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The role of innovation and digitalization in the sustainable use of natural resources to accelerate the implementation of climate-resilient and low-emission pathways in agrifood systems

Executive Summary

This background document examines the central role of innovation and digitalization in advancing the realization of climate-resilient and low-emission pathways within agrifood systems. It emphasizes their significance in enabling and catalysing sustainable natural resource management, which includes land, forests and water resources. By exploring existing solutions and innovations, the document provides an overview of the landscape of interventions in the Europe and Central Asia region, while highlighting challenges and risks associated with their adoption and scale-up potential. Additionally, the document outlines recommendations for FAO, serving as a strategic guide for harnessing the full potential of innovation and digitalization. These recommendations chart a course for sustainable land, water and forest management towards realizing climate-resilient and low-emission pathways in agrifood systems.

Suggested action by the Regional Conference

The Regional Conference is requested to review the document and call upon Members to:

a. promote harmonized and adaptive policy frameworks to create a responsible and equitable enabling environment for innovation and digitalization in natural resource management and climate action, while ensuring the safe and productive use of emerging technologies;

b. catalyse investments in digital public infrastructure, develop institutional and human capacities, and implement incentive structures and support mechanisms to facilitate the widespread adoption of innovative practices and digital technologies to reduce emissions and utilize natural resources sustainably, especially for smallholders and vulnerable groups;

c. promote capacity development of agricultural innovation systems for co-creation and to bridge the gaps among scientific advancements, innovative technologies and their adoption for sustainable use of natural resources, and

d. encourage research and development in climate-smart technologies, and harness public-private partnerships to translate advancements into practical solutions.

In supporting the implementation of the aforementioned recommendations, the Regional Conference is invited to request FAO to:

a. lead intersectoral engagement for improved governance of water, land and forest resources, fostering knowledge exchange, collaboration and the development of harmonized policies for an innovation-friendly environment, and emphasizing sustainable and inclusive technologies that leave no one behind;

b. accelerate the implementation of flagship initiatives, such as the 1000 Digital Village Initiative, to address the rural digital divide and invest in democratizing technologies as digital public goods, enhancing accessibility and fostering equitable digital opportunities; and

c. expand climate change support for resilience, adaptation and emission reduction, aligning with the FAO Strategy on Climate Change 2022–2031 and its Action Plan (2022–2025), and the FAO Science and Innovation Strategy.

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I. Introduction

1. The natural resources that contribute to global agrifood systems are at risk of depletion and degradation. By 2050, the agriculture sector will need to produce 56 percent more food compared to 2010 to feed a growing global population,[1,2] while crop yield could decrease by up to 30 percent.[3,4] Land degradation, desertification, drought and land abandonment can lead to erosion, decreased soil quality, depletion of nutrients and drops in groundwater levels. Unhealthy soils release more greenhouse gases into the atmosphere and lead to a decrease in yields.[5] The World Bank estimates that economic damage from droughts and floods in Central Asia could reach up to 1.3 percent of the gross domestic product per year. Water scarcity is also an issue, especially for the Central Asian region; by 2030, every country in Central Asia and the Caucasus other than Georgia is expected to be experiencing high or extremely high water stress.[6] The lack of coordination across water, agriculture and forestry has led to a lack of integration and poor management of watersheds.[7] It is urgent that the implementation of climate-resilient, low-emission and nature-positive pathways in the agrifood sector be expedited. These measures are critical for effectively addressing the spectrum of challenges the world and the Europe and Central Asia region are facing.

2. This document examines the central role of innovation and digitalization in advancing climate-resilient and low-emission pathways for agrifood systems transformation, with international examples and those that are specific to the Europe and Central Asia region. In particular, it focuses on digital solutions and innovative policies, processes and knowledge-sharing practices for better management of water, land and forestry resources. While the management of resources related to livestock has an important role in agrifood systems and low-carbon pathways, it is not within the scope of this document.

