A., Cook-Patton, S.C., Ellis, P.W., Fargione, J., Sanderman, J., Smith, P., Wood, S. *et al.*** 2020. The role of soil carbon in natural climate solutions. *Nature Sustainability*, 3(5), 391–398. doi:10.1038/s41893-020-0491-z

[35] **Amanullah, Ondrasek, G. & Al-Tawaha, A.R.** 2023. Editorial: Integrated nutrients management: an approach for sustainable crop production and food security in changing climates. *Frontiers in Plant Science*, 14. https://doi.org/10.3389/fpls.2023.1288030

[36] **Selim, M.M.** 2020. Introduction to the Integrated Nutrient Management Strategies and Their Contribution to Yield and Soil Properties. *International Journal of Agronomy*, 2020, 2821678. https://doi.org/10.1155/2020/2821678

[37] **European Environment Agency.** 2023. *How pesticides impact human health and ecosystems in Europe.* European Environment Agency. https://www.eea.europa.eu/publications/how-pesticides-impact-human-health

[38] **Pavlović, A.S. & Jovanović, L.** 2025. Economic indicators of effectiveness and efficiency with a focus on the development of organic production in the Western Balkans. *Ecologica*, Vol. 32(118), 143-149. https://doi.org/10.18485/ecologica.2025.32.118.8

[39] **Vavilov, N.I.** 2009. *Origin and geography of cultivated plants.* Translated by Doris Löve. Cambridge University Press.

[40] **Liu, B., Ahnemann, H., Arlotti, D., Huyghebaert, B., Cuperus, F. & Tebbe, C.C.** 2024. Impact of diversified cropping systems and fertilization strategies on soil microbial abundance and functional potentials for nitrogen cycling. *Science of The Total Environment*, 932, 172954. https://doi.org/10.1016/j.scitotenv.2024.172954

[41] **Heinz, M., Sager, A., Wenzl, P. & Schmalzbauer, I.** 2024. How to find alternative crops for climate-resilient regional food production. *Agricultural Systems*, 213, 103793. https://doi.org/10.1016/j.agsy.2023.103793

climate and sustainable finance is crucial for building a sustainable and resilient agrifood system. Education and advisory services help farmers value ecosystem services.[42] It is crucial to integrate sustainability and climate-smart practices into the curricula of educational institutions to prepare future professionals for food, energy and water systems challenges.[43] Participatory models – such as Farmer Field Schools in Azerbaijan, Kyrgyzstan, Montenegro, Republic of Moldova, Türkiye and Uzbekistan – promote peer learning and the hands-on adoption of climate-resilient practices.

29. Institutional capacity building is as essential as access to environment and climate finance. The European Union Strategic Dialogue on Agriculture[44] calls for stronger advisory services, integrated sustainability in curricula, and interdisciplinary approaches through farmer networks and demonstration farms. Agricultural extension services in Central Asia, the Caucasus and the Western Balkans still need substantial development to offer comparable advisory support and foster knowledge transfer at scale.

3.5. Monitoring

30. Building a sustainable and resilient agrifood system demands robust monitoring systems and sound governance. In Europe, the modernized Common Agricultural Policy will expand the Farm Accountancy Data Network in 2025 to track fertilizer, pesticide, water and energy use on roughly 80 000 farms.[45] These richer data streams should sharpen evidence-based policymaking and reinforce the sustainability goals set by the European Parliament and Commission.[46,2] Central Asia starts from a different point, hampered by "scarce climate observation networks" that weaken forecasts of climate impacts on crops.[47] Closing these data and capacity gaps requires transboundary cooperation and targeted training.[48]

3.6. Governance and intersectoral policy coherence

31. Strengthening intersectoral policy coherence is critical to avoid fragmented approaches and contradictory incentives across agrifood systems. Aligning agriculture, water, energy, environment, trade and rural development policies ensures that measures in one sector do not undermine progress in another – for example, subsidies for water- or energy-intensive crops that conflict with climate and biodiversity goals. Improved coherence can unlock synergies, enhance resource efficiency and provide a stable policy environment that encourages investment in sustainable practices, ultimately reinforcing resilience and competitiveness in agrifood systems across the region.

