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Agriculture technology for sustainable development: leaving no one behind

Report of the Secretary-General**

Summary

At the halfway point of the 2030 Agenda for Sustainable Development, the application of science and technology in developing sustainable agricultural practices has the potential to accelerate transformative change in support of the Sustainable Development Goals. Technological advancements in the areas of biotechnologies, digital technologies, renewable energy, mechanization, automation and data advancement present opportunities to boost production, improve efficiency, minimize waste and reduce drudgery in agrifood systems, benefiting economic, social and environmental well-being. Good governance, an enabling environment and inclusive planning are key to ensuring that new technologies benefit vulnerable populations rather than widen inequality gaps. Addressing the digital divide and gender inequality is also key to ensuring that no one is left behind.

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I. Introduction

1. The present report has been prepared in response to General Assembly resolution 76/200, in which the Secretary-General was requested to submit to the Assembly, at its seventy-eighth session, an action-oriented report that examines the current technological trends and key advances in agricultural technologies, provides illustrative examples of the transformative use of technologies at scale and includes recommendations that assist Member States in accelerating their efforts to implement the relevant goals and targets of the 2030 Agenda for Sustainable Development.

2. For the purposes of the report, "agriculture" refers to the crop, livestock, fishery and forestry sectors. "Agrifood systems"[1] encompass the entire range of actors, and their interlinked value-adding activities, engaged in the primary production of food and non-food agricultural products, as well as in the storage, aggregation, post-harvest handling, transportation, processing, distribution, marketing, consumption and disposal of all food products, including those of non-agricultural origin. "Agricultural technologies" for sustainable development involve technologies that support more sustainable food systems, that build healthy and resilient agroecosystems with positive impacts on the environment and that can contribute to the transition from subsistence to innovative sustainable farming, thus helping smallholders and family farmers to improve their own food security and nutrition, generate marketable surpluses, add value to production and secure their livelihoods. These include technologies for the production and post-harvest storage, processing, handling and transportation of agricultural products.

II. Overview

3. In his 2021 report on agriculture technology for sustainable development (A/76/227), the Secretary-General observed that biotechnologies, digital technologies, renewable energy technologies, mechanization and data advancement presented opportunities to boost agricultural production, improve efficiency, minimize waste and reduce drudgery in agrifood systems, thus benefiting economic, social and environmental well-being. He further highlighted the importance of governance and inclusive planning to ensure that new technologies would benefit vulnerable populations rather than widen inequality gaps.

4. The present report builds on the previous report with reference to food insecurity, climate-related risks, rapid urbanization, food loss and waste, the degradation of natural resources and transboundary pests and diseases that agricultural technologies can help to address. In it, the Secretary-General highlights how agricultural technologies can be scaled up, with attention paid to assuring access by women and young people, ensuring efficient, inclusive, resilient and sustainable agrifood systems and leveraging emerging opportunities for achieving the Sustainable Development Goals, in particular in times of crisis, including the coronavirus disease (COVID-19) pandemic.

5. In the report, the Secretary-General reflects on recent and upcoming events, including the 2023 United Nations Water Conference, the 2023 United Nations Food Systems Summit stocktaking moment, aimed at reviewing progress in implementing the outcomes of the 2021 Food System Summit, and the 2023 Sustainable Development Goal Summit. The report is highly relevant in the context of the work of the Technology Facilitation Mechanism and the related United Nations inter-agency task

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[1] As defined in the report of the Council of the Food and Agriculture Organization of the United Nations (FAO) on its 166th session, report No. CL 166/REP (Rome, 2021).

team on science, technology and innovation and the annual multi-stakeholder science, technology and innovation forum for the Sustainable Development Goals.

6. In the report, the Secretary-General highlights recent technological trends in agriculture that contribute to agrifood system transformation and emphasizes the need for scaling up agricultural technologies with a range of enabling policy, social and institutional factors. Particular consideration must be focused on the needs of small-scale producers, including farmers, pastoralists, fisherfolks, foresters and Indigenous Peoples, with attention paid to women and young people. In addition, he highlights the need to identify and analyse opportunities, risks and trade-offs associated with technologies and to ensure the availability, accessibility and affordability of relevant technologies for small-scale producers and family farmers and all actors of the agrifood systems.

III. Challenges

7. The prevalence of undernourishment is still far above pre-pandemic levels, affecting around 9.2 per cent of the world population in 2022 compared with 7.9 per cent in 2019. It is estimated that between 691 and 783 million people in the world faced hunger in 2022. Considering the mid-range (about 735 million), some 122 million more people faced hunger in 2022 than in 2019.[2] Acute food insecurity in the world grew from 108 million people in 2016 to 258 million people in 2022.[3] On the other hand, the rapidly increasing share of highly processed foods of high-energy density and minimal nutritional value is linked to a rise in obesity and non-communicable diseases. Globally, in 2022, an estimated 148.1 million children under 5 years of age (22.3 per cent) were stunted, 45 million (6.8 per cent) were wasted and 37 million (5.6 per cent) were overweight.

8. Food loss and waste is significant, yet more than 3.1 billion people in the world, or 42 per cent, were unable to afford a healthy diet in 2021. Approximately 14 per cent of the world's food, valued at $400 billion, is lost on an annual basis, while an estimated 17 per cent of food is wasted at the retail and consumer levels. At the same time, globally, unsafe food is known to cause acute and chronic diseases, affecting vulnerable and marginalized people and their livelihoods. Rapid urbanization, together with income growth in low- and middle-income countries, is accelerating the dietary transition towards higher consumption of meat, sweetened sugary beverages and processed foods that are high in fats, sugar and salt and, for some income groups, higher demand for fruits and vegetables relative to that of cereals, requiring shifts in output and adding pressure on natural resources.

9. Climate change and associated climate extremes like droughts and floods are severely affecting agriculture and food security. Agriculture continues to absorb 26 per cent of the damage and loss brought on by disasters, especially droughts and floods. Over 80 per cent of all damage and loss caused by drought was absorbed by agriculture in low- and lower-middle-income countries.[4] On the other hand, agrifood systems account for one third of total anthropogenic greenhouse gas emissions.[5]

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[2] FAO, International Fund for Agricultural Development (IFAD), United Nations Children's Fund (UNICEF), World Food Programme (WFP) and World Health Organization (WHO), *The State of Food Security and Nutrition in the World 2023: Urbanization, Agrifood Systems Transformation and Healthy Diets across the Rural-Urban Continuum* (Rome, FAO, 2023).

[3] Food Security Information Network and Global Network against Food Crises, *Global Report on Food Crises 2023: Joint Analysis for Better Decisions* (Rome, 2023).