3. Specifically, Section II highlights key regional trends and challenges. Section III examines the role of innovation and digitalization in advancing climate-resilient and low-emission pathways within agrifood systems. Section IV explores existing solutions and best practices, offering insights from international and regional initiatives. Section V addresses challenges and risks in implementing innovation and digitalization, highlighting potential barriers. Section VI provides recommendations to Members for overcoming challenges and embracing opportunities, including infrastructure gaps, funding limitations, inadequate capacities, policy support and limited enforcement. Finally, Section VII presents a call to action for FAO, outlining specific collaboration areas to support sustainable agrifood systems.

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[1] European Commission on Agriculture. 2023. *Governance of tenure in the context of integrated land and water management in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

[2] Searchinger, T.D., Waite, R., Hanson, C., Ranganathan, J. and Matthews, E. 2019. *Creating a sustainable food future: A menu of solutions to sustainably feed more than 9 billion people by 2050*. Washington, DC, World Resources Institute.

[3] European Commission on Agriculture. 2023b. *Enhancing the resilience and sustainability of national agri-food systems through integrated land and water resources management in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

[4] World Bank. 2022. Climate Change in Europe and Central Asia. In: The World Bank. https://www.worldbank.org/en/region/eca/brief/climate-change-in-europe-and-central-asia

[5] FAO. 2022. *The State of the World's Land and Water Resources for Food and Agriculture – Systems at breaking point. Main report*. Rome, FAO. https://doi.org/10.4060/cb9910en

[6] European Commission on Agriculture. 2023. *Sustainable use of land and water resources in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

[7] European Commission on Agriculture. 2023. *Sustainable use of land and water resources in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

II. Key trends and challenges

4. Climate change poses a significant threat to agrifood systems in Europe and Central Asia, with the region experiencing rising temperatures, changes in precipitation patterns and increased climate uncertainties, including extreme events. Central Asia, in particular, is highly vulnerable, facing potential temperature increases of up to 6.5 °C by the century's end.[8,9,10,11] These climate shifts adversely impact food production and productivity, elevating agricultural costs and, consequently, influencing consumer prices and food security more broadly – emphasizing the urgent need for resilient and sustainable solutions in the face of climatic challenges.[12]

5. The 2023 United Nations Climate Change Conference (COP28) emphasized the transformative potential of agriculture and food systems in addressing climate change and promoting shared prosperity. The *COP 28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action*[13] highlighted the need for urgent commitments, including scaling up adaptation efforts, strengthening the integrated management of water in agriculture and food systems, providing financial and technical support, and fostering innovative solutions for sustainable food security.

6. Forests help to facilitate resilient agrifood systems, but forest resources need to be sustainably managed to promote ecosystem services by conserving biodiversity and water resources. Improving forest health is important, as it is connected to water and food security and the maintenance of biodiversity,[14] and it highlights the links among ecosystems, agriculture and nutrition.[15,16]

7. In areas that are water scarce and rely on irrigation, careful water management is important to ensure resources are used optimally.[17] In Europe and Central Asia, reductions in precipitation, inefficient irrigation methods and a lack of integrated management have led to significant water

[8] Intergovernmental Panel on Climate Change (IPCC).. *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge>Cambridge University Press, 2023. https://doi.org/10.1017/9781009325844

[9] Reyer, C.P.O., Otto, I.M., Adams,] *et al*.. *Climate change impacts in Central Asia and their implications for development*. Reg Environ Change 17, 1639–1650 (2017). https://doi.org/10.1007/s10113-015-0893-z

[10] Shaw, R., Luo, T.S., Cheong, S., Abdul Halim, S., Chaturvedi, S., Hashizume, M., Insarov, G.E. *et al.* 2023. Asia. In: *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. First edition, p. Cambridge University Press.

