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# FAO REGIONAL CONFERENCE FOR ASIA AND THE PACIFIC

## Thirty-fifth Session

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### Bytes to Sustain Our Bites: Leveraging Digital Agriculture for Sustainable Development Goals (SDGs)

#### Executive Summary

Food and agriculture systems across the globe are undergoing fast systemic changes. A few key emerging trends in the agriculture sector are going to significantly influence the achievement of many of the Sustainable Development Goal (SDG) targets. As food and agriculture systems are becoming more knowledge-intensive, digital technologies will play a more prominent role in the future so that farmers can achieve higher total factor productivity (comprising all of the land, labour, capital, and material resources employed in farm production *vis-à-vis* the total amount of crop and livestock output of farms) with lesser negative impact to the environment. Mobile telephony, hyperconnectivity and 5G, artificial intelligence and machine learning, Internet of Things (IoT), remote sensing, big data analytics and blockchain are just some of the emerging digital technologies that are expected to transform the food and agriculture systems into Agriculture 4.0 (the Fourth Agriculture Revolution).

In order to make the best of technology advancement in the agriculture sector, it is important to understand how technologies evolve, function and flourish in the real world, in tandem with other factors such as infrastructure, policies and legislations and human skills, termed as “Digital Pathways” in this paper.

Analysing and understanding these digital pathways will help to strategize, prioritize and actualize the benefits of digital technologies so that they can address the challenges faced by the agriculture and food systems, while at the same time help in gaining better insights about the possible consequences of the digitalization of the agriculture sector in order to identify, avoid or mitigate the associated risks and challenges that technologies might bring in.

<sup>1</sup> Rescheduled from 17-20 February 2020, Thimphu, Bhutan

### **Suggested action by the Regional Conference**

The Regional Conference is invited to:

- provide advice on cohesive actions by FAO to support member countries in developing digital agriculture (e-agriculture) strategy for the respective countries in Asia and the Pacific region;
- provide guidance on policy-level interventions by FAO to tap into private sector investment and innovations in digital agriculture in order to extend the benefits of digital technologies to small and family farmers through a win-win public-private-people partnership approach;
- recommend actions for creating data standards and operation procedures for data collection, verification, synchronization and sharing (interoperability) for the agriculture sector in order to help member countries integrate isolated digital agriculture systems and develop cross-sectoral digital solutions and achieve better return on investment in digital agriculture;
- acknowledge the importance of sharing knowledge and technology between countries with improved Information and Communication Technology (ICT) infrastructure and skills and with countries with lesser developed ICT infrastructure and skills, within the overarching scope of FAO's Hand-in-Hand initiative; and
- support development of a regional innovation hub for digital agriculture as a think tank and incubator for digital agriculture innovation and experimentation in the region.

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## Introduction

1. Feeding close to 9 billion people in 2030<sup>2</sup> will be a big challenge for humanity. Despite progress made by many member countries, the number of undernourished people in the world has increased from 784 to 820 million during 2015–18, underscoring the immense challenge of achieving the Zero Hunger target by 2030.<sup>3</sup> Together with hunger, rural poverty may also not be completely eradicated; 6 percent of the world's population will still be living in extreme poverty in 2030, if current trends continue<sup>4</sup>. Climate change impact will worsen in future and natural resources will be scarcer. Business as usual will surely not change this trend and a drastic change in the food and agriculture systems may be the only way forward.

2. The sheer immensity of the challenges to achieve the Sustainable Development Goal (SDG) targets compels to think out of the box; can digital technologies possibly revolutionize farming, thus making it possible to achieve higher food production without taxing the shrinking natural resources and damaging the already fragile environment? If yes, then what are those technologies that could usher in a completely new way of growing, distributing and consuming food, thereby fundamentally changing or disrupting the conventional food and agriculture systems? How can these disrupting technologies help in achieving “digital equity” among the “digitally included” and “digitally-excluded”, the developed and the least developed, the rich and poor countries, as it is critically important that the technological innovations must catalyse growth; targeting the poorest, the least developed countries (LDCs), landlocked developing countries (LLDCs), small island developing states (SIDS), and countries in global food crises, and help them to achieve food and nutrition security and resilient livelihoods, while safeguarding the environment and conserving natural resources.

3. Digital technologies can potentially bridge the gap of inequity by removing or diminishing barriers to cooperation, collaboration and mutual gains. Technology can be an effective “matchmaker”, bringing multiple stakeholders to a common platform where developed countries can help countries with the highest poverty and hunger rates by infusing innovation, investment and entrepreneurship and making inclusive development possible at subregional, regional and global levels.