[4] FAO, *The Impact of Disasters and Crises on Agriculture and Food Security: 2021* (Rome, 2021).

[5] FAO, "Greenhouse gas emissions from agrifood systems: global, regional and country trends, 2000–2020", FAOSTAT Analytical Brief, No. 50 (Rome, 2022).

Energy use in food chains is unsustainable, given that agrifood systems currently consume one third of the world's energy production, with about 70 per cent of the energy consumption attributed to the transportation and processing of food products once they leave the farm.[6]

10. There is little room for expanding the area of productive land, yet more than 95 per cent of global food production is land-based.[7] Water scarcity directly affects agriculture, as the sector with the highest demand for freshwater resources. Meanwhile, the lack of wastewater management increases water pollution, with approximately 80 per cent of global wastewater going untreated, contributing to structural issues relating to water quality.[8] Poor soil health results in nutrient-poor crops, which in turn contributes to multiple micronutrient deficiencies and nutrient-poor diet, leading to malnutrition and associated health problems. In addition, a rapid rise in fertilizer prices has lowered their affordability and use by farmers, leading to additional issues of food availability and compounding the problem of food access.[9]

11. Globally, loss of biodiversity and species extinction risk has worsened by about 10 per cent over the past three decades.[10] The expansion of agricultural land continues to be the main driver of deforestation and is linked to the outbreak of zoonotic and vector-borne diseases.[11] Evidence suggests that the proportion of livestock breeds at risk of extinction is increasing. Nearly a third of fish stocks are overfished, and a third of freshwater fish species assessed are threatened. The proportion of fish stocks that are within biologically sustainable levels decreased from 90 per cent in 1974 to 65.8 per cent in 2017.[12]

12. Transboundary pests and diseases continue to pose significant threats. The global spread of transboundary pests and diseases, such as African swine fever, lumpy skin disease, high pathogenicity avian influenza and the fall armyworm, has severely affected food and nutrition security and agricultural livelihoods and slowed recovery from the COVID-19 pandemic. Highly hazardous pesticides disrupt pollinators, the natural enemies of crop pests, and 64 per cent of global agricultural land is at risk of pesticide pollution by more than one active ingredient, with 31 per cent at high risk.[13]

13. Women in agriculture have less access than men to inputs, and the burden of labour on women is increasing, owing to their lack of access to labour-saving technologies. Limited access to capital and services, geographical inequalities in access to electricity, the Internet and cell phone coverage, higher costs, lower literacy levels, gender-biased sociocultural norms and lower participation in decision-making

[6] International Renewable Energy Agency (IRENA) and FAO, *Renewable Energy for Agri-food Systems: Towards the Sustainable Development Goals and the Paris Agreement* (Abu Dhabi and Rome, 2021).

[7] FAO, *The State of the World's Land and Water Resources for Food and Agriculture: Systems at Breaking Point – Synthesis Report 2021* (Rome, 2021).

[8] Anja du Plessis, "Persistent degradation: global water quality challenges and required actions", *One Earth*, vol. 5, No. 2 (18 February 2022).

[9] FAO and the World Trade Organization (WTO), "Global fertilizer markets and policies: a joint FAO/WTO mapping exercise", 1 December 2022.

[10] See https://unstats.un.org/sdgs/report/2020/goal-15/.

[11] Serge Morand and Claire Lajaunie, "Outbreaks of vector-borne and zoonotic diseases are associated with changes in forest cover and oil palm expansion at global scale", *Frontiers in Veterinary Science*, vol. 8 (March 2021).

[12] FAO, *The State of World Fisheries and Aquaculture 2022: Towards Blue Transformation* (Rome, 2022).

[13] Fiona H. M. Tang and others, "Risk of pesticide pollution at the global scale", *Nature Geoscience*, vol. 14 (April 2021).

on agricultural innovations[14] are barriers to technology access by women. In 2022, 63 per cent of women globally were using the Internet, compared with 69 per cent of men.[15] Rural women are less likely to own a cell phone than rural men.[16] A lack of employment opportunities erodes human capital and decreases labour productivity. In some regions, where the youth population is rising fast, there is limited access to land and productive resources, leading younger generations to turn away from working in agriculture and towards internal and international migration.

14. The lack of accurate, timely and relevant data constrains policymaking. Inadequate analytical capacity, in particular in low- and middle-income countries, has been a crippling weakness in agricultural data systems. Although there are enormous opportunities for data science and data use in agriculture, they also come with some risks, such as with regard to data privacy and ethics. In addition, shifting to digital methods of farming requires significant financial resources, which could increase inequalities between large-scale producers and small-scale producers farmers.

IV. Technological trends and key advances

15. Agricultural biotechnologies include a series of technologies, from low-tech artificial insemination, fermentation techniques, biofertilizers and nuclear techniques, to high-tech advanced DNA-based methodologies, including genetic modification, whole genome sequencing, gene editing and synthetic biology. Those technologies provide opportunities, but also carry risks, such as unexpected gene interactions and biosafety issues.[17] Benefits include the genetic improvement of plants and animals to increase yield, the efficiency of input use, resilience to biotic and abiotic stresses, the prevention of plant and animal diseases, nutritionally enhanced and longer-lasting foods, the reduction of allergens, foodborne disease detection, food safety surveillance, the monitoring of biodiversity, phytoremediation, the efficient use of nutrients in feed by animals, the rapid diagnosis of diseases and the development of vaccines.

16. Gene-editing technology, including clustered regularly interspaced short palindromic repeats, and its application in plant and animal breeding can contribute to improvements in various aspects of agricultural production. The technology has the potential to enhance precision and efficiency as compared with current breeding methods and to contribute to the rapid development of improved plant varieties and animal breeds. Gene-editing technology has the potential to improve food productivity and nutrition, increase environmental benefits and reduce the costs of food production.[18]

17. Cell-based food production refers to growing animal products directly from cell cultures instead of using conventional livestock systems. Cell-based food products are already under development, making it critical to objectively assess the benefits they might bring, as well as any risks associated with them, including food safety, human health and quality concerns.[19] Cellular agriculture is divided into two types: cultured meat and precision fermentation. In cultured meat, animal cells are grown in

[14] United Nations Conference on Trade and Development, *Teaching Material on Trade and Gender Linkages: The Gender Impact of Technological Upgrading in Agriculture* (United Nations publication, 2020).

[15] International Telecommunication Union (ITU), *Measuring Digital Development: Facts and Figures 2022* (Geneva, 2022).

[16] GSM Association, *Connected Women: The Mobile Gender Gap Report 2021* (London, 2021).