[11] World Meteorological Organization. 2023. *State of the Climate in Europe 2022*. Geneva, WMO. https://library.wmo.int/records/item/66206-state-of-the-climate-in-europe-2022

[12] European Commission on Agriculture. 2023. *Enhancing the resilience and sustainability of national agri-food systems through integrated land and water resources management in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

[13] COP28 UAE. 2023. *COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action*. In: *COP28 UAE*. [Cited 9 January 2024]. https://www.cop28.com/en/food-and-agriculture

[14] FAO. 2023. *Biodiversity in action — #2*. Europe; Central Asia. FAO. https://www.fao.org/documents/card/en/c/cc3397en

[15] European Commission on Agriculture. 2023. *Enhancing the resilience and sustainability of national agri-food systems through integrated land and water resources management in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

[16] FAO. 2020. *The State of Food and Agriculture 2020. Overcoming water challenges in agriculture*. Rome. https://doi.org/10.4060/cb1447en.

[17] European Commission on Agriculture. 2023. *Importance of water governance for enhancing water security in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

scarcity.[18] Additionally, pollution from pesticides and industrial pollutants has decreased water quality.

8. More than half of the land under agricultural use in Central Asia is salinized due to unsustainable agricultural practices such as overgrazing, excessive use of chemical fertilizers and pesticides, improper water management and irrigation techniques, and monoculture farming. In western and northern Europe, land degradation is a consequence of land-use change through increased urbanization and the development of new infrastructure, while in the Mediterranean region, soil degradation is primarily caused by soil loss through erosion.[19]

9. While some efforts – including elements of the European Green Deal[20] and FAO's *Action plan for mainstreaming biodiversity across agricultural sectors in Eastern Europe and Central Asia 2022-2023*[21] – call for integrated resources management approaches, further momentum is needed in accelerating the implementation of these approaches, while ensuring necessary coordination mechanisms exist for integrating land, forest and water resource management and biodiversity.

III. The role of innovation and digitalization in accelerating the implementation of climate-resilient and low-emissions pathways

10. Innovation and digitalization can play a pivotal role in steering agrifood systems towards more climate-resilient and low-emission pathways. They have much to contribute to enhancing resource efficiency, monitoring their use and climate change, improving climate resilience and enhancing or protecting carbon sinks and carbon sequestration in agrifood systems, while contributing to supporting the decrease of emissions.

11. FAO recognizes the importance of innovation and digitalization in advancing its mission to achieve food security for all and to realize the 2030 Agenda for Sustainable Development, as outlined in the FAO Strategic Framework 2022–31[22] and reiterated in the FAO Science and Innovation Strategy.[23] These identify digital agriculture as one of the 20 Programme Priority Areas and recognize technology and innovation as key accelerators, together with data and other complements. Digitalization is a key element of the Regional Priorities for Europe and Central Asia[24] as an accelerator facilitating the achievement of the Sustainable Development Goals (SDGs) in the region. The digital approach in Europe and Central Asia for 2022–2030[25] emphasizes the importance of digitalization and innovation for rural areas and smallholder farmers. The approach stresses two main priorities: a) creating an enabling environment for e-agriculture through assessments, sharing good practices, and supporting strategies and digital literacy initiatives; and b) expediting the development and adoption of scalable digital agriculture solutions, services and data.[26]

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[18] European Commission on Agriculture. 2023. *Sustainable use of land and water resources in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

[19] European Commission on Agriculture. 2023. *Sustainable use of land and water resources in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

[20] For more information on the European Green Deal, please visit https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.

[21] This action plan is available online at https://www.fao.org/documents/card/en?details=cc1159en.

[22] FAO's Strategic Framework 2022–31 is available online at https://www.fao.org/3/cb7099en/cb7099en.pdf.

[23] The FAO Science and Innovation Strategy is available online at https://www.fao.org/3/cc2273en/cc2273en.pdf.

