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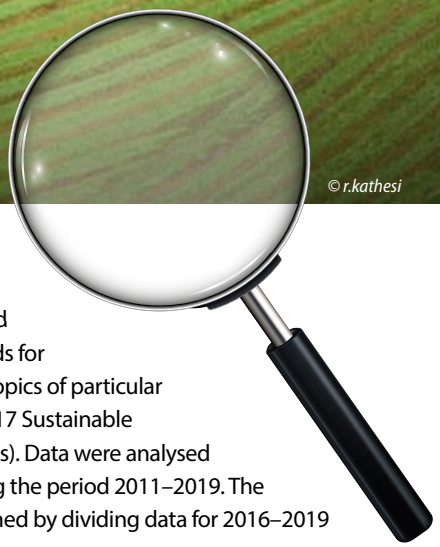
UNESCO SCIENCE REPORT
The race against time for smarter development

Science for the Sustainable Development Goals
# SDG 2 : Zero Hunger



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## Trends in scientific publishing

- Southeast Asia (from 25.4% to 33.2%), sub-Saharan Africa (from 2.9% to 3.6%), North Africa (from 1.6% to 2.4%) and Eastern Europe (from 2.9% to 3.4%) all increased their global share of scientific publications on agriculture, fisheries and forestry between 2015 and 2019.

- At the global level, international collaboration in this broad field rose from 20.7% over 2014–2016 to 22.8% over 2017–2019 (see Figure 1.16 in the report).

- Although agriculture, fisheries and forestry is an important field of science around the world, this focus is not always translating into sizeable contributions to the global literature.

  – For example, in The Gambia, just 4% of academic publications concerned agricultural sciences, fisheries and forestry between 2017 and 2019, even though 60% of researchers worked in this field. Despite two-thirds (67%) of Mauritanian researchers working in agriculture and fisheries in 2016, research expenditure in this sector remained relatively low, at just 0.49% of the value contributed to GDP by the agricultural sector (see chapter 17 and Table 19.2 in the report).

  – Only four out of 141 Arab journals are dedicated to agricultural and veterinary sciences, in a region where agricultural activity constitutes a key source of employment opportunities for much of the population (see chapter 17).

  – Output by researchers from the Caribbean Community (Caricom) on agriculture, fisheries and forestry came a distant second (less than 10% of the total) to health sciences (about 60%) between 2017 and 2019 (see Figure 6.5 in the report). Trinidad and Tobago's solid lead in this field (about 30% of the region's total scientific output) may be the result of efforts by the University of the West Indies in 2010 to revive a faculty devoted to agriculture and food sciences, academic programming in these areas having been absorbed by the Faculty of Science since the 1990s.

- In 2020, UNESCO analysed scientific publishing trends for a sample of 56 research topics of particular relevance to eight of the 17 Sustainable Development Goals (SDGs). Data were analysed for 193 countries covering the period 2011–2019. The growth rate was determined by dividing data for 2016–2019 by data for 2012–2015.

- In the field of sustainable food production (SDG2: Zero hunger), UNESCO analysed trends in the fields of *agro-ecology, traditional knowledge, pest-resistant crops, precision agriculture*[1]*, maintaining the genetic diversity of food crops and help for smallholder food producers.* For publication trends about climate-ready crops, see the factsheet on SDG 13.

- The topic of help for smallholder food producers showed the **fastest growth** among the six topics related to SDG2 with output increasing from 338 (2011) to 885 (2019) publications worldwide. Research into help for smallholder food producers accounted for just 0.02% of global scientific production between 2011 and 2019. Precision agriculture[1] was the next-fastest growing agricultural topic.

- Agro-ecology had the **largest volume** of output of the agriculture-related topics under study, with 23 988 publications over 2012 to 2019 (0.12% of global publications).

***Countries on the frontlines of climate change and those most reliant on natural resources are investing heavily, proportionately, in research on topics such as agro-ecology and climate-ready crops. Most are developing countries.***


1. Precision agriculture uses advanced technologies like remote sensing to monitor soil temperature and humidity, weather patterns, plant growth, irrigation rates and other factors. Crops are also rotated to preserve soils and improve biodiversity.

# Research trends by income group

For an interactive version of these data, please visit the online data visualization. Publication data by country and selected regions are freely available from the *UNESCO Science Report* web portal.