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[48] **GIZ.** 2024. *Climate Risk Management in Central Asia.* https://www.giz.de/de/downloads/giz2024-april-en-factsheet-CRM.pdf

IV. Integrated policies, approaches and innovative technologies for balancing crop productivity and sustainability

32. Achieving sustainable and resilient agrifood systems requires integrated policies,[49] inclusive governance, sustainable practices, innovative technologies and coordinated finance tailored to the national context that can mitigate climate change impacts, withstand climate shocks and support long-term food and nutrition security. This integration is critical because isolated sustainability policies often have limited impact if not embedded in broader governance frameworks.

33. At the European Union level, the European Green Deal and its Farm to Fork Strategy set ambitious targets for 2030: halving the use and risk of hazardous pesticides, reducing fertilizer use by 20 percent and nutrient losses by 50 percent, halving antimicrobial use in livestock, and converting at least 25 percent of farmland to organic. Reaching these goals demands strong intersectoral coordination, significant investments in sustainable farming, and the deployment of modern technologies. However, progress varies among Members due to differences in agricultural structures and adoption capacities.

34. Countries in the Western Balkans, the Caucasus and Central Asia are initiating similar principles. Western Balkans economies align national programmes with Green Deal priorities, and Eastern partners are redirecting public farm support to water conservation, soil restoration and food safety. For example, Central Asia's 2024 regional strategy, led by an Inter-Governmental Working Group, targets water scarcity and land degradation.

35. Living labs are emerging as an effective approach for integrating diverse stakeholders – end users, researchers, private-sector actors and policymakers – to address development challenges. These labs are essential for transitioning towards sustainable agrifood systems by fostering co-creation, rapid prototyping and scaling innovations that benefit all parties involved. FAO has piloted this approach in Uzbekistan and Tajikistan through the Digital Village Initiatives.[50] However, living labs are not the only solution for co-innovation. Other multistakeholder approaches also are effective and should be acknowledged.

4.1. Sustainable and resilient agrifood systems through integrated approaches

36. Building sustainable agrifood systems in Europe and Central Asia requires a shift from fragmented interventions to integrated, systemic solutions and holistic approaches across the entire agrifood chain.

37. Climate-smart agriculture provides an approach to boosting productivity, enhancing resilience and cutting farm-sector emissions.[51] Integrating climate-smart agriculture into national budgets and mandates means replacing blanket subsidies with targeted grants, soft loans and payments for ecosystem services.

[49] Integrated policies can be understood as holistic approaches that align actions across multiple sectors such as agriculture, environment, health, social protection and trade to create a coherent enabling environment and avoid fragmented interventions. For more, please see: https://www.policycoherencehandbook.eu/what-is-policy-coherence/policy-coherence-and-related-topics

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38. Practices such as crop rotation, integrated pest and nutrient management, conservation tillage, agroforestry and landscape planning deliver productivity, resilience and mitigation.[52]

39. Agroecology is a holistic approach to food system transformation that blends scientific and traditional knowledge to create context-specific solutions guided by its ten elements, addressing environmental, social and economic challenges in alignment with the Sustainable Development Goals (SDGs).[53] Closely related to climate-smart agriculture and agroecology is climate-smart soil and ecosystem management.[54] Integrated pest management shows that pesticide use can decline without yield loss, supported by cross-border cooperation.[55] Emerging technologies also are key. Precision agriculture boosts input efficiency through data-driven decisions, while controlled environment systems – such as soilless culture, aquaculture and vertical farming – address land and water constraints. Circular practices such as manure recycling in crop–livestock systems cut fertilizer costs and close nutrient cycles, embracing waste-to-energy solutions, nutrient recovery and integrated crop–livestock–aquaculture systems[56] across the entire agrifood chain.