[17] Agata Tyczewska, Tomasz Twardowski and Eva Woźniak-Gientka, "Agricultural biotechnology for sustainable food security", *Trends in Biotechnology*, vol. 41, No. 3 (March 2023).

[18] FAO, *Gene Editing and Agrifood Systems* (Rome, 2022).

[19] FAO and WHO, *Food Safety Aspects of Cell-based Food* (Rome, 2023).

bioreactors to produce components of muscle tissue. Precision fermentation involves growing microbial hosts as “cell factories” to produce food ingredients.

18. Digital technologies range from low-cost nascent technologies using mobile devices and platforms, to weather or market price information systems accessible through text messaging or interactive voice response, to advanced technologies with knowledge-intensive and high-Internet penetration requirements, such as big data, the Internet of things, artificial intelligence and machine learning, distributed ledgers, remote sensing and geospatial analysis. Those technologies have the potential to increase agricultural productivity, improve access to markets, efficiency of inputs, and ensure timely communication for informed decision-making. Artificial intelligence makes it possible to increase the efficiency of farm activities through agricultural robotics, soil, crop and livestock monitoring, predictive analysis and agricultural advisories with automated chat functions.

19. Geospatial technologies, including remote sensing, geospatial analysis and such tools as satellite imagery, geographic information systems, open-access geospatial platforms and smartphone applications, enable the transformation of data, with real-time distribution for targeted users, into actionable information for efficient natural resource management, improved production and strengthened early warning systems. Remote sensing applications contribute to the monitoring of hazards, biomass production and crop evapotranspiration, irrigation management, the identification of crop stress and weed and pest infestations, weather forecasting, early warning of droughts and floods and plant health evaluation.

20. Precision agriculture with sensors could help farmers to manage inputs precisely and in a timely manner and to reduce the spatial variability of crop yields. The ability to place sensors in the soil that transmit real-time data helps farmers to predict soil health. Sensors placed on dairy cows can help in developing dedicated algorithms that would enable optimized feeding and milking in dairy farming. Sensors and their corresponding data sets can thus provide for cost-effective, timely detection of threats that affect the health and/or productivity of animals and crops, which can empower producers.

21. Agricultural mechanization allows farmers to place seeds, fertilizer and other inputs more precisely and to monitor soil conditions, nutrient deficiencies, crop health, weather conditions and pest infestations with accuracy and efficiency. Technologies as simple as balers for mechanized crop residue management help farmers to move away from burning straw residue towards using it for fertilizer, fodder, base material for mushroom growing and clean energy production. Mechanization can empower women by reducing their dependence on men for physical labour.[20] Developing digital platforms can facilitate the hiring of services by small-scale farmers for agricultural mechanization. For example, digital platforms enable tractor owners to track the movement of their equipment using a global navigation satellite system.

22. Automation technologies help farmers to manage their farming practices remotely.[21] Drones equipped with cameras and sensors can monitor crops, collect data on soil conditions and detect signs of disease or pests. Automated irrigation systems can be used to water crops on the basis of soil moisture levels and weather conditions. Livestock monitoring systems can detect the health and behaviour of livestock remotely. Agricultural robots can substitute for arduous labour, including when there is limited labour availability. These technologies could attract young people and

[20] FAO, *The Status of Women in Agrifood Systems* (Rome, 2023).

[21] FAO. *The State of Food and Agriculture 2022: Leveraging Automation in Agriculture for Transforming Agrifood Systems* (Rome, 2022).

entrepreneurs into the sector, reducing rural-urban migration.[22] However, the supply of agricultural automation can be affected by high import duties, lengthy customs procedures and non-tariff barriers to trade, such as sanitary measures and a lack of skill sets and training, making access to and use of the technologies more difficult in certain rural areas.

23. Climate technologies contribute to environmentally sound, low-carbon and climate-resilient development. Technologies that generate carbon credits in agriculture and forestry can enhance ecosystem services and nature-positive carbon markets.[23] Climate-resilient technologies include breeding for genetic improvement of crops, animals and fish to support growth under changing climate conditions; technologies for soil fertility improvement; nitrification inhibitors for reducing greenhouse gas emissions; conservation technologies, including zero tillage, to sequester soil carbon and reduce emissions; nanotechnology applied to improving productivity; technologies for manure management and the reduction of enteric fermentation; and digital technologies, remote sensing and automation for weather, soil and crop monitoring, forecasting and early warning systems.

24. Renewable energy technologies can increase the efficiency of agrifood systems. Renewable energy solutions and integrated water-energy-food nexus systems can directly advance energy use and food security, while also contributing to job creation, gender equality and climate resilience.[24] Integrated food-energy systems could leverage synergies in water and land use if forward market linkages, affordable financing and concerns about sustainability are addressed by Governments. It is important to remain mindful, however, that bioenergy production may lead to shifts in land use from food to biofuel production, thereby undermining the right to food.

25. Technologies can help to ensure food safety and quality. Record-keeping, regulatory requirements and food safety risk mitigation have prompted investments in digitization and logistics.[25] Distributed ledgers and "omics" technologies, including genome sequencing, help in tracking food and its ingredients along the agrifood system and in linking the production, processing and distribution chain of food and ingredients. Isotopic and elemental fingerprinting provide a robust analytical tool for determining the origin of food. Those techniques, together with food safety surveillance programmes, provide independent verification of food traceability systems and help Governments to identify contamination sources. The Joint Food and Agriculture Organization of the United Nations (FAO)/International Atomic Energy Agency (IAEA) Centre of Nuclear Techniques in Food and Agriculture conducts research and supports capacity-building on nuclear and isotopic techniques.

26. Food processing technologies can address the demand for nutritious and sustainably produced food by minimizing the degradation of food components that support good health and well-being. Processing technologies must ensure food safety and comply with sustainability principles to ensure resource efficiency, minimize waste and use environmentally friendly packaging. Trends include sensor technology, cold plasma technology, sustainable packaging, refrigeration climate control, non-thermal pasteurization, sterilization and nano- and microtechnology. In fisheries,

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[22] Linh N. K. Duong and others, "A review of robotics and autonomous systems in the food industry: from the supply chains perspective", *Trends in Food Science and Technology*, vol. 106 (December 2020).

[23] Global Environment Facility, *Innovative Finance for Nature and People: Opportunities and Challenges for Biodiversity-Positive Carbon Credits and Nature Certificates* (2023).

[24] IRENA and FAO, *Renewable Energy for Agri-food Systems*.

[25] Pratyusha Reddy, Sherah Kurnia and Guilherme Luz Tortorella, "Digital food supply chain traceability framework", *Proceedings*, vol. 82, No. 1 (2022).

solar tent dryers help to improve the drying process, are financially profitable, produce better fish quality and prevent contaminants.