[24] For more information, please see documents ERC/24/8, *FAO results in the region – 2022-2023* and ERC/24/9 *Priorities for FAO in the Europe and Central Asia region under the FAO Strategic Framework 2022-31*."

[25] For more information, please visit https://www.fao.org/3/nn296en/nn296en.pdf.

[26] European Commission on Agriculture. 2023. *Advancing the digital transformation of agriculture and rural areas through national strategies, e-Government systems, and Digital Villages - update for Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

12. Innovations across various domains are essential for guiding agrifood systems towards climate-resilient and low-emission pathways. These innovations encompass technological, policy, institutional, financial and social dimensions. *Technological* innovations can leverage digital and non-digital (e.g. greenhouses, drip irrigation) advancements to enable farmers to implement climate-resilient and low-emission agricultural practices. These may entail sustainable intensification, focusing on diversified crops, agroecology, biotechnology and integrated pest management; adaptation, involving the use of climate-resilient crop varieties, efficient water and soil management; and mitigation, which includes conservation agriculture, agroforestry and sustainable livestock management to reduce emissions and sequestrate carbon from the soil. **Policy** innovations can establish frameworks that incentivize more sustainable practices and equitable resource management. **Institutional** innovations can play a role in fostering coordination among food and agricultural systems and other tightly interconnected systems, including water and forests. **Financial** innovations mobilize resources for sustainable practices and can contribute to their scale-up, while **social** innovations can empower communities through knowledge sharing. Together, these diverse forms of innovation offer comprehensive avenues for advancing climate resilience and emission reduction in agrifood systems.

13. The integration of digitalization in agrifood systems can further accelerate climate-resilient pathways. Earth observation, sensors, global positioning systems, the internet of things, artificial intelligence (AI) and drones can offer insights into flora, fauna, soil moisture, plant pests, water level and quality, and carbon content. They can enable the early detection of forest fires, pests and diseases; the tracking of land-use changes; and improvements to environmental monitoring. Blockchain technology can help combat illegal logging or control illicit trade in timber harvesting. Precision agriculture harnesses these advanced technologies to make farming more precise and efficient. Through data analytics, real-time monitoring and early alerts, farmers can monitor their fields directly from their mobile phones, optimize resource use such as water and pesticides, manage crop variability, predict weather and pest hazards, and make informed decisions, significantly contributing to sustainable and climate-resilient agricultural systems. Overall, digitalization plays a crucial role in better monitoring climate change, collecting valuable data and facilitating data-driven decisions that are essential for adaptive and resilient agricultural practices at all levels. It can improve automation, efficiency, food safety and resource management, which ultimately can lower emissions and minimize environmental impacts.[27] The green[28] and digital transitions need to be viewed as a "twin transition" that highlights their interconnected nature and the importance of making simultaneous, coordinated progress on both.[29] Digitalization has a strong potential for strengthening the green transition; however, its effectiveness relies heavily on the social, technical, economic and enabling policy context it is in.

IV. Existing solutions and best practices

14. Sustainably managing natural resources to combat climate change and reduce emissions, while maintaining food security, requires innovative and integrated approaches that take advantage of digital technologies and innovations at various levels, such as technological, institutional, social, policy and financial. This section refers to selected examples of regional and global innovations and digital solutions.

[27] Sridhar, A., Ponnuchamy, M., Kumar, P.S., Kapoor, A., Nguyen Vo, D.-V. and Rangasamy, G. 2023. Digitalization of the agro-food sector for achieving sustainable development goals: a review. Sustainable Food Technology, 1(6): 783–802. https://doi.org/10.1039/D3FB00124E

[28] The term "green growth" ensures that natural resources sustainably maintain the ecosystem services on which livelihoods, diets and economic development depend. The term generally refers to the shift towards more sustainable, environmentally friendly and resource-efficient practices across various sectors, including agriculture, to address climate change and ensure long-term sustainability.