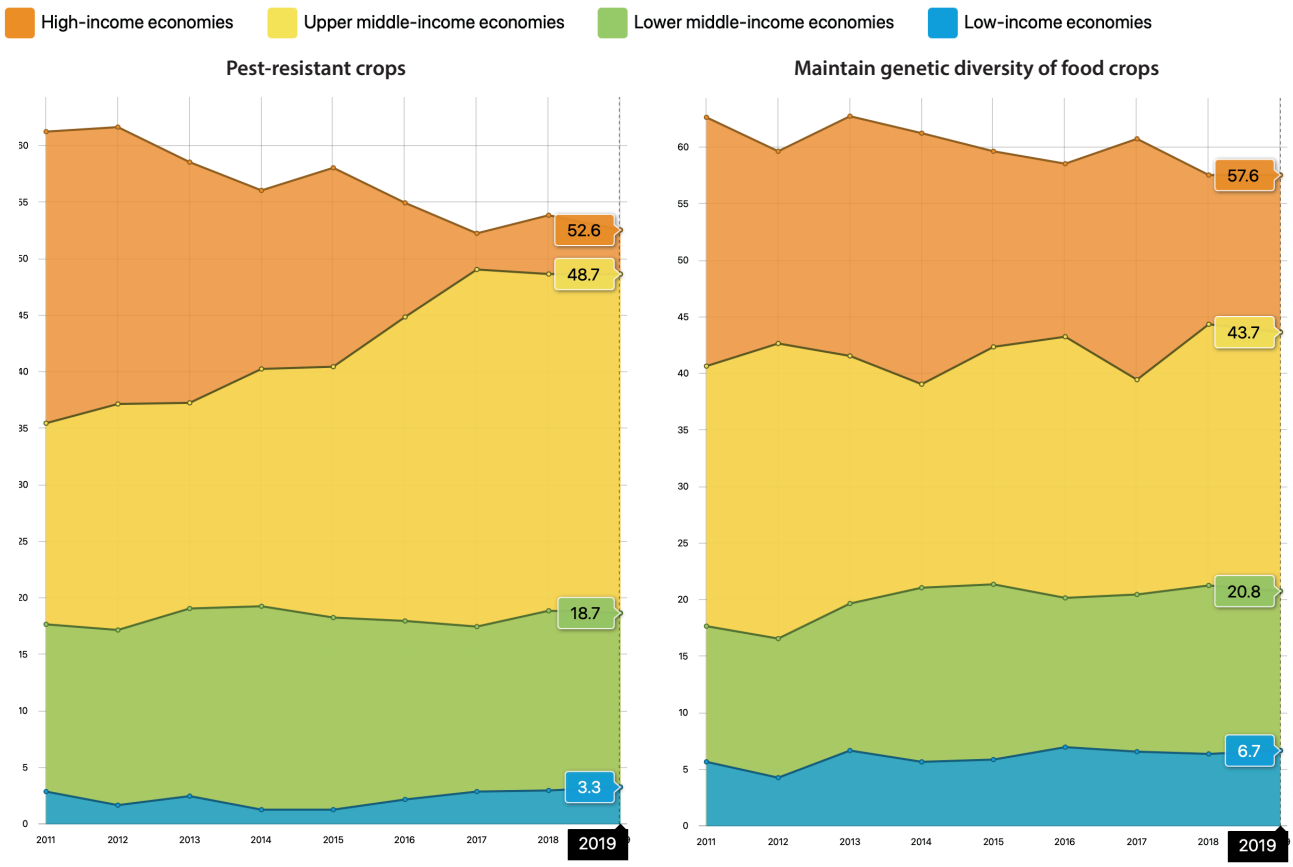
## Topic: *Pest-resistant crops*

- Scientists produced 12 053 publications on pest-resistant crops between 2012 and 2019, equivalent to 0.06% of global scientific output.
- Global scientific output on this topic increased from 1 189 to 1 741 publications over 2011–2019, with 5 482 (2012–2015) and 6 571 (2016–2019) publications.
- China produced the largest output on this topic over 2016–2019: 2 035 publications.
- Among countries producing at least 20 publications on this topic over 2012–2019, Tanzania showed the fastest growth, from 5 (2012–2015) to 27 (2016–2019) publications.
- Among countries with at least 100 publications on this topic over 2012–2019, the Russian Federation showed the fastest growth, with 40 (2012–2015) and 85 (2016–2019) publications.

## Topic: *Maintain genetic diversity of food crops*

- Scientists produced 8 541 publications on maintaining genetic diversity of food crops between 2012 and 2019, equivalent to 0.04% of global scientific output.
- Global scientific output on this topic increased from 759 (2011) to 1 460 (2019) publications, with 3 553 (2012–2015) and 4 988 (2016–2019) publications.
- China produced the largest output on this topic over 2016–2019: 963 publications.
- Among countries with at least 100 publications on this topic over 2012–2019, the Russian Federation showed the fastest growth with 38 (2012–2015) and 121 (2016–2019) publications.
- Among countries producing at least 100 publications over 2012–2019, Kenya led by specialization, with 16 times the global average intensity: 54 (2012–2015) and 80 (2016–2019) publications.

**Contribution by income group to global publishing on selected research topics related to Sustainable Development Goal 2: Zero hunger, 2011–2019 (%)**




*Source:* Scopus data treated by Science-Metrix and visualized by Values Associates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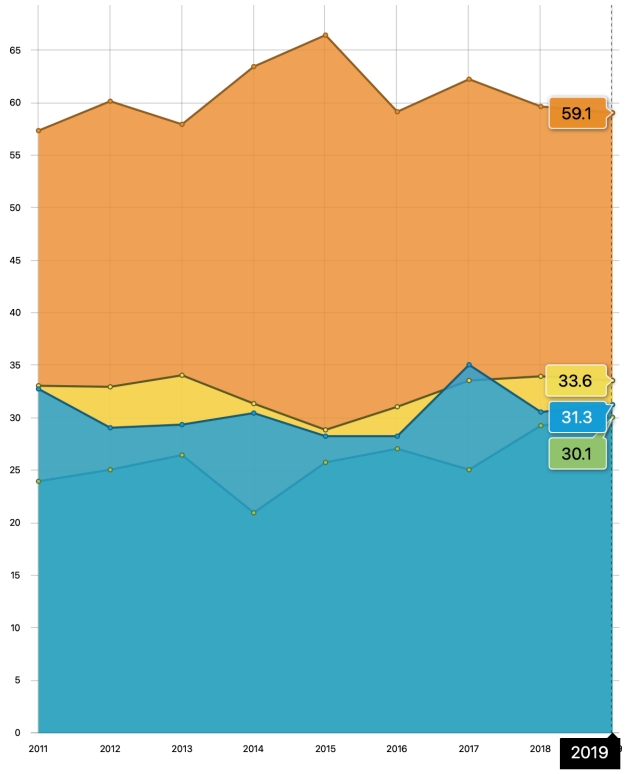
## Topic: *Help for smallholder food producers*