4. However, a very pertinent question that needs to be answered is whether technologies can drive, as well as actualize, this massive transformation alone or whether an agricultural innovation system, which will include both a network of actors and an enabling environment, needs to be developed to ensure that the disruptions are systemic and equitable enough to reach the last mile and deliver the benefits of digitalization to the smallest and the poorest farmers.

5. Hence, it is critical for policy-makers to evaluate digital technologies holistically, with a “whole of government” approach, in order to strategize the most optimal digital pathway to maximum impact, considering the overall status of the information and communication technologies prevailing in the country and their capacity to build and invest in infrastructures and human resources that would foster technology innovations and transformation of the agriculture sector.

## Emerging challenges of food and agriculture systems

6. Although there is a plethora of challenges that is affecting the food and agriculture system, there is an emerging trend among them.<sup>5</sup> In the coming decades, five of these emerging or “trending” challenges will become more impactful and critical. Without being successfully mitigated, the goal of

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<sup>2</sup> United Nations, Department of Economic and Social Affairs, P.D. 2019. *World Population Prospects 2019*. 49–78 pp. Available at <http://www.ncbi.nlm.nih.gov/pubmed/12283219>.

<sup>3</sup> FAO, IFAD, UNICEF, WFP & WHO. 2019. *The state of food security and nutrition in the world: safeguarding against economic slowdowns and downturns*. Rome, Italy. 239 pp. Available at <http://www.fao.org/3/ca5162en/ca5162en.pdf>.

<sup>4</sup> <https://unstats.un.org/sdgs/report/2019/goal-01/>

<sup>5</sup> FAO. 2017. *The future of food and agriculture: trends and challenges*. Rome, Italy. 163 pp. Available at <http://www.fao.org/3/a-i6583e.pdf>.

“zero hunger” could be impossible to achieve, which is why a detailed understanding of the following five key emerging challenges is important:

- a. Sustainable consumption of natural resources.
- b. Climate change and natural disasters.
- c. Changing food systems as a result of growing urbanization.
- d. Food loss and waste.
- e. Extreme poverty and reducing inequality.

### ***Sustainable consumption of natural resources***

7. Expanding and uncoordinated human activities are fast depleting the finite repository of natural resources, namely land and water, with consequences such as water scarcity, land degradation and deforestation.<sup>6</sup>

8. It is expected that to feed a growing population, the demand for agricultural land and water will increase and will become a growing constraint for development in low-income countries, particularly in areas where production systems are exposed to high environmental and social stress. Developing countries in Asia and the Pacific region are particularly susceptible to water scarcity and land degradation. Between 2000 and 2015, over 20 percent of the land area in the region became degraded,<sup>7</sup> while global estimates on the sustainability of groundwater usage strongly indicate that current groundwater consumption for some regions in Asia, such as the upper Ganges River Basin and North China Plain, is likely to face serious aquifer depletion and water shortage problems, causing a significant reduction in agriculture production that will threaten food security in this region,<sup>8</sup> impeding the achievement of SDGs 2, 6, 13, 14 and 15.

### ***Climate change and natural disasters***

9. Growing human activities are accelerating extreme climate change, to the extent that already four key Planetary Boundaries<sup>9</sup>, namely biosphere integrity, climate change, biogeochemical flows and freshwater use, have been pushed beyond their limits<sup>10</sup> in the last few decades.

10. Increasing global surface temperature is expected to reduce crop yields (by an estimated 20 percent) and increase crop loss due to increased pest activities (by an estimated 10 to 25 percent), which could result in greater food scarcity and increased food prices (estimated to rise by as much as

<sup>6</sup> FAO and ITPS. 2015. *Status of the World's Soil Resources - Main Report*. Rome, Italy. 650 pp. Available at <http://www.fao.org/3/a-i5199e.pdf>; Richey, A.S., Thomas, B.F., Lo, M.H., Reager, J.T., Famiglietti, J.S., Voss, K., Swenson, S., Rodell, M. 2015. *Quantifying renewable groundwater stress with GRACE*. *Water Resources Research*, 51(7): 5217–5238. Available at <https://doi.org/10.1002/2015WR017349>; WWF. 2016. *Living Planet Report 2016: Risk and Resilience in a New Era*. Gland, Switzerland. 74 pp. Available at [https://c402277.ssl.cf1.rackcdn.com/publications/964/files/original/lpr\\_living\\_planet\\_report\\_2016.pdf?1477582118&\\_ga=1.148678772.2122160181.1464121326](https://c402277.ssl.cf1.rackcdn.com/publications/964/files/original/lpr_living_planet_report_2016.pdf?1477582118&_ga=1.148678772.2122160181.1464121326).