[29] European Commission, Joint Research Centre, Muench, S., Stoermer, E., Jensen, K. *et al*., *Towards a green & digital future – Key requirements for successful twin transitions in the European Union*. Publications Office of the European Union, 2022. https://data.europa.eu/doi/10.2760/977331

15. The **1000 Digital Village Initiative** is a flagship initiative of FAO, which aims to transform 1 000 villages into digital hubs. Various countries in the region – such as Albania, Azerbaijan, Bosnia and Herzegovina, Georgia, Kyrgyzstan, Tajikistan, Türkiye and Uzbekistan – are actively implementing the Initiative. For example, in the Fergana Valley of Uzbekistan, smallholder farmers from pilot villages are embracing smart sensors based on the internet of things and open-source technologies to optimize resource efficiency in greenhouse farming.

16. FAO's **land degradation neutrality (LDN) decision support system** for Europe and Central Asia[30] is a tool that integrates information to support the identification of target areas for landscape interventions, with the goal of achieving neutrality. The system is based on a Google Earth Engine application and includes evidence on land degradation causes, impacts and status**.** Türkiye has proactively developed a sustainable land management action plan for LDN, strategically outlining measures to prevent, mitigate or reverse land degradation. This plan identifies specific sustainable land management efforts and maps the LDN hierarchy within a customized national decision support system, offering a pioneering model for sustainable land management and aiding decision-makers in prioritizing interventions.

17. The **Central Asia Water and Land Nexus** programme, coordinated by FAO and funded by the Global Environment Facility (GEF) with USD 26 007 810, aims to address complex water and land management challenges in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The programme focuses on improving water generation through LDN activities, reforestation and pasture improvement and on decreasing water consumption via saving irrigation technologies and drought-resilient crop types. The programme plans to restore 5 350 ha of land, implement improved practices on 1 329 000 ha, mitigate 11 118 670 tonnes of greenhouse gas emissions, and directly benefit 487 000 people, contributing to increased climate resilience and improved livelihoods in the region.[31]

18. The **FAO Integrated Natural Resources Management in Drought-prone and Salt-affected Agricultural Production Landscapes in Central Asia and Turkey (CACILM-2)**[32] project in Kyrgyzstan installed remote sensors and associated software to enable real-time, continuous monitoring of water levels. This empowers water management personnel to observe water volume and distribution among users' associations, with the added benefit of archiving data for subsequent analysis. Seven demonstration fields were created for agricultural experimentation, aiding in the testing and implementation of innovative practices. Targeted assistance was provided to 1 067 farmers impacted by the COVID-19 pandemic, and more than 200 specialists underwent capacity-building programmes through regional and national trainings, promoting expertise in innovative and climate-resistant technologies.

19. Across Europe and Central Asia, several digital solutions are transforming forest management practices. Drones are increasingly utilized for early forest fire detection, significantly reducing response times, with Türkiye serving as a prime example. Other countries, such as Kyrgyzstan, employ drones to monitor forest health, detect pests and track disease outbreaks. Azerbaijan, Kyrgyzstan and Türkiye utilize global positioning systems and similar tools to streamline forest data collection, sharing and reporting processes. Photo traps and drones are deployed in countries such as Ukraine to combat illegal logging activities effectively. Türkiye leads in implementing low-impact harvesting equipment to minimize environmental damage during timber extraction. Moreover, innovative approaches such as using mycorrhizal agents in forest nurseries, particularly in Türkiye, enhance seedling survival rates and aid in dryland restoration efforts amid climate change challenges.

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[30] **European Commission on Agriculture**. 2023. *Overview of land degradation neutrality in Europe and Central Asia*. Forty-third Session, Budapest, Hungary, 2023. https://www.fao.org/events/detail/43rd-session-of-the-european-commission-on-agriculture/en

[31] **Global Environment Facility**. 2024. *Work Program for GEF Trust Fund*. Sixty-sixth GEF Council Meeting, Washington, DC, 2024. https://www.thegef.org/sites/default/files/documents/2024-01/EN_GEF.C.66.04_Work%20Program%20for%20GEF%20Trust%20Fund.pdf

[32] The Central Asian Countries Initiative for Land Management (CACILM) includes Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

Additionally, the integration of computer technology and mass media equipment facilitates effective communication and outreach activities across the forestry sector.