- Scientists produced 4 699 publications on help for smallholder food producers between 2012 and 2019, equivalent to 0.02% of global scientific output.
- Global scientific output on this topic increased from 338 (2011) to 885 (2019) publications. Between 2012–2015 (1 683) and 2016–2019 (3 016), output almost doubled.
- In 2019, sub-Saharan authors contributed to 361 (41%) of the world's 885 publications on this topic and the European Union to 294 articles (33%) on the same, suggesting a high level of scientific collaboration between these two regions.
- The USA produced the largest output on this topic over 2016–2019: 531 publications.
- Among countries with at least 100 publications on this topic over 2012–2019, Ghana rshowed the fastest growth, with 30 (2012–2015) and 112 (2016–2019) publications.
- Researchers in Zimbabwe published over 200 times more than the global average intensity on this topic, producing 79 (2012–2015) and 118 (2016–2019) publications.
- Between 2011 and 2019, East and Southeast Asia's global share of output on this topic increased from 15% to 23%.

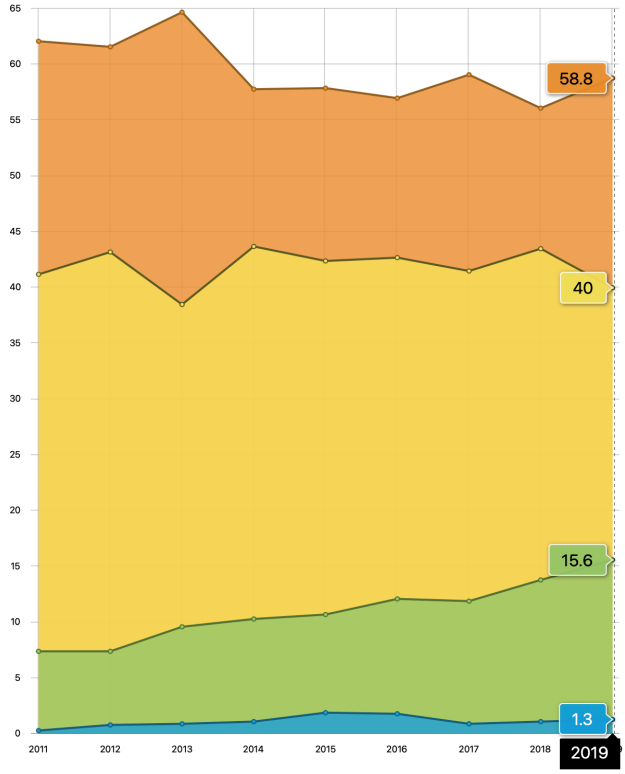
## Topic: *Precision agriculture*

- Scientists produced 9 627 publications on precision agriculture between 2012 and 2019, equivalent to 0.05% of global scientific output.
- Global scientific output on this topic increased from 792 (2011) to 2 094 (2019) publications, doubling between 3 553 (2012–2015) and 6 074 (2016–2019) publications.
- Lower middle-income economies' contribution to this topic rose from 10% to 14% of total output over 2011–2019, while high-income economies maintained their share (ca 60%) (see Figure 2.5 in the report).
- China produced the largest output on this topic over 2016–2019: 1 598 publications. China, India, Israel, the Russian Federation and UK all boosted their output on precision agriculture by 70% or more between 2011 and 2019.
- Among countries with at least 20 publications on this topic over 2012–2019, Ecuador showed the fastest growth, both raising output from 3 (2012–2015) to 24 (2016–2019) publications.
- Among countries with at least 100 publications on this topic over 2012–2019, the Russian Federation rshowed the fastest growth, with 19 (2012–2015) and 116 (2016–2019) publications.
- Lower middle-income economies' contribution to this topic rose from 7.4% to 15.6% between 2011 and 2019 (see Figure 2.8 in the report).