27. Technologies for anticipatory actions in humanitarian operations should ensure the availability of relevant data, analytical tool and skills in forecasting, which offer an opportunity to predict and prevent future shocks and crises. The combination of increasingly accurate weather forecast models and remote sensing information help in identifying triggers for anticipatory action and risk reduction. Such technologies enable a much-needed linkage between early warnings, flexible financial mechanisms and concrete actions taken by Governments, humanitarian and development agencies and communities to protect agricultural livelihoods and food security, before humanitarian impacts escalate.

V. Adoption and use of technologies at scale

Ending hunger and improving nutrition and human health

28. Agricultural biotechnologies could, demonstrably, be harnessed and scaled to enhance the productivity of agricultural and food production systems. However, national agricultural research systems in developing countries seldom use those advanced biotechnologies, owing to restricted access, intellectual property right regimes, limited funding and regulatory frameworks. The application of genome editing (or gene editing) is advancing in some countries[26] and is considered relatively inexpensive and not technically challenging. Gene editing has the potential to improve food security, nutrition and environmental sustainability, but issues of safety must be considered through careful risk assessment, evaluation and regulation.[27]

29. Fermentation is a well-established food preservation and nutrition improvement strategy, but the benefits of microbial transformation are currently underutilized. Scaling up sustainable and profitable production of these foods would necessitate the standardization and formalization of fermentation and processing by ensuring that processed products adhere to food safety parameters and food quality needs.[28] Similarly, biofortification is a feasible and cost-effective means of delivering micronutrients to populations that have limited access to diverse diets to improve food nutrition. Currently, more than 86 million people are eating biofortified foods – a number that is expected to progress rapidly towards 100 million before the end of 2023.[29]

30. Technologies applied in urban and peri-urban agriculture include the adoption of vertical farming, rooftop farming, aquaponics and hydroponic systems for the local production of vegetables such as tomato, sweet potato, sweet pepper, cucumber, lettuce, basil and mushrooms. Hydroponic systems have also been successfully deployed in remote areas, through the World Food Programme initiative, H2Grow,[30] which brings locally adaptable hydroponic units to food-insecure communities. Challenges such as competition with other sectors for the use of scarce resources (land, water, labour and energy), land and water contamination and limited access to credit

[26] Nicholas G. Karavolias and others, "Application of gene editing for climate change in agriculture", *Frontiers in Sustainable Food Systems*, vol. 5 (2021).

[27] FAO, *Gene Editing and Agrifood Systems*.

[28] Valentina C. Materia and others, "Contribution of traditional fermented foods to food systems transformation: value addition and inclusive entrepreneurship", *Food Security*, vol. 13 (2021).

[29] Howart E. Bouis, "Biofortification: an agricultural tool to address mineral and vitamin deficiencies", in *Food Fortification in a Globalized World*, M. G. Venkatesh Mannar and Richard F. Hurrell, eds. (Elsevier, 2018), pp. 69–81.

[30] See https://innovation.wfp.org/project/h2grow-hydroponics.

can constrain the use of such technologies.[31] City region food systems, the urban food agenda and the Green Cities Initiative are some examples that support resilient urban and peri-urban food systems through the use of relevant technologies.[32] At the same time, food systems have a strong territorial dimension, which is why intermediary cities can play a role addressing the challenges faced today.

Adoption of climate-resilient technologies at scale

31. The adoption of new crop varieties, livestock breeds and fish strains offer significant benefits to increase climate resilience. The International Year of Millets (2023) provides opportunities to scale up the adoption of millets, which are resilient to biotic and abiotic stresses.[33] The sustainable management of cropland, grassland, soil and water resources plays a vital role in enhancing agricultural productivity, while reducing carbon emissions. Optimizing nutrient requirements and enhancing the efficiency of fertilizer use can reduce carbon footprints. The use of soil test-based fertilizer applications and of fertilizer quality control in accordance with the principles set out in *The International Code of Conduct for the Sustainable Use and Management of Fertilizers*, published by FAO in 2019, can contribute to adaptation and mitigation.

32. Adopting alternative fertilizer sources, improving soil fertility and using synthetic and biological nitrification inhibitors are options for increasing nutrient use efficiency and limiting greenhouse gas emissions. Cropping systems that couple biologically based technologies, agroecology, agroforestry, regenerative and conservation agriculture decrease greenhouse gas emissions and increase carbon sequestration. Nanotechnology has the potential to improve productivity using nanopesticides and nanofertilizers, improve the quality of the soil using nanozeolites and hydrogels, stimulate plant growth using nanomaterials and provide smart monitoring using nanosensors.[34] New technological advances in post-harvest storage and processing reduce both food losses and greenhouse gas emissions.[35]

33. The application of crop models combined with climate services based on climate scenarios, ground observations, remote sensing and agronomic data help in identifying areas with higher climate risks. With agrometeorological advisories, digital technologies and insurance products, farmers can better manage weather-related risks and make informed decisions on crop selection, irrigation, fertilization and pest and disease control.[36] For example, climate information, provided through the Laos Climate Services for Agriculture system,[37] employed by the Lao People's Democratic Republic to interpret weekly agrometeorological data and climatological forecasts, provides farmers with options for climate-resilient practices.[38]

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[31] FAO, Rikolto and RUAF Global Partnership on Sustainable Urban Agriculture and Food Systems, *Urban and Peri-urban Agriculture Sourcebook: From Production to Food Systems* (Rome, FAO and Rikolto, 2022).

[32] FAO, *Building Sustainable and Resilient City Region Food Systems: Assessment and Planning Handbook* (Rome, 2023).

[33] See www.fao.org/millets-2023/about/en.

[34] L.F. Fraceto and others, "Nanotechnology in agriculture: which innovation potential does it have?", *Frontiers in Environmental Science*, vol. 4 (2016).

[35] FAO, *Managing Risks to Build Climate-smart and Resilient Agrifood Value Chains: The Role of Climate Services* (Rome, 2022).

[36] FAO, *Global Outlook on Climate Services in Agriculture: Investment Opportunities to Reach the Last Mile* (Rome, 2021); and Kwang-Hyung Kim, "Prospects for enhancing climate services in agriculture", *Bulletin of the American Meteorological Society*, vol. 104, No. 2 (2023).

[37] See www.fao.org/in-action/samis/agrometeorology/en/.

[38] FAO, *National Agrometeorological Services and Pest and Disease Early Warning in Asia and the Pacific* (Bangkok, 2021).