20. The EX-Ante Carbon-balance Tool (EX-ACT)[33] is based on the Intergovernmental Panel on Climate Change's methodology for greenhouse gas emissions inventories. The EX-ACT helps users estimate and track the outcomes of agricultural interventions on emissions and covers the whole agricultural sector, which includes agriculture, forestry, land use, inland and coastal wetlands, fisheries and aquaculture, and agricultural inputs and infrastructure.[34] A reduction in more than 27 million tonnes of carbon dioxide equivalent resulted from climate mitigation projects within the Europe and Central Asia region, namely in Azerbaijan, Georgia, Kyrgyzstan, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.

21. Knowledge platforms such as FAO's Regional Technical Platform on Green Agriculture,[35] FAO's regional AgriTech Observatory,[36] and the World Overview of Conservation Approaches and Technologies (WOCAT)[37] can be instrumental in disseminating knowledge on green and digital practices, facilitating the identification of solutions to scale, and contributing to building capacities at several levels.

22. In the framework of the Tropical Agriculture Platform,[38] a Group of 20 (G20) initiative supported by the European Commission under the Development Smart Innovation through Research in Agriculture promotes integrated Agricultural Innovation Systems (AIS) by strengthening national agricultural research systems (NARS), agricultural extension and advisory services (AEAS) and other AIS actors for the co-creation of innovation and to help farmers, foresters, livestock owners and rural communities address their current and future challenges, including climate change. To ensure that relevant people get connected, the right policies and governance mechanisms are in place, and knowledge is shared among various AIS actors, effective Agricultural Knowledge and Innovation Systems are being promoted in Azerbaijan and Ukraine and in several countries in other regions.

V. Risks ahead

23. Several key challenges have been encountered in advancing the science, technology and innovation agenda in the Europe and Central Asia region. The sustainable transformation of agrifood systems in the poorer and less developed areas of the region is impeded by poor infrastructure, low innovation adoption and limited access to technologies. Smallholder farmers in particular, together with family farms and marginalized agrifood system actors, face adoption obstacles due to high costs and inadequate training. Moreover, integration into the global research space is hindered by language barriers and insufficient collaboration support. Sustainable natural resource management and biodiversity preservation are hampered by a lack of localized scientific evidence, monitoring data and mechanisms to translate research into policies. Indigenous knowledge and practices are often marginalized, leading to the underutilization of their contributions in innovation and science development. Despite the significant role of farmers and marginal communities, their expertise remains insufficiently recognized and integrated into modern knowledge systems.

24. The absence of a supportive legal infrastructure and enabling environment poses a significant challenge. Ambiguous or outdated legal frameworks can hinder the adoption of innovative solutions. There is a need for clear and adaptive legal systems that foster the responsible and equitable use of technology and data, also in natural resources management and for climate action.

[33] For more information on the EX-Ante Carbon-balance Tool, please visit https://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act/en/.
[34] FAO. 2024. Economic and Policy Analysis of Climate Change. In: *Food and Agriculture Organization of the United Nations*. [Cited 11 December 2023]. https://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act/en/
[35] FAO's Regional Technical Platform on Green Agriculture is available online at https://www.fao.org/platforms/green-agriculture/en.
[36] FAO's AgriTech Observatory is available online at https://agritechobservatory.review.fao.org/.
[37] For more information on the WOCAT, please visit https://qcat.wocat.net/en/wocat/.
[38] For more information, please visit https://www.fao.org/in-action/tropical-agriculture-platform/en/.