**Help for smallholder food producers**




**Precision agriculture**



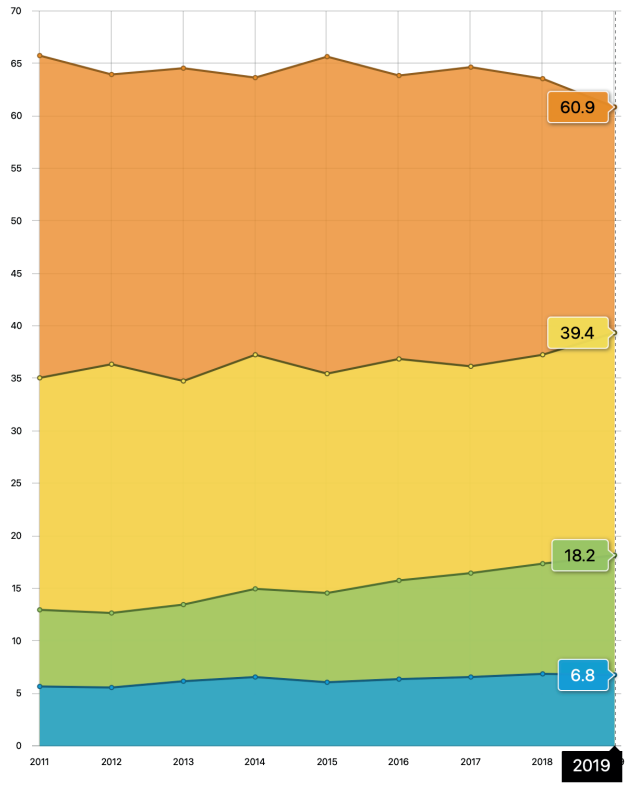
## Topic: *Agro-ecology*

- Scientists produced 23 988 publications on agro-ecology between 2012 and 2019, equivalent to 0.12% of global scientific output.
- Global scientific output on agro-ecology doubled from 2 192 (2011) to 4 308 (2019) publications, with 9 666 (2012–2015) and 14 322 (2016–2019) publications.
- The USA produced the largest output on this topic over 2016–2019: 2 895 publications.
- Among countries with at least 15 publications on this topic over 2012–2019, output grew fastest in Afghanistan (1/14), Iraq (3/24), Luxembourg (3/18) and Singapore (4/17).
- Among countries with at least 100 publications on this topic over 2012–2019, the Russian Federation ranked first for growth rate, producing 31 (2012–2015) and 142 (2016–2019) publications.
- Seven of the ten top countries by specialization in agro-ecology are in sub-Saharan Africa, namely Zimbabwe, Benin, Mali, Niger, Kenya, Madagascar and Malawi (in order of specialization).
- Low-income economies' contribution to this topic grew from 5.7% to 6.8% between 2011 and 2019 (see Figure 2.8 in the report).

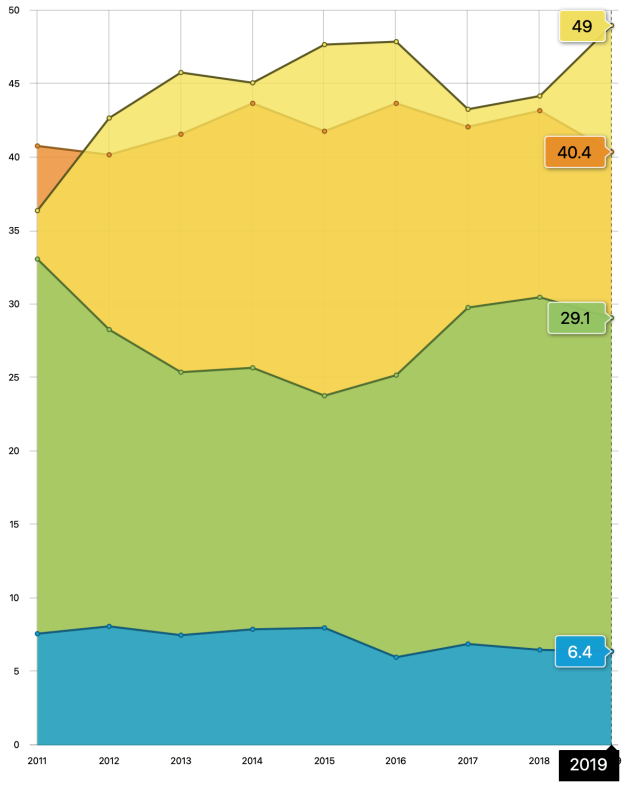
## Topic: *Traditional knowledge*

- Scientists produced 14 271 publications on traditional knowledge between 2012 and 2019, equivalent to 0.07% of global scientific output.
- Global scientific output on traditional knowledge increased from 1 467 (2011) to 2 254 (2019) publications, with 6 601 (2012–2015) and 7 670 (2016–2019) publications.
- China produced most on this topic over 2016–2019: 1 211 publications. Chinese traditional medicine was excluded from this topic.
- Indonesia showed the fastest growth, with output rising from 44 (2012–2015) to 296 (2016–2019) publications, nearly four times the global average intensity.
- Lower middle-income countries' contribution to this topic dipped from 33.1% (2011) to 29.1% (2019), while that of low-income economies dropped from 7.6% (2011) to 6.4% (2019).
- Among countries with at least 20 publications on this topic over 2012–2015 and 2016–2019, a surge was observed in Benin (25/47), Ecuador (15/43), Myanmar (5/19) and the Russian Federation (17/50).
- Among countries with at least 100 publications on this topic over 2012–2019, Cameroon led by specialization, with 85 (2012–2015) and 66 (2016–2019) publications.

**Agro-ecology**




**Traditional knowledge**



# Strategies for sustainable agriculture

## Regional and supranational strategies

- Greater investment in science, technology and innovation (STI) to enhance agricultural development figures among the recommendations for fast-track implementation of the commitments under the *Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods* adopted by the **African Union** (AU) in 2014 (see chapter 19).

  – The *Malabo Declaration* has set targets to 2025 with 43 defined indicators to assess countries' progress. A first Biennial Review Report and Scorecard was presented to the AU's General Assembly in January 2018. It found that 20 out of 47 countries were on track to fulfil the commitments of the *Malabo Declaration*, which include 'ending hunger, tripling intra-African trade in agricultural goods and services, enhancing the resilience of livelihoods and production systems and ensuring that agriculture contributes significantly to poverty reduction'.

  – According to this Scorecard, **Rwanda** has the highest reported share (61.3%) in sub-Saharan Africa of agricultural land that is managed sustainably (see Table 19.2).

- The agriculture sector remains the largest source of employment in **Central Africa**, in particular. The prospects for agriculture to remain an economic driver in the region remain uncertain, owing to overreliance on rainfed agriculture and agricultural commodity exports.

  – The Central African Economic and Monetary Community has adopted the *Central Africa Regional Strategy for Risk Prevention, Disaster Management and Adaptation to Climate Change* (2016). The strategy lays out plans to fund a satellite and meteorological information centre in Douala for disaster resilience, with support from the African Development Bank.

  – The Economic Community of Central African States, meanwhile, has adopted the *Central African Common Agricultural Policy* (2014), with financial support from the World Bank and technical assistance from the Rural Hub supporting development and food security in West and Central Africa.

  – The East African Community is prioritizing better agricultural practices, such as mechanization, irrigation, improved seeds and fertilizer use.