40. Conservation agriculture, grounded in minimal soil disturbance, permanent cover and crop rotation, mimics natural ecosystems to restore and maintain soil productivity[57]. Wider adoption of conservation agriculture could be encouraged through targeted grants, soft loans and tailored extension services aligned with sustainability goals.

41. Building on conservation agriculture, regenerative agriculture redesigns farming systems to restore carbon, biodiversity and water functions while maintaining yields.[58] Its principles align with the European Union Green Deal and Farm to Fork Strategy.

42. Circularity should expand beyond manure recycling to embrace waste-to-energy solutions, nutrient recovery and integrated crop–livestock–aquaculture systems.

43. While integrated farming practices and technological innovations are critical, a systemic transformation also depends on enabling market and economic incentives, inclusive governance and resilient financing.

44. Sustainable agricultural practices need to be made attractive through mechanisms such as premium pricing, carbon credits, green insurance schemes and payments for ecosystem services, which require repurposing subsidies and aligning financial flows with sustainability goals. The paper on unlocking

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[58] **Van den Hoorn, H., Jellema, A., van Dam, D., Pessers, R., Geerling-Eiff, F. & Manshanden, M.** 2024. *Regenerative Agriculture in the EU: Exploring the Transition.* Wageningen Economic Research Report 2024-141. https://doi.org/10.18174/680029

sustainable and inclusive finance (ECA/44/25/6) states the need to boost inclusive and green finance, strengthen public–private partnerships, and create supportive policies.

45. Resilience also should be understood in a broader sense, addressing not only climate but also economic, market and social shocks. Achieving this vision demands strong intersectoral policy coherence across agriculture, water, energy, environment, trade and rural development; robust monitoring and digital data systems for adaptive management; and scaling pathways such as farmer networks, demonstration farms and participatory extension models that accelerate adoption.

46. These approaches must align sustainable policies, practices and technologies with broader climate and environmental goals. The European Union Common Agricultural Policy illustrates how a unified policy framework can integrate sustainability, resilience and competitiveness, providing lessons for other countries in the region.

4.2. Innovative technologies and tools in the cropping systems

47. Developing high-yielding, nutrient-dense and stress-tolerant crop varieties is vital for resilient agrifood systems in Europe and Central Asia.[59] These traits improve tolerance to drought, heat, salinity, pests and diseases, ensuring food security. Advanced and speed breeding and gene-editing tools offer faster, targeted improvements,[60] though European Union regulations remain restrictive.

48. The International Atomic Energy Agency (IAEA) supports mutation breeding in the region to develop varieties resilient to drought, heat and salinity. This aligns with the 2022–2027 Regional Profile for Europe and Central Asia, which prioritizes isotope and radiation technologies.[61] In 2023, the IAEA assisted several countries in aligning crop development with climate adaptation and market needs.

49. “Innovation is not only the most sophisticated technology, sometimes it’s the simplest of things”, said United Nations Secretary-General Antonio Guterres. Frugal innovation has emerged as a transformative approach that focuses on resource efficiency, affordability and accessibility. In the context of agriculture, it involves developing simple, low-cost and effective solutions to enhance farming practices, particularly in resource-limited areas.[62] An example is the artificial glaciers in Kyrgyzstan, which provide water for food production. Evidence shows that packages combining nature-based, policy and financial innovations with technology yield the highest impact.[63]

4.3. Challenges and opportunities in scaling up integrated policies

50. The transition to sustainable and resilient agrifood systems depends on the design and implementation of integrated policies that balance productivity with environmental sustainability. Such policies must address multiple objectives simultaneously – improving crop yields, conserving resources and safeguarding ecosystems – while ensuring fairness and inclusiveness.