25. Securing funding presents a challenge, particularly for non-European Union countries. This applies to Western Balkan countries, the Caucasus, Republic of Moldova and Ukraine, and especially to Central Asia, where the region's classification as middle income limits its ability to obtain external funds for large-scale implementation projects, including those related to innovative and sustainable technologies.

26. Building the necessary human and institutional capacity is essential for successful adoption. This involves not only providing technical training, but also enhancing the understanding of the socioeconomic and environmental implications of these technologies. In addition, NARS and AEAS, which are the key actors of agricultural innovation systems, are constantly weakened due to underfunding and inadequate functional and technical capacity. The lack of capacity to co-create innovations might hinder the proper adoption and scale-up of solutions, which emphasizes the need for comprehensive training initiatives targeting local communities, government agencies and other relevant actors.

27. For instance, in Kyrgyzstan, an analysis of technology adoption barriers highlighted the need for substantial policy reforms to improve the adoption of technologies. Conservation agriculture adoption demands increased knowledge dissemination, pilots with lead farmers and improved support services. Drip irrigation deployment would benefit from streamlined water governance and heightened awareness. Encouraging greenhouse technology adoption requires sensitization campaigns and capacity development. Meanwhile, promoting efficient field machinery involves educating farmers on fuel-saving practices, providing technical support and improving capital access, especially for small-scale farmers. Addressing these obstacles is crucial for advancing sustainable and technologically advanced crop farming practices.[39]

28. Another impediment is the inadequate digital infrastructure to support the widespread adoption of technologies and digital innovations. In many regions, especially rural areas such as Tajikistan, limited rural connectivity hampers the seamless integration of technological tools aimed at sustainable natural resource management.

29. Effective technology adoption often relies on data access and sharing across different sectors. The scarcity and difficulty in obtaining data, coupled with uncertainties about the reliability of available data, pose significant challenges. Moreover, there is a lack of trust in sharing data, which hinders collaborative efforts. Challenges related to interoperability, data ownership, data protection and sharing protocols can impede the seamless flow of information and the further adoption of some technologies.

30. The adoption of AI in agriculture presents a spectrum of risks, including challenges in data management, design and deployment, and scaling. Issues include limited access to quality and trustworthy data, potential biases in AI models and unequal adoption, which impact socioeconomic factors. Deploying AI at scale raises concerns about bias amplification, data privacy and security vulnerabilities.

31. The integration of technology in countries affected by conflict introduces unique challenges related to the adoption and sustained implementation of innovative solutions for sustainable natural resources management. This emphasizes the need to navigate and mitigate risks and uncertainties arising from conflict to ensure resilience and effectiveness of technological interventions.

VI. Recommendations to Members

32. In order to further utilize the potential of innovation and digitalization to accelerate the implementation of climate-resilient and low-emission pathways in agrifood systems and achieve the SDGs in the Europe and Central Asia region, governments are requested to:

a. Adopt a holistic approach with intersectoral collaboration among the agriculture, land, water, forestry, energy and technology sectors and formulate harmonized and adaptive policies to

[39] Polo, M. d. M., Santos, N. & Berdikeev, S. 2022. *Adoption of climate technologies in the agrifood system: investment opportunities in the Kyrgyz Republic*. FAO.https://doi.org/10.4060/cb6812en

create a conducive enabling environment for innovation and digitalization that fosters a responsible use of technology, promotes trust and security, and protects human rights, aligning with the "leaving no one behind" principle and the Principles for Digital Development.[40]

b. Strengthen the capacity of integrated AIS, involving NARS and AEAS,; and promote the development of multi-actor agricultural innovation platforms and innovation hubs and scale-up of innovative approaches, such as agroecology, technologies for farm mechanization, precision agriculture and digitalization including digitally enabled extension and advisory services.

c. Disseminate knowledge on innovations and digital technologies that have proven viable in improving the management of natural resources and lowering of emissions; and develop financial mechanisms and incentive structures to facilitate their widespread adoption, availability and affordability,[41] especially among smallholder farmers and vulnerable groups.