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- The **Southern African Development Community** (SADC) has adopted a Regional Climate Change Programme (2016). In 2017, SADC and UNESCO launched a Water Programme for Building Resilience to Floods and Droughts.

- The **European Union**'s new growth strategy, the *European Green Deal* (2020), seeks to accelerate the 'green' transition in all five socio-economic systems (energy; agrifood; manufacturing; transportation; and buildings–housing) by pointing resource mobilization and regulatory and other reforms in the same direction. The aim is to become the world's first climate-neutral continent by 2050, while making sure that jobs lost in one industry can be recreated elsewhere. A Just Transition Mechanism will help vulnerable countries weather the transition, such as in the event of widespread job losses tied to the phasing out of a polluting industry.

  – Soil, health and food represent one of the five concrete missions introduced by Horizon Europe, the bloc's seven-year framework programme for research and innovation to 2027. Each mission is accompanied by specific targets.

- The **Organisation of Islamic Cooperation**, which groups 57 Muslim-majority countries, adopted its *STI Agenda 2026* in 2017. This strategy advocates large multinational projects and stronger international linkages with 'the best in the world' to build collective competence in areas ranging from water, food and agriculture to energy and basic and applied sciences.

## National strategies

Agriculture features as a priority sector in the national development plans and research strategies of many countries. Here, we focus on policies and strategies specific to sustainable agriculture.

- **Guinea** developed the *Sustainable Agricultural Development 2016–2020*, one of several sectoral policies under the *National Plan for Economic and Social Development 2016–2020*. The *National Plan* was the first five-year implementation plan of *Emerging Guinea: Vision 2040*, which was drafted by the government in the wake of the devastating Ebola outbreak in 2014.

- In **Zambia**'s *Climate-Smart Agriculture Investment Plan* (2019) predicts that climate change could diminish the yields of key crops by 25% but, crucially, that climate-smart agriculture could increase crop yields by 23%.

- Agriculture (mainly rainfed) employs 90% of the population of **Burundi**, yet only 36% of land is arable. According to the 2018 World Hunger Index, around 15% of the population is living in acute food insecurity. This vulnerability worsens during the long dry season, which is getting drier and hotter. To meet its objectives for food security, the country will need to boost its agricultural productivity, currently the lowest in the region. This is what the *National Agricultural Strategy* (2018–2027) and *National Agricultural*

*Investment Plan* (2018–2022) set out to do. The aim is to facilitate equitable access to arable land and develop and implement policies and programmes to support crop diversification and greater productivity for livestock and fisheries (see chapter 19). Between 2011 and 2019, Burundi scientists produced seven articles on ways to help smallholder food producers increase their income and six on the sustainable use of terrestrial ecosystems.

- The government of **Ethiopia** committed 60% of its 2018 budget to poverty-targeted sectors such as agriculture, education, health, water and roads.

- The combination of drought and flooding in **Malawi** over the 2015/2016 agricultural season led to the declaration of a State of Disaster. Malawi's *National Agricultural Policy* (2016) and *National Irrigation Policy* (2016) together provide a strategic framework for improving productivity, economic diversification and value addition.

- Released in November 2018, the *Artificial Intelligence Strategy* of **Mauritius** identifies uses for artificial intelligence (AI) in health care, fintech and in agriculture, where AI is perceived as a tool for crop and pest management as well as precision farming.

- The **United Arab Emirates'** *National Food Security Strategy* 2051 (2018) outlines 38 initiatives to diversify sources of food imports and identify alternative supply schemes. The country is experimenting with indoor vertical farming, which uses non-soil substrates to limit water use. As of 2020, 89 hydroponic projects were active.

- Agriculture is identified as one of seven national priority sectors for artificial intelligence in **Bangladesh**'s draft National Strategy for Artificial Intelligence for 2019–2024.

- Food and nutrition security is a defined priority area in the **Philippines**' *National Integrated Basic Research Agenda* (2017). The National Technical Education and Skills Development Authority Plan 2018–2022 focuses on developing requisite skills for occupations in seven sectors, such as in agriculture, fisheries and forestry (including agroprocessing).

- **Thailand**'s *National Strategy* (2018–2037) focuses on developing value-added agriculture through, for instance, biological and smart farming. To promote industrial research and development (R&D), the Cabinet approved tax incentives in May 2017 for companies that form clusters to raise their investment in five priority areas, including food, agriculture and biotechnology.

- Deforestation in the **Lao People's Democratic Republic** has been largely driven by the expansion of agriculture and clearing for infrastructure development. Despite the *National Forestry Strategy 2020* (2005), forest cover has fell from 61% to 58% between 2000 and 2015 (see chapter 26).

- The **Russian** *Strategy for the Development of Science and Technology to 2035* (2016) has been touted as a new national policy model. It fixes seven mission-oriented priorities, one of which is sustainable agriculture. Sustainable agriculture features among the seven mission-oriented priorities of the government's *Strategy for the Development of Science and Technology to 2035* (see chapter 13).

## Sustainable agriculture can help fight pandemics


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A workshop report published in October 2020 by the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES), which is co-sponsored by UNESCO, the United Nations Development Programme, United Nations Environment Programme and United Nations' Food and Agricultural Organization, observes that the majority (70%) of emerging diseases such as Ebola and Zika and almost all known pandemics (e.g. influenza, HIV/AIDS and Covid-19), are zoonoses, meaning that they are caused by microbes of animal origin. These microbes 'spill over' when humans, wildlife and livestock come into contact with one another, such as through agricultural expansion, deforestation or wildlife trade.