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[62] **Alexandrova-Stefanova, N., Nosarzewski, K., Mroczek, Z.K., Audouin, S., Djamen, P., Kolos, N. & Wan, J.** 2023. *Harvesting change: Harnessing emerging technologies and innovations for agrifood system transformation – Global foresight synthesis report.* Rome, FAO and Cirad. https://doi.org/10.4060/cc8498en

[63] **FAO.** 2025. Regional Technical Platform on Green Agriculture. In: *Food and Agriculture Organization of the United Nations*. https://www.fao.org/platforms/green-agriculture/en

51. Agri-environmental policies demonstrate how coherent frameworks can reduce fertilizer use, lower pesticide risks and improve soil management without compromising yields.

52. However, fragmented or poorly enforced measures often shift environmental pressure elsewhere or undermine farm incomes. The European Union experience shows both the potential and the limitation of integrated policies: While reforms have cut fertilizer use substantially, conflicting subsidies and market incentives continue to drive intensive practices.[64]

53. Similar tensions also are observed in Central Asia and the Western Balkans, where ambitious strategies face uneven outcomes due to weak enforcement, outdated data and limited advisory services.

54. Scaling up integrated policies require overcoming three key barriers:

- **Incentive structures:** Farmers often remain locked into input-intensive models without financial mechanisms such as payments for ecosystems services, carbon credits or premium markets for sustainable products.
- **Institutional capacity:** Weak governance, fragmented responsibilities and insufficient monitoring systems reduce policy effectiveness.
- **Equity and participation:** Smallholders, women and youth face greater constraints in accessing finance, technology and decision-making platforms, limiting the inclusiveness of policy outcomes.

55. At the same time, there are opportunities to build momentum. Integrated approaches such as climate-smart Agriculture, agroecology and conservation farming can be scaled though demonstration farms, farmer networks and living labs. Embedding these practices in National Adaptation Plans and nationally determined contributions offers a pathway to mainstream sustainability into broader development strategies.

56. Ultimately, integrated policies are not only about technological measures but also about governance and incentives. Aligning agriculture, environmental and trade frameworks, ensuring enforcement, and supporting farmers with financial and knowledge-based tools will be critical for accelerating the shift towards resilient agrifood systems.

V. Conclusion and policy recommendations

57. Agrifood systems in Europe and Central Asia face interlinked challenges that need urgent action. Decades of prioritizing short-term productivity enhancement have contributed to environmental degradation, climate vulnerability and geopolitical instability – undermining food security, rural livelihoods and ecosystems.

58. Transformation cannot rely on technology alone; it requires coherent, integrated and inclusive policy frameworks, supported by governance mechanisms that ensure enforcement, equity and long-term impact. While recent initiatives like the Green Deal emphasize environmental safeguards, ensuring food security and nutrition demand over the long term requires better integration between productivity goals and environmental limits. Current policies often incentivize high yields through intensive chemical use, unintentionally undermining environmental goals.

59. This calls for coordinated reforms in policy, innovation and consumer behaviour, supported by collaboration among governments, researchers, farmers and civil society.

[64] **Brunelle, T., Chakir, R., Carpentier, A., Dorin, B., Goll, D., Guilpart, N., Maggi, F., et al.** 2024. Reducing chemical inputs in agriculture requires a system change. *Commun Earth Environ* 5, 369 (2024). https://doi.org/10.1038/s43247-024-01533-1

60. Holistic and integrated agricultural approaches and innovative policies are needed to enhance both productivity and sustainability while addressing institutional and regulatory barriers.

61. Transformational integrated farming approaches – such as climate-smart agriculture, integrated soil fertility management, integrated pest management, integrated crop–livestock–aquaculture systems and agroecology – offer scalable solutions to enhance resilience, improve yields, reduce environmental pressure and secure livelihoods, especially for smallholders with limited access to finance, technology and knowledge.

62. Achieving a sustainable balance is a governance challenge. More regulations aren't the solution; success relies on policy coherence, enforcement, institutional integrity and inclusive, adaptive processes. It requires co-design, learning and a shared long-term vision across sectors and borders.