d. Develop human capacities at all levels, including promoting digital literacy and skills of women, youth and men, particularly in rural areas.

e. Improve rural connectivity and champion digital public goods,[42] such as open-source software, open data, open AI systems, open standards and open content collections that adhere to data privacy and protection standards and other laws and best practices and do no harm.

f. Promote investments in research and development focused on sustainable agriculture practices, climate-smart technologies and renewable energy resources, and foster collaboration among stakeholders – including farmers, scientists, policymakers, the private sector and consumers – to bridge the gaps among scientific advancements, innovative technologies and policy frameworks.

g. Harness transformative public–private partnerships at international, regional and national levels, including with research and development institutes and academia. For example, a cooperation with the Joint FAO/International Atomic Energy Agency Centre of Nuclear Techniques in Food and Agriculture can leverage research and development activities for innovative and evidence-based technological solutions to improve animal production and health, plant breeding and genetics, insect pest control, food safety and control, soil and water management and crop nutrition.

h. Implement mechanisms for improved data collection and the monitoring and evaluation of the environmental and socioeconomic impacts of innovations and digital technologies for sustainable resource use, climate resilience and emissions reduction in the agrifood sector, supporting information gathering for policymakers.

VII. Requests for FAO

33. It is requested that FAO:

a. Promote the formulation of harmonized policies and regulations across sectors to create an enabling environment for innovation, and emphasize the adoption of sustainable innovations and technologies that leave no one behind.

[40] The Principles for Digital Development are nine living guidelines that are designed to "serve as a compass for those working to promote sustainable and inclusive development in today's complex digital landscape." For more information, please visit https://digitalprinciples.org/.

[41] For example, please see the Broadband Commission for Sustainable Development's Working Group on Smartphone Access at https://www.broadbandcommission.org/working-groups/smartphone-access/.

[42] According to the United Nations Secretary-General's *Roadmap for Digital Cooperation*, digital public goods are open-source software, open standards, open data, open AI systems and open content collections that adhere to privacy and other applicable laws and best practices, do no harm, and help attain the SDGs. See: United Nations. 2020. *Report of the Secretary-General: Roadmap for Digital Cooperation*. https://www.un.org/en/content/digital-cooperation-roadmap/assets/pdf/Roadmap_for_Digital_Cooperation_EN.pdf

b. Promote more coherent and integrated AIS, including national agricultural research systems and extension and advisory services that facilitate cross-sectoral engagement of various institutions and activities aimed at co-creating innovations, improving coherence in the governance of water, land and forest resources, and fostering collaboration across sectors.

c. Invest in digital public goods to democratize technologies and enhance their widespread availability and accessibility, fostering equitable opportunities for smallholder farmers to benefit from and contribute to technological advancements.

d. Accelerate the implementation of flagship programmes such as the 1000 Digital Village Initiative to address the rural digital divide, including through facilitating digital literacy and capacity-building programmes, and fostering digital cooperation among stakeholders.

e. Continue disseminating knowledge and good practices on digital solutions and innovations through various fora and platforms, such as FAO's AgriTech Observatory and the Regional Technical Platform on Green Agriculture, in an interoperable and reusable way, based on common data standards and taxonomies.

f. Expand and support climate--change information and services to enhance resilience, adaptation and emissions reduction. Prioritize evidence-based decision-making and policy development by actively engaging in the development, update, enhancement, implementation and integration of nationally determined contributions, National Adaptation Plans, National Biodiversity Strategies and Action Plans and national food systems pathways.

g. Continue its support for climate action and ambition focused on agriculture and agrifood systems, including in the context of the 2024 United Nations Climate Change Conference (COP29), to be organized in Azerbaijan in November 2024, and guided by the FAO Strategy on Climate Change 2022–2031 and its Action Plan (2022–2025).

Further reading

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