34. Technologies support the monitoring of natural hazards, helping with the analysis and design of interventions aimed at addressing risks and vulnerabilities. For example, in 2020, an inter-agency anticipatory action framework for floods established in Bangladesh helped farmers to improve livestock health, increase storage space for food, water and seeds in their households and store crop seeds for timely planting of *boro* rice, which follows the monsoon season.[39] Similarly, a range of satellite tools used in the Afghanistan Drought Early Warning Decision Support Tool helped to improve food security and livestock production in the country. The technological applications in the Integrated Food Security Phase Classification help in implementing a range of anticipatory actions.[40]

Sustainable management of natural resources and biodiversity conservation

35. Some examples of technologies developed for the management of natural resources are genetic improvement and germplasm research; the development of crop species for disease resistance and drought tolerance; and DNA barcoding for the identification of plant and fish species[41] to combat the illegal trade in and use of species, as well as for regulatory control. Genetic technologies have also created powerful tools for fish stock identification, genetic improvement and domestication of aquaculture species and the characterization of changes in aquatic life due to environmental or anthropogenic factors. Emerging genetic tools help to improve understanding of organisms in aquatic ecosystems in terms of diversity, distribution, abundance, movement, function and adaptation and could be applied in large-scale aquaculture facilities and aquaculture value chains.[42]

36. Sustainable mechanization contributes to the management of natural resources and to increasing the resilience of small-scale producers in the face of erratic weather by ensuring timely planting and harvesting. At the same time, locally available post-harvest equipment, such as dryers, threshers and mills, increases resilience by reducing harvest losses caused by rain or pest attacks, and timely mechanization services enable farmers to store or sell their produce in the market more quickly. Sustainable mechanization can increase water use efficiency by powering drip irrigation systems, by scaling up conservation agriculture, sustainable land and water management, environmental protection and climate resilience and by reducing soil erosion up to 99 per cent.[43]

37. Using remote sensing on land cover, biomass fires and peatland degradation, monitoring water productivity, optimizing land-sharing for agriculture and biodiversity conservation, forest monitoring, planning aquaculture development or coastal areas management, water-saving irrigation techniques and the use of robotic sensors to measure soil and water quality contribute to sustainable management of natural resources. Earth Map supports natural resources management by facilitating the interlay between the use of satellite imagery and natural resources data sets. It provides valuable information on land use and land cover, agricultural extent,

[39] FAO, “Bangladesh: impact of anticipatory action – striking before the floods to protect agricultural livelihoods” (Dhaka, 2021).

[40] Integrated Food Security Phase Classification, “IPC Global Strategic Programme 2019–2022: Towards improved evidence based decision making at global, regional, and country levels in response to food insecurity and malnutrition”, brochure, October 2019.

[41] Yawen Mu and others, “Next-generation DNA barcoding for fish identification using high-throughput sequencing in Tai Lake, China”, *Water*, vol. 15, No. 4 (2023).

[42] K. J. Friedman and others, *Current and Future Genetic Technologies for Fisheries and Aquaculture: Implications for the Work of FAO*, FAO Fisheries and Aquaculture Circular No. 1387 (Rome, 2022).

[43] Naomi Millner and others, “Exploring the opportunities and risks of aerial monitoring for biodiversity conservation”, *Global Social Challenges Journal*, vol. 2 (2023).

deforestation and the monitoring of conservation areas for biodiversity and ecosystem service provisions, among other features.

38. The Earth Map tool places a strong emphasis on user-friendliness, through its user-friendly interface, easy exploration and analysis of geospatial data and robust data visualization and interpretation of complex information for sustainable resource management.[44] Technologies support the sustainable use and conservation of biodiversity. For example, drones help in monitoring habitat changes in real time, to stop illegal poaching and habitat destruction;[45] using remote sensing on land cover, artificial intelligence, machine learning and virtual reality helps to scale the detection and monitoring of species and populations.

One Health approach for tackling transboundary animal and plant pests and diseases

39. Technologies are applied to improve early warning, risk forecasting, early detection, biosecurity and mitigation measures for health threats. Digitally enabled tools developed by FAO are being adopted in specific regions. These include the Emergency Prevention and Response System Global Animal Disease Information System, a global early warning system for high-impact animal diseases, including zoonoses; the Event Mobile Application, for tracking the emergence and notification of disease events; the Desert Locust Information Service, for monitoring and early warning; and the Fall Armyworm Monitoring and Early Warning System. These tools are used to collect field data on incidence, prevalence and management operations in real time to support decision makers for the effective management of animal and plant pests and diseases.

40. The International FAO Antimicrobial Resistance Monitoring System is used to collect, analyse, and share antimicrobial-resistant data in agriculture and will improve decision-making in antimicrobial selection and use. Technologies for improved prevention and control of agricultural threats and diseases are also progressing, including a sterile insect technique using nuclear techniques to control vectors that cause pests and diseases. Technologies for transboundary pest and disease management, such as drones, remote sensing and biopesticides, are being promoted and scaled. Partnerships between public and private sector actors serve to promote recombinant technologies for the development, piloting and uptake of thermotolerant and multivalent vaccines against animal diseases, as well as the development of rapid diagnostic tools and the use of metagenomics for early detection of diseases and antimicrobial-resistant pathogens.

41. Advanced systems for monitoring, early warning and forecasting of transboundary plant pests, such as locusts and fall armyworm,[46] enable preparedness and early response actions. These include such tools as the eLocust3, which is used to record field observations and transmit them in real time, by satellite, to inform stakeholders through various channels. Custom long-distance drones are used by national survey teams for mapping green areas and to detect desert locust infestations, in particular in inaccessible areas. Virtual learning modalities and e-learning tools help to improve readiness and to build broad capacity for the effective management of threats.

[44] Carmen Morales and others, "Earth Map: a novel tool for fast performance of advanced land monitoring and climate assessment", *Journal of Remote Sensing*, vol. 3 (January 2023).

[45] FAO, *The State of Food and Agriculture 2022*.

[46] FAO, *The Global Action for Fall Armyworm Control: Action Framework 2020–2022 – Working Together to Tame the Global Threat* (Rome, 2020).

Scaling technologies for improving food quality and safety

42. Blockchain technology is increasingly used to track food products, thus helping to identify the source of foodborne disease outbreaks and enabling quick recalls of contaminated products. Internet of things sensors and real-time monitoring systems are used to detect changes in temperature, humidity and other environmental factors that can affect food quality and safety.[47] Intelligent devices that make use of sensors, such as smart fridges and smart bins, are widely used in the food service sector to monitor the quality and quantity of food waste, and mobile apps are used to promote the sharing and reuse of surplus food.[48] Digital technologies, such as machine learning, artificial intelligence, smart packaging sensors, radio frequency identification tags and computer vision, are used for quality control and testing of food samples and to identify contaminants, such as pathogens and allergens.