Key policy recommendations for Europe and Central Asia

63. To transform agrifood systems in Europe and Central Asia into more efficient, inclusive, sustainable and resilient systems, Members should pursue integrated, coherent and multilevel policy approaches:

- Integrate agriculture, environment, water, energy, trade and rural development policies using a systems approach. Aligning these sectors will eliminate contradictory incentives, such as subsidies that encourage unstainable practices, and unlock synergies that enhance resource efficiency, resilience and competitiveness.

- National strategies must be combined with decentralized, locally adapted solutions. Local governance and community-level innovation are essential to ensure that policies reflect the diverse agroecological and socioeconomic context of the region. Empowering smallholders, women and youth in decision-making will strengthen inclusiveness and ensure that transformation benefits those who depend the most on agriculture for their livelihoods.

- Regional coordination should be promoted to address transboundary challenges such as water scarcity, land/soil degradation and biodiversity loss. Shared platforms and cooperative mechanisms can harmonize approaches, facilitate cross-border learning and enhance collective resilience to climate and market shocks.

- Monitoring and data systems must be strengthened to provide a robust evidence base for policymaking. Investment in digital platforms, harmonized indicators and regional data-sharing arrangements will enable countries to track progress, anticipate risks and design adaptive strategies.

- Governments should create enabling incentives for sustainable practices. Repurposing subsidies, payment for ecosystems services, carbon markets and green insurance schemes can make sustainability economically attractive, and mobilizing targeted public and private investment will accelerate the adoption of innovative solutions.

- Capacity development and scaling mechanisms are essential. Farmer Field Schools, innovation labs and farmer networks should be expanded to spread integrated practices such as climate-smart agriculture, agroecology and regenerative approaches. Embedding these practices into National Adaptation Plans and nationally determined contributions will further mainstream sustainability into broader development strategies.

64. FAO, through its Strategic Framework and the four betters, as well as the regional priorities, can support Members in Europe and Central Asia in advancing sustainable and resilient agrifood systems.

65. Building on its normative, technical and convening function, FAO can help governments translate these policy priorities into practice. The following are actions for FAO to address:

- Continue to provide policy advice and technical assistance to align national agricultural, climate and environmental frameworks with FAO's four betters, the Rio Conventions and the SDGs. This includes integrating climate risk assessments, biodiversity objectives and sustainable input management into national sectoral strategies, ensuring that productivity targets and long-term sustainability are balanced.
- Strengthen governance and inclusiveness by facilitating multistakeholder dialogues at national and regional levels. Through these platforms, smallholders, women and youth can actively contribute to the shaping of agrifood polices. FAO could assist Members in developing governance mechanisms that connect local issues with national strategies and foster regional cooperation, ensuring that decision-making is transparent, participatory and accountable.
- Strengthen institutional and human capacities by scaling up Farmer Field Schools, innovation policy labs, vocational training and extension and advisory services to promote integrated farming practices such as climate-smart agriculture, agroecology, regenerative practices, integrated pest and nutrient management, efficient water-use technologies and nature-inspired, community-based and frugal innovations.
- Facilitate intersectoral coordination by supporting multistakeholder platforms – such as the Regional Technical Platform on Green Agriculture and the Regional Land Degradation Neutrality Decision Support System – that connect the agriculture, water, environment and rural development sectors, fostering integrated approaches to address challenges such as water scarcity, land degradation and biodiversity loss.
- Support the scaling up of innovations and technologies through technical cooperation projects, demonstration farms and South-South cooperation, enabling the transfer and adaptation of precision agriculture tools, renewable energy solutions, stress-tolerant crop varieties and nature-based solutions. Expanding Farmer Field Schools, innovation labs and living labs will accelerate the adoption of integrated practices such a climate-smart agriculture, agroecology and regenerative farming. Support also could be provided to vocational training and extension and advisory services to build the human capacity needed for the agrifood systems transformation.
- Work with the Members to enhance data and monitoring systems. By supporting the development of agri-environmental monitoring frameworks, harmonizing indicators and building digital platforms, FAO will help governments track resource use, climate risks and sustainability outcomes. Regional knowledge exchange and capacity development in data collection and analysis will further strengthen evidence-based decision-making.