<sup>7</sup> UNSD. 2019. *The Sustainable Development Goals Report 2019*. Department of Economic and Social Affairs (DESA). Available at <https://unstats.un.org/sdgs/report/2019/>.

<sup>8</sup> Lee, E., Jayakumar, R., Shrestha, S., Han, Z. 2018. *Assessment of transboundary aquifer resources in Asia: Status and progress towards sustainable groundwater management*. *Journal of Hydrology: Regional Studies*, 20(February): 103–115. Available at <https://doi.org/10.1016/j.ejrh.2018.01.004>; Bonan, G.B. 2008. *Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests*. *Science*, 320(5882): 1444 LP – 1449. Available at <https://doi.org/10.1126/science.1155121>; FAO. 2011a. *The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk*. Rome, Italy. 308 pp. Available at <http://www.fao.org/3/a-i1688e.pdf>; Mekonnen, M.M., Hoekstra, A.Y. 2016. *Sustainability: Four billion people facing severe water scarcity*. *Science Advances*, 2(2): 1–7. Available at <https://doi.org/10.1126/sciadv.1500323>.

<sup>9</sup> Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., et al. 2009. *Planetary boundaries: Exploring the safe operating space for humanity*. *Ecology and Society*, 14(2). Available at <https://doi.org/10.5751/ES-03180-140232>.

<sup>10</sup> Steffen, W., Richardson, K., Rockstrom, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., Vries, W. De, Wit, C.A. De, et al. 2015. *Planetary boundaries: Guiding changing planet*. *Science*, 347(6223): 1–10. Available at <https://doi.org/10.1126/science.1259855>.

31 percent) and aggravate hunger and malnutrition, especially among rural poor and other vulnerable communities.<sup>11</sup>

11. Natural disasters are becoming more frequent, affecting the lives, livelihood and even the entire economies of Asia and the Pacific region. In 2018, about 140 natural disasters occurred in the region, causing economic losses amounting to nearly USD 675 billion, about 2.4 percent of the region's gross domestic product (GDP).<sup>12</sup>

12. Climate change is also a significant "hunger-risk multiplier". Some forecasts anticipate that by 2050, as a consequence of climate change, an additional 120 million people will be at risk of undernourishment, of whom 24 million will be children.<sup>13</sup> Thus climate change and its ensuing natural disasters will affect the life and livelihoods of millions of people, affecting the achievement of SDGs 1, 2, 5, 11, 13, 15 and 16.

### ***Changing food systems as result of growing urbanization***

13. By 2030 there will be an additional two billion urban middle-class people with higher purchasing power, resulting in an increased demand for food, water and energy in urban areas.<sup>14</sup> Increased urbanization will require food to be easily stored, transported and made available. This implies that organized food retailing such as supermarkets and online groceries will play more significant roles in the food systems. As of 2015, the share of organized food retailers in Asia was 36 per cent<sup>15</sup>, which, however, is expected to grow further and grocery shopping will increasingly happen digitally than physically as studies indicate that on average 60 percent of consumers in the developing markets of Asia and the Pacific region are willing to use digital retailing options in the future.<sup>16</sup>

14. The prevalence of supermarkets and online retailing may result in increased demand for processed and ready-to-eat foods. Between 2001 and 2014, the share of processed food distributed through supermarkets significantly increased in upper-middle-income countries, from less than 40 percent to 50 percent, while it went from 22 percent to 27 percent in lower-middle-income countries.<sup>17</sup>

15. This new emerging order of urban food systems could create barriers for smallholders' access to markets, as supermarkets and digital retail channels will be more vertically coordinated and digitally connected, demanding increased digital literacy and faster technology adoption by its suppliers or the farmers. Hence, if farmers are not able to keep pace with the technological transformation in food retail,