The IPBES report estimates that there are another 1.7 million currently 'undiscovered' viruses in mammals and birds, up to half of which could have the ability to infect people. It predicts that future pandemics will emerge more often, spread more rapidly, do more damage to the global economy and kill more people than Covid-19, unless there is a transformative change in the global approach to dealing with infectious diseases.

As the report recalls, the risk of a pandemic can be significantly lowered by reducing the human activities that drive the loss of biodiversity, such as agricultural expansion and intensification, the unsustainable exploitation of biodiversity-rich regions and unsustainable production and consumption patterns.

See Box 2.1 in the *UNESCO Science Report* (2021)

# Innovative partnerships and programmes for sustainable agriculture

- To guarantee safe, clean and well-managed water supplies, the federal government of **Canada** mandated the Minister of Environment and Climate Change and the Minister of Agriculture and Agri-food in December 2019 to create a Canada Water Agency which would work in conjunction with provinces, territories, indigenous communities, local authorities and scientists (see chapter 4).
  - Indigenous students formed 1.8% of graduates in the field of agriculture and natural resources, following social and behavioural sciences for the largest share of indigenous representation. However, this share amounts to less than half of the share of indigenous peoples in Canada's total population (see Figure 4.5 in the report).
- Agribusiness is a priority sector for investment in the majority of countries belonging to the **Caribbean Community** (Caricom) (see Figure 6.2 in the report). Most of the business innovation coming out of the Caricom region is focusing on health or agriculture. The Mona Institute of Applied Sciences, a company set up by the University of the West Indies in 2001, is in the process of turning the challenges faced by manufacturers and agro-processors into business opportunities. It secured support from the Inter-American Development Bank in 2019 for castor oil production.
- Implemented between 2017 and 2020, the Innovation for Firms in Suriname scheme was **Suriname**'s only policy instrument supporting private-sector innovation at the time. It focused on the agriculture, food processing and tourism sectors (see Box 6.3 in the report).
- Between 2012 and 2017, **Liberia**'s Smallholder Agricultural Productivity Enhancement and Commercialization (SAPEC) programme sought to improve household income and food security by using sustainable methods to intensify production of vegetable and cassava crops, adding value to produce and refining marketing techniques. To date, 14 climate-smart rice varieties have also been introduced to farmers, in collaboration with AfricaRice. It is estimated that 135 000 people benefited from SAPEC, 60% of them being women. This is close to the target of 150 000. The programme developed the first farmer e-database, with over 321 766 farmers from all 15 counties agreeing to record their phone numbers, identity photos and assigned identity numbers. SAPEC was implemented with funding from the Global Agriculture and Food Security Programme, the African Development Bank and Ministry of Agriculture (see chapter 18).
- In 2012, the government of **Senegal** created, by law, the Sovereign Fund for Strategic Investments. This fund uses state revenue from oil and gas to invest in capital funds targeting small- and medium-sized enterprises in sectors prioritized by the *Senegal Emerging Plan*, which include agriculture. The long-term goal is to reduce dependence on this form of revenue through a diversified investment portfolio (see Box 18.4 in the report).
- In 2015, the Southern Africa Network for Biosciences, a programme run by the New Partnership for Africa's Development, launched FemBioBiz to empower women entrepreneurs in the agrifood, health and nutrition sectors. It is billed as the largest programme of its type in **Southern Africa**. Its objectives are to heighten the visibility of women in biosciences and contribute to the investment-readiness of women-led businesses, as well as to the entrepreneurship ecosystem as a whole. To this end, it is currently developing peer-to-peer networks, conducting training and providing mentorship in eight Southern African countries (see chapter 20).
- Climate-smart agricultural practices are being explored to mitigate the impact of extreme weather events. In **Madagascar**, where an estimated nine-tenths of the population works in agriculture, the Manitatra 2 project has been promoting organic warm compost, which offers higher yields and improves crops' resistance to drought and disease. Funded by the European Union and implemented by the Groupement Semis Direct Madagascar over the period 2018–2021, the project estimated that it had reached 18 000 Malagasy farmers by August 2020 (see chapter 20).
- The **Afghanistan** Reconstruction Trust Fund (ARTF) has added three emergency projects to its portfolio to cushion the Covid-19 pandemic's socio-economic impact, which was expected to push up to 72% of the population into poverty in 2020. A project administered by the Ministry of Agriculture, Irrigation and Livestock has been teaching farmers, who often have small plots of land, the techniques of high-density planting (see chapter 21).
- **New Zealand**'s 2019 industrial policy identifies four priority sectors, based on their potential to develop and apply digital technologies: agtech, food and beverages, forestry and wood-processing. Entitled *From the Knowledge Wave to the Digital Age: Growing innovative industries in New Zealand* (2019), the policy foresees the creation of a Horticultural Robotics Institute and a specialist agtech venture capital fund, among other schemes. (see chapter 26).

# Applying agricultural research and technology

- The period from 2015 to 2020 has seen a rapid expansion of digital technology in agriculture in **Brazil** (see Box 8.5 in the report). For example, CPqD, a non-profit research institute based in Campinas which is, currently, the largest software registering organization in Brazil, has partnered with Usina São Martinho, one of the largest sugarcane producers in the world, to develop an Internet of Things system which uses a radio frequency to connect agricultural equipment in the field without recourse to public telecommunications infrastructure.

- Agricultural technology is one of ten cutting-edge sectors of manufacturing identified in the **Made in China 2025** policy, with specific sector-by-sector goals for expanding the global market share of Chinese suppliers.

- **China**'s BeiDou Navigation Satellite System, the Chinese equivalent of the US Global Positioning System, now covers many countries participating in the Belt and Road Initiative, providing support for land planning and coastline mapping in **Indonesia** and for agricultural automation in China and the **Russian Federation**.