43. Digital technologies open new horizons relating to food authenticity, managing recalls and food fraud control, as well as in reducing food loss and waste. The integration of blockchain and artificial intelligence[49] has gained a lot of attention with regard to improving security, efficiency and productivity in business environments characterized by volatility and uncertainty.[50] At the international level (Codex Alimentarius), new guidance is being considered for the use of emerging technologies, while recognizing the need for flexibility in adopting different instruments for traceability systems. Many large food processing plants, which supply food primarily to urban areas, are being optimized and automated with robotics to improve food safety.[51] However, challenges such as availability, high costs, capacity, interoperability between systems and a lack of common data standards across countries need to be addressed, to ensure scaling.

44. Whole genome sequencing technologies provide rapid detection of foodborne pathogens, as well as antimicrobial-resistant organisms transmitted to humans by other routes. Using whole genome sequencing in food control systems reduces the time of detection of contaminated products and abrogates foodborne disease outbreaks. The decreasing cost and increasing availability of portable DNA sequencing equipment are making the deployment of this technology feasible in low- and middle-income countries. In addition, whole genome sequencing and other omics-based technologies are being deployed to better understand the distribution and transmission of foodborne pathogens and antimicrobial-resistant microorganisms in agrifood systems. This allows for robust risk assessments to inform science-based decisions to control food contamination and foodborne diseases.

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[47] Usha Ramanathan and others "Adapting digital technologies to reduce food waste and improve operational efficiency of a frozen food company: the case of Yumchop Foods in the UK" *Sustainability*, vol. 14, No. 24 (2022).

[48] United Nations Environment Programme (UNEP) and UNEP Technical University of Denmark Partnership, *Reducing Consumer Food Waste Using Green and Digital Technologies* (Copenhagen and Nairobi, 2021).

[49] Brandon Zemp, "The intersection between AI and blockchain technology: industries of tomorrow", Forbes, 28 February 2023.

[50] Vincent Charles, Ali Emrouznejad and Tatiana Gherman, "A critical analysis of the integration of blockchain and artificial intelligence for supply chain, *Annals of Operations Research*, vol. 327, No. 1 (August 2023).

[51] Mario Herrero and others, "Articulating the effect of food systems innovation on the Sustainable Development Goals. *The Lancet: Planetary Health*, vol. 5, No. 1 (January 2021).

Reducing the digital divide, generating decent rural employment and promoting gender inclusion

45. Initiatives to bridge the digital divide in order to accelerate rural transformation are important. For example, the Digital Village Initiative[52] is aimed at converting villages around the world into digital hubs to support the acceleration of rural transformation. Similarly, the FAO Digital Services Portfolio[53] promotes the shift towards digitalization and modernization in agriculture, including with regard to data on environment and climate, through the efficient use of digital tools and technology. The open-access Hand-in-Hand Geospatial Platform[54] developed by FAO is a digital public good that provides advanced information on nearly a dozen domains, including food security, crops, soil, water, climate, fisheries, livestock and forests.

46. Mobile money transfers for livelihood assistance and e-commerce platforms can be scaled up. In Somalia, mobile money and livelihood assistance platforms deliver cash directly to beneficiaries' cell phones, allowing farming families to purchase goods and services in their local markets. The registration of recipients using biometric data and a voice-recognition system provides a safer, cheaper and better-targeted means than physical delivery and distribution.[55] E-commerce platforms provide a safe, functional and transparent option for agricultural producers to sell their products, which increases profit margins and competitiveness and reduces dependence on intermediaries.[56]

47. Digital technologies for financial inclusion, e-commerce, land titles, farm mechanization, and e-extension contribute to decent rural employment. While these trends help to raise overall productivity, the expected widespread social benefits driven by economy-wide spillovers are still to be harnessed in many contexts.[57] Even though the spread of advanced technologies is expected to create new job opportunities, increasing capital intensity in food value chains may reduce labour demand, with the risk of a negative net job balance.[58] Investments in human capital development, as well as policy and regulations, are required to minimize risks and to guarantee the affordability of technology.

48. Young farmers, who are more inclined to adopt technologies, can benefit from new entrepreneurship opportunities if they have access to such technologies and to adequate financing and training. Mobile money platforms offering free or affordable e-learning courses[59] can be a solution. Integrated agrofood parks represent another tool for providing access to training and services. These agricultural industrial parks are proving to be a successful model in many developing countries, with demonstration farms where farmers can learn about different technologies first-hand, and through the provision of infrastructure and agribusiness-related services. Distributed ledger technologies and geographic information systems have the potential to improve due diligence to address the causes of child labour in agrifood

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[52] See www.fao.org/platforms/digital-village-initiative/en.

[53] See www.fao.org/digital-services/en.

[54] See www.fao.org/hih-geospatial-platform/en/.

[55] FAO, "FAO Biometric Mobile Money Cash Transfer Modality in Somalia (USAID-Funded)", video, 22 May 2020.

[56] Victor Guzun and Adrian Cojocaru, *Development of an E-commerce Platform (D2C) for Small and Medium-sized Farmers and Returned Migrants Agri-entrepreneurs: Feasibility Study – Roadmap Recommendations* (Chisinau, FAO, 2022).

[57] International Labour Organization, *World Employment and Social Outlook: Trends 2023* (Geneva, International Labour Office, 2023).

[58] FAO, "The state of food and agriculture: agriculture food systems transformation – from strategy to action", forty-second session of the FAO Conference, document C 2021/2 Rev.1.

[59] FAO offers a free e-learning course for young agripreneurs, entitled "Agripreneurship 101". See https://elearning.fao.org/course/view.php?id=908.

value chains[60] and promote safe working environments, offering new learning tools for children of legal working age.

49. A gender-responsive approach for promoting technological solutions should ensure income generation and employment for women along value chains, through access to labour-saving equipment adapted to their needs. Furthermore, access to gender-responsive financing, social protection and crop insurance should be improved by leveraging cell phones and satellite data, training and awareness-raising campaigns.[61] Integrated and multi-stakeholder approaches could provide gender-responsive technical support and provide opportunities to discuss business development skills and to find innovative solutions that are more efficient, more profitable and more cost-effective.[62] For example, the Amplio Talking Books initiative in Uganda is designed to enable people with limited access to the Internet and electricity, in particular rural women, to reflect on and discuss the gender dimension of land issues within households and whole communities.[63]

Boosting resilience to vulnerabilities, shocks and stress (including COVID-19)

50. COVID-19 has highlighted the importance of using technologies in preparing for outbreaks, mitigating emergencies and addressing zoonotic diseases at source. With its extensive experience managing epidemics in animals, the FAO Emergency Centre for Transboundary Animal Diseases led One Health interventions in several countries in response to the pandemic. The Centre served as an entry point for addressing COVID-19 by using a smartphone app and telemedicine system in Bangladesh and by using animal health laboratories to test human samples for COVID-19 and training livestock health-care staff on COVID-19 detection in Cameroon. The Centre also supported veterinary laboratories with the installation of information management systems to improve the traceability of samples tested for COVID-19 in Ghana.