- Under the *Climate Change Adaptation Act* of 2018, the **Japanese** government formulated a *Basic Policy on Economic and Fiscal Management Reform 2018: Realizing Sustainable Economic Growth by Overcoming the Decreasing Birth Rate and Ageing Population*, approved by the Cabinet in June 2018. This policy promotes the establishment of an adaptation platform and outlines measures related to agriculture and disaster prevention, among other areas. For example, the government is promoting 'smart agriculture' to compensate for labour shortages, by developing drones, autonomous tractors and other technologies.

- Following the **Republic of Korea**'s *National Innovation Cluster* plan (2018) to foster regional autonomy, the Jeollabuk-Do cluster has specialized in smart agricultural life science (see Figure 25.3 in the report).

- Convinced that biorefineries have the potential to kickstart an era of **Thai** leadership in bio-industry, the director of the Eastern Economic Corridor of Innovation, scheduled to become fully operational in mid-2021, plans to establish model biorefineries to transform agricultural produce and other outputs into biofuel and bioplastic palettes for use in various bioproducts (see Box 26.1 in the report).

- In December 2019, El Salvador's Minister of the Environment and Natural Resources presented the **Central American Integration System**'s strategic framework and action plan for achieving carbon neutrality in the agriculture and forestry sectors.

- Agritourism has been identified as a priority sector in preparations for **Albania**'s smart specialization strategy (see chapter 12).

# Research and training in sustainable agriculture

- The Caribbean Agricultural Research and Development Institute has research stations in all **Caricom** countries except Haiti and Suriname.

- Two Earth observation satellites developed by the **Argentine** space agency CONAE with fellow agencies were launched in 2018 and 2020 as part of a constellation that will provide real-time information to monitor soil moisture, plagues of agricultural pests, outbreaks of dengue and Zika, forest fires and climate change, among other applications. The production of local parts for the project has spawned a network of 1 500 high-tech small and medium-sized enterprises in Argentina.

- Faced with increasingly capricious weather patterns that are playing havoc with food security, countries in **West Africa** (chapter 18) are developing expertise in climate science with international support. For instance, the Economic Community of West African States (ECOWAS) has partnered with the German government since 2012 to create the West African Science Service Centre on Climate Change and Adapted Land Use, which encompasses a Climate Research Programme, a Graduate Studies Programme and observation networks. One focus of the climate research programme is sustainable agriculture. Among the doctoral programmes proposed by universities in participating countries, that in climate change and agriculture is dispensed, in Mali, by the University of Science and Technology and the Rural Polytechnic Institute of Training and Applied Research and, in Ghana, by the University of Cape Coast (see Box 18.1 in the report).

- Since 2014, the World Bank has supported the Africa Higher Education Centers of Excellence programme, including the West Africa Centre for Crop Improvement at the University of **Ghana**, which is developing climate-resilient strains of food crops, and a centre focusing on climate change, biodiversity and agriculture at Felix Houphouët-Boigny University in **Côte d'Ivoire**. **Nigeria** is home to two such centres with a focus on agriculture: one at the Federal University of Agriculture and one at Bayero University, Kano (see Table 18.1 in the report).

- The World Bank has extended its Centres of Excellence Programme to East Africa. Since 2017, there has been a centre specializing in climate-smart agriculture at Haramaya University in **Ethiopia** and a centre for sustainable agriculture and agribusiness management at Egerton University in **Kenya**, for instance (see chapter 19).

- Between 2013 and 2018, the Governments of **Norway** and **Malawi** implemented an initiative entitled Capacity Building for Managing Climate Change in Malawi, which sought to boost national research capacity and outreach, especially in the agricultural sector. The scheme provided research grants and scholarships, as well as subsidized farm inputs and livestock.

- In **Benin**, four public universities were created through mergers between 2012 and 2016, one of which specializes in agriculture (see chapter 18).

- **Togo**'s new policy vision is to restructure the economy through the development of processing centres for agricultural, manufacturing and extractive products. To this end, the government is upgrading vocational training centres for young men and women working in industry, agriculture, tourism, finance and crafts (see chapter 18).

- **Burkina Faso** has introduced what it terms 'federative research programmes' with relevant other ministries to ensure more efficient delivery. To date, the Ministries of Health and Agriculture are each leading a programme in partnership with the Ministry of Higher Education, Scientific Research and Innovation (see chapter 18).

- In **Burkina Faso**, the National Fund for Research and Innovation for Development (FONRID, est. 2011) has been partnering with **Senegal** to obtain joint research grants in food and agriculture through the Science Granting Councils Initiative (see chapter 18).

- The **Republic of Congo**'s sectoral research policy, defined in the National Development Programme 2018–2028, is articulated around three strategic capacity-building programmes. One capacity-building programme focuses on agriculture. It aims to improve seeds and planting material, soil fertility, pest control, farming techniques and food crop productivity (see chapter 19).

- **Kenya**'s first graduate school in information technology, the Kenya Advanced Institute of Science and Technology, is set to admit its first intake of master's and PhD students in 2021. They will be enrolled in three faculties: Mechanical, Electrical and ICT Engineering; Chemical, Civil and Agriculture Engineering and Biotechnology; and Basic Science (see chapter 19).

- In 2019, **Malawi**'s National Commission for Science and Technology developed collaborative calls for agricultural research with Mozambique and Zimbabwe, to address common knowledge gaps (see chapter 20). In co-ordination with Namibia's National Commission

on Research, Science and Technology, Mozambique's National Research Foundation has launched a bilateral call for collaborative research in agriculture, with a focus on agroprocessing (see chapter 20).

- Under **Pakistan**'s *National Adaptation Plan for Climate Change Impacts 2016–2025*, a national network is to be set up of agencies and universities carrying out research on adaptation to climate change to improve co-ordination of related research and the dissemination of information. The National Science Foundation, National Research Council and Council for Agricultural Research Policy, among others, are to develop and manage a co-ordinated multidisciplinary small research grant programme on thematic areas relating to climate change adaptation, which will be facilitated by the Climate Change Secretariat (see chapter 21).

- The Fab Lab **Bhutan** was established in 2017 as a creative space for developers of digital products and prototypes (see Box 21.3). A number of research projects have already been completed. For instance, an app has been developed which uses artificial intelligence to inspect the health of beehives and provide updates continually throughout the day (Beehive Monitoring Assistant). Another project has developed a platform which uses robotic tools to compile research, data and shared documentation to help farming communities increase their productivity and improve their working conditions (Karma farmBot – Open Tool for Farming) [See chapter 21].

- The **Nicaraguan** Institute of Agricultural Technology (INTA) has run several workshops in agro-nanotechnology since 2017 which bring together researchers, technicians, students and producers from around the country.

- **Peru**'s Ministry of Agriculture has administered the National Agrarian Innovation Programme (PNIA) since 2014. This six-year programme sought to foster a more inclusive and sustainable agriculture sector by improving the competitiveness and profitability of smallholders and medium-sized producers. PNIA was funded jointly by the Peruvian government, the World Bank and International Development Bank. It had the twin objective of improving both supply and demand for innovation services, notably by strengthening the capacity of the National Institute of Agricultural Research to deliver quality services and by developing a market for these.

- Founded in 2015, the Research and Development Institute for Information Technologies in Biosystems (BioSense Institute) in Novi Sad cross-fertilizes the two most promising sectors in **Serbia**: information and communication technologies and agriculture (see Box 10.3 in the report). The BioSense Institute is participating in more than 30 Horizon 2020 projects. The most important of these, Antares, aims to transform the BioSense Institute into a European centre of excellence for advanced technologies in sustainable agriculture and food security.

Israeli scientists are collecting crop data which they will then analyse using the Evogene company's GeneRator computational platform, which employs artificial intelligence to decode a plant's biology, in order to guide the development of improved crops.
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- Over 2017–2018, **Algeria**, **Egypt**, **Jordan**, **Lebanon**, **Morocco** and **Tunisia** signed agreements to participate in the European Union's Partnership for Research and Innovation in the Mediterranean Area (PRIMA) programme running to 2028. This programme is exploring new approaches to research and innovation in sustainable agriculture production and water availability. The European Union is allocating € 220 million to the programme, with participating countries providing a further € 52 million. This project has been hailed as a major advance in science diplomacy. Six calls for research proposals were launched in February 2020 on water management, the agrifood value chain, the water–ecosystem–food nexus and farming systems.

- The **United Arab Emirates** is experimenting with indoor vertical farming, which uses non-soil substrates to limit water use and artificial lighting. About 97% of groundwater is currently used for agriculture. In April 2020, the Abu Dhabi Investment Office, a government body founded in 2018 to support start-ups and SMEs, announced plans to allocate US$ 100 million to four agritech firms as an initial investment in a larger US$ 272 million programme in support of agritech. The four firms are developing an indoor tomato farm (Madar Farms); a research centre (Aerofarms); an irrigation system compatible with sandy soil; and more efficient fertilizers.

- In May 2019, an act of parliament established the **Mauritius** Research and Innovation Council and the National Research and Innovation Fund. In January 2020, the council signed a collaboration agreement with the Technology Innovation Agency of **South Africa**. The partners then released a call for research proposals focusing on 'real-world solutions' in the following broad areas: the green and blue economies; smart agriculture and life sciences; manufacturing; social innovation; and emerging sectors.

- The United Nations' Adaptation Fund was launched in 2015 to support implementation of the *Paris Agreement* on climate action. A US$ 13 million project approved in November 2019 has been strengthening resilience to drought among smallholder farmers in **Djibouti**, **Kenya**, **Sudan** and **Uganda**.

The Smart Acres' vertical farm in the United Arab Emirates uses non-soil substrates to limit water use. Seen here in March 2021 is kale, or leaf cabbage, growing in one of the company's eight freight containers. Smart Acres plans to set up a research institute to develop a local potato seed with an international team to reduce costly imports of seeds. © Smart Acres

# Ties to relevant UNESCO programmes

## Food and agricultural heritage

UNESCO recognizes the significance and global relevance of agricultural landscapes and culinary traditions, as part of sustainable life on a shared planet. Over 63 food preparation and culinary traditions are included in Representative Lists of Intangible Cultural Heritage. There are 97 connections, 38 of which are considered 'strong', between Intangible Cultural Heritage elements and SDG2: Zero hunger. For more, see: https://ich.unesco.org/en/dive&display=sdg#tabs

UNESCO has also collated educational resources relating to SDG2: https://en.unesco.org/themes/education/sdgs/material/02

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## Supporting skills for sustainable agriculture

The European Union and UNESCO launched a programme on Skills Development in Rural Areas of Uzbekistan in 2020. Funded by the European Union to the tune of € 9.6 million, the programme will be implemented by UNESCO over 2020–2023. The aim of this project is to enhance living standards in rural areas through better employability and to prepare women and men with relevant skills for the needs of sustainable, diversified and modernized agriculture (see photo above).

For more, see: https://en.unesco.org/news/european-union-and-unesco-presented-implementation-roadmap-skills-development-agriculture

Haitians enjoy a meal of Joumou soup. This local delicacy was inscribed on UNESCO's List of Intangible Cultural Heritage in 2021. © DPH-2021/photo by Walter Séjour