51. Technologies are used to bring together vast amounts of data and apply machine learning and computational models to assess risk and predict the occurrence of shocks and stress, as well as to inform targeted surveillance for early detection and response and for policy planning and control interventions. The FAO Data in Emergencies Hub-Impact initiative,[64] originally developed to inform the response to the COVID-19 pandemic, helps in understanding the impact of large-scale hazards by combining technologies such as remote sensing with secondary data from household surveys, interviews, focus group discussions and crowdsourcing surveys. Its assessments provide granular and rapid information on the impact of hazards on agricultural livelihoods and an estimate of damage and losses. In addition, the data is used by digital payment mechanisms in the delivery of cash transfers by leveraging national social protection systems before and during shocks and crises.

52. E-learning courses on such topics as developing anticipatory action systems and on managing climate risks through social protection are widely used to enhance people's capacities, while mobile-friendly products help in reaching fragile areas. Knowledge products developed in innovative formats, such as animated videos or

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[60] Emma Termeer and others, Digitalization and Child Labour in Agriculture: Exploring Blockchain and Geographic Information Systems to Monitor and Prevent Child Labour in Ghana's Cocoa Sector – Design Paper (Rome, FAO, 2023).

[61] FAO, *Protecting Livelihoods: Linking Agricultural Insurance and Social Protection* (Rome, 2021).

[62] FAO, "Women farmers' access to sustainable agricultural mechanization: a way to reduce drudgery and optimize farm management in Nepal", brochure, 2022; and FAO, "Sustainable mechanization as a means to empower women processors in Benin", brochure, 2023.

[63] FAO, "Talking books provide an innovative solution to reach rural communities in Uganda", 15 September 2022.

[64] See https://data-in-emergencies.fao.org/pages/impact.

digital stories, reach different types of audiences and serve to share good practices, as with the FAO knowledge-sharing platform on emergencies and resilience.[65]

VI. Conclusions and recommendations

Scaling agricultural technologies for sustainable development

53. It is important to analyse the potential impacts, benefits and risks of agricultural technologies before they are scaled up, to ensure that agrifood system transformations are inclusive, equitable, efficient, resilient and sustainable. The strategies developed to promote technologies should enable complementary inputs, infrastructure, training, better science communication, regulations, governance and policies aimed at triggering and/or accelerating changes in trends for impact at scale. The development and implementation of new technologies should always ensure the application of adequate environmental, health and human rights safeguards.

54. Coherent and integrated agricultural innovation systems with national agricultural research and extension systems, investments in agricultural research for development and participatory approaches for technology development and sharing are critical for joint development and adoption at scale.[66] Agricultural innovation systems, a multi-stakeholder approach involving national agricultural research systems, extension and advisory services, business enterprises, farmers organizations, farmer groups and other value chain and marketing actors can enhance inclusive technology development and improve adoption, ownership and equality among the most vulnerable communities. One tool available to enhance the investments needed is the World Trade Organization (WTO) Agreement on Agriculture, which allows WTO members to provide support for research and to support extension and advisory services for farmers.

55. Human capital, governance, enabling institutions and investment in rural infrastructure can support scaling, as can education and training, which enable not only access to technologies for rural communities, but also their active contributions to the joint creation of locally adapted solutions. Farmer Field Schools, which have been scaled to reach more than 100 countries, create spaces for rural communities to gain functional and technical skills, while shaping group training and solutions based on the diagnosis of problems in their respective agroecosystems.

Addressing risks and promoting equity, inclusion and access to technologies

56. Considerations on social and ethical concerns, cultural values and risks are fundamental to fostering adoption of technologies at scale. Ethical issues with regard to the application of artificial intelligence should be examined carefully, using robust global standards and guidelines to maximize benefits and minimize downsides.[67] International standards, in general, can be leveraged to enhance agricultural production processes and provide guidance to relevant stakeholders on agricultural operations throughout the food supply chain.[68] Artificial intelligence technologies in agriculture should be based on human rights; animal welfare principles; food safety; and environmental concerns, including the sustainable management of natural

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[65] See www.fao.org/in-action/kore/home/en/.

[66] FAO, "Promoting more coherent and integrated agricultural innovation systems (AIS) by strengthening national agricultural research and extension systems", twenty-eighth session of the Committee on Agriculture, document COAG/2022/10 Rev.1.

[67] United Nations Educational, Scientific and Cultural Organization, Recommendation on the Ethics of Artificial Intelligence (2022).

[68] The ITU/FAO Focus Group on Artificial Intelligence and Internet of Things for Digital Agriculture examines the role of emerging technologies within the agricultural sector.

resources and the conservation of biodiversity. Appropriate regulations should be in place to avoid negative consequences relating to gene-edited products, and farm mechanization and automation should avoid aggravating existing inequalities and high upfront costs for smallholders.

57. Acceptability and safety aspects of technologies should be addressed by providing gender-balanced access and access to young people and by bringing low- and middle-income countries and small island developing States on board to avoid technological divides. Special attention must be given to prioritizing the needs of the poorest and most vulnerable, and targeted efforts are needed to support smallholder farmers, migrant farm labourers and elderly workers. There is a specific need to apply gender-responsive approaches to technology adoption and reduce women's drudgery in agriculture and to enable equal access to inputs and mechanized equipment for women and men.[69]

58. The development of and access to new technologies should be combined with traditional knowledge, where relevant, to attract local communities and enable young people to be drivers of agrifood system transformation. Investments are needed in building the digital competences of young rural people, while removing barriers to access and enabling them to be innovators. Leveraging information and communications technologies and strengthening entrepreneurial, digital and soft skills will help to foster interest among young people and their ability to pursue decent jobs and livelihoods. Relevant and effective policy frameworks and incentives, regulatory measures and economic and legal instruments should be promoted to ensure equity and inclusion in the development of and access to technologies.

Partnering to adopt technologies at scale

59. Coherent multilateral efforts can accelerate technological adoption by encouraging Governments to implement national policies and plans and put people at the centre thereof. Promoting international cooperation, increasing investments in research, reducing asymmetries and guaranteeing access to digital public goods, as well as calling for innovative business models, help with adopting technologies at scale. Opportunities for low- and middle-income countries and least developed countries to leapfrog onto agricultural technologies should be pursued. Policies relating to intellectual property can contribute to the quick, effective and fair diffusion of technologies. The WTO Agreement on Trade-Related Aspects of Intellectual Property Rights provides a framework for innovation and for the transfer of technology. Partnerships among Governments, civil society organizations and farmers associations can help to bring local and traditional knowledge, including that of Indigenous Peoples, as a key input.

60. Fostering synergies between government departments, research institutions, national and international organizations, alliances and coalitions can accelerate the adoption of technologies. Some examples are the Tropical Agriculture Platform,[70] which supports the development of national capacities for agricultural innovation, and the Digital Public Goods Alliance,[71] which supports the development and use of open-source information technology products, such as the Hand-in-Hand Geospatial

[69] FAO, *The Status of Women in Agrifood Systems*.
[70] Tropical Agriculture Platform, *Common Framework on Capacity Development for Agricultural Innovation Systems: Synthesis Document* (Wallingford, United Kingdom of Great Britain and Northern Ireland, CAB International, 2016).
[71] See https://digitalpublicgoods.net/blog/bringing-the-benefits-of-digital-agriculture-to-all-fao-joins-digital-public-goods-alliance/.

Platform, the FAO Digital Services Portfolio, the Water Productivity Open-Access Portal[72] and Open Foris.[73]

61. The private sector plays a critical role in the development and adoption of technology and innovation at scale. Innovation in agriculture requires enterprises that invest in, develop and deploy agrotechnologies and technological platforms. Inclusive agribusiness models that address the needs of low-income smallholder farmers and create value for both the farmers and the investor company can offer a critical and sustainable pathway for leaving no one behind.

Role of the United Nations in fostering adoption and collective actions

62. The proposed global digital compact, to be discussed at the Summit of the Future in 2024, is expected to provide an outline of shared principles for an open, free and secure digital future for all. General Assembly resolution 75/1, adopted to mark the seventy-fifth anniversary of the United Nations, contained a pledge to improve digital cooperation, as did the report entitled "Our Common Agenda", released by the Secretary-General in September 2021. The United Nations can help to ensure better alignment of actions in a common ecosystem for digital initiatives to enable mutual benefits.

63. The Secretary-General's Road Map for Digital Cooperation is focused on enabling digital transformation and championing digital public goods, which are tools for the future of agriculture. As the landscape of science, technology and innovation is changing rapidly, with amplified digital tools, big data, artificial intelligence and public-private partnerships on the rise, the importance of the participation of the widest range of actors is increasingly recognized as a factor in the co-creation and adoption of technologies.

64. In 2022, the twenty-seventh Conference of the Parties to the United Nations Framework Convention on Climate Change adopted a decision on the Sharm el-Sheikh joint work on implementation of climate action on agriculture and food security, in which important recommendations for sustainable and climate-resilient agricultural systems, including on the role of technology, were highlighted. Parties to the Convention will have a four-year window in which to discuss ways to ramp up climate action in agrifood systems. Furthermore, the holder of the presidency of the twenty-eighth Conference of the Parties to the Convention and the United Nations Food Systems Coordination Hub have announced a new strategic partnership aimed at elevating the role of food systems as a catalyst for achieving both the Sustainable Development Goals and the Paris Agreement targets. It is important to support parties by providing technical information on climate-relevant policies, technologies and other concrete solutions.

65. Participants in the 2023 United Nations Food Systems Summit stocktaking moment reviewed progress made since 2021 on Summit-related commitments and identified successes, while seeking solutions to overcome gaps in implementation. The event provided an opportunity to strengthen the role of agrifood systems as critical Sustainable Development Goal accelerators and to advocate in favour of urgent action at scale, building on the latest evidence that sustainable food systems contribute to more sustainable outcomes for people, planet and prosperity. In his call to action for accelerated food system transformation, the Secretary General prioritized investing in research, data, innovation and technology capacities, including stronger connections with science, experience and expertise.

[72] See www.fao.org/in-action/remote-sensing-for-water-productivity/en/.
[73] See www.fao.org/redd/news/detail/en/c/1308759/.

66. The Food and Agriculture for Sustainable Transformation[74] initiative is aimed at supporting climate action in agrifood systems around three pillars: access to finance and investment; knowledge and capacity development; and policy support and dialogue. It helps with the implementation of nationally determined contributions, national adaptation plans and long-term low emissions and development strategies. Renewable energy in agrifood systems contributes to climate action and creates opportunities for the scaling of innovative technologies. In that context, it is crucial to support countries through sustainable energy actions and to lead international discussions on sustainable energy and UN-Energy initiatives.

67. On biodiversity conservation, the Kunming-Montreal Global Biodiversity Framework, adopted in December 2022 by the fifteenth Conference of the Parties to the Convention on Biological Diversity, is aimed at halting biodiversity loss and promoting the sustainable use of natural resources. Through the Framework, the Parties to the Convention recognized the role of science, technology and innovation in the sustainable management and use of biodiversity in agriculture, aquaculture, fisheries and forestry through the application of biodiversity-friendly practices and access to and the transfer of technologies and by raising awareness of and strengthening technical capacities to monitor biodiversity and develop innovative solutions.

68. In the agreed conclusions to its sixty-seventh session, the Commission on the Status of Women focused on innovation, technological change and education in the digital age for achieving gender equality and empowering all women and girls. The Commission highlighted the need to promote equal access by women in the rural economy to agricultural and digital technologies that are affordable, sustainable and accessible, through the transfer of technology and financing. Member States also agreed to promote technical, agricultural and vocational education and training and relevant information programmes for rural and women farmers, fishers and growers, to improve digital skills, productivity and employment opportunities.

69. Participants at the multi-stakeholder forum on science, technology and innovation for the Sustainable Development Goals and associated special events held in May 2023 under the Technology Facilitation Mechanism discussed technology needs and gaps, promoted scientific cooperation, innovation and capacity development and examined the impact of rapid technological change on sustainable development. Forum attendees highlighted the need to build trust in technologies, addressing their development challenges and enhanced partnerships on science, technology and innovation for road maps to achieving the Goals.

70. The Sustainable Development Goals Summit offers an opportunity to secure breakthroughs in agricultural technologies by focusing on high-impact initiatives and mobilizing further leadership and investment. The concrete role of agricultural technologies in transformation and in the achievement of the Goals needs to be demonstrated by further review and continuous monitoring of technological trends in agriculture across all regions.

[74] See www.fao.org/3/cc2186en/cc2186en.pdf.