<sup>11</sup> Deutsch, C.A., Tewksbury, J.J., Tigchelaar, M., Battisti, D.S., Merrill, S.C., Huey, R.B., Naylor, R.L. 2018. *Increase in crop losses to insect pests in a warming climate*. Science, 361(6405): 916–919. Available at <https://doi.org/10.1126/science.aat3466>; Early, R., Gonzalez-Moreno, P., Murphy, S.T., Day, R. 2018. *Forecasting the global extent of invasion of the cereal pest Spodoptera frugiperda, the fall armyworm*. NeoBiota, 40: 25–50. Available at <https://doi.org/10.3897/neobiota.40.28165>; Ignaciuk, A., Mason-D'Croz, D. 2014. *Modelling Adaptation to Climate Change in Agriculture*. Science(70). Available at <https://doi.org/10.1787/5jxrcllnbxq-en>; Olsson, L., Opondo, M., Tschakert, P., Agrawal, A., Eriksen, S.H., Ma, S., Perch, L.N., Zakieldean, S.A., Cutter, S., Pigué, E., et al. 2015. *Livelihoods and poverty*. Climate Change 2014 Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. 793–832. Available at <https://doi.org/10.1017/CBO9781107415379.018>.

<sup>12</sup> UN-ESCAP. 2019. *The Disaster Riskscape Across Asia-Pacific: Pathways for Resilience, Inclusion and Empowerment*. 130 pp. Available at <https://www.unescap.org/publications/asia-pacific-disaster-report-2019>.

<sup>13</sup> FAO. 2017. *The future of food and agriculture: trends and challenges*. Rome, Italy. 163 pp. Available at <http://www.fao.org/3/a-i6583e.pdf>.

<sup>14</sup> Serraj, R., Pingali, P. 2018. *Agriculture and food systems to 2050*. Brief 72 edition. New Jersey, USA. 680 pp. Available at <https://doi.org/10.1142/11212>.

<sup>15</sup> FAO. 2017. *The future of food and agriculture: trends and challenges*. Rome, Italy. 107 pp. Available at <http://www.fao.org/3/a-i6583e.pdf>.

<sup>16</sup> Nielsen. 2015. *The Future of Grocery E-Commerce: E-commerce, digital technology and changing shopping preferences around the world*. New York, USA. 1-35 pp. Available at <https://www.nielsen.com/wp-content/uploads/sites/3/2019/04/nielsen-global-e-commerce-new-retail-report-april-2015.pdf>.

<sup>17</sup> Global Panel on Agriculture and Food Systems for Nutrition. 2016. *Food systems and diets: Facing the challenges of the 21st century*. London, UK. 93 pp. Available at <https://www.glopan.org/wp-content/uploads/2019/06/ForesightReport.pdf>.

it will put them in a disadvantageous position in the market, undermining their livelihoods and resulting in negative impact on achievement of SDGs 1, 2, 5, 8, 10 and 14.

16. Increased production of processed food available at affordable prices could result in unhealthy dietary habits, especially of low-income populations, who would find it more difficult to adopt pricey high-quality diets and would be more likely to consume low-cost processed foods with more “empty calories”, resulting in overweight, obesity and diet-related non-communicable diseases, magnifying the “triple burden of malnutrition”<sup>18</sup> thereby hindering achievement of SDGs 2 and 3.

#### ***Food loss and waste***

17. Food loss and waste are growing concerns for food and agriculture systems. Globally about one-third of all food produced, estimated to be 1.3 billion tonnes per year and valued at USD 750 billion, is lost or wasted along the food value chain, from production to consumption.<sup>19</sup> Food loss and waste also hold back the transition to environmentally sustainable food systems. They represent a considerable waste of land, water, energy and agricultural inputs, and cause the emission of greenhouse gases. The total carbon footprint of food losses is estimated to be 4.4 gigatonnes of carbon dioxide equivalent to about 8 percent of global anthropogenic greenhouse gas emissions.<sup>20</sup>

18. In low-income countries, significant levels of food loss occur at harvest, post-harvest and further upstream in the value chain owing to poor infrastructure, low levels of technology, a limited knowledge base and lack of investment in processing, packaging, supply chains and marketing.

19. Managing food loss and waste, especially in the context of the challenge of sustainably feeding a burgeoning world population, is a priority for governments, businesses and individuals alike. Minimizing food loss and waste and making the most of resources underpinning the food system are considered particularly important, and will impact the achievement of a number of SDG targets; directly to SDG target 12.3 and indirectly SDGs 2, 8, 9, 10 and 14.

#### ***Extreme poverty and reducing inequality***

20. In spite of global economic growth and considerable efforts made by countries and development programmes to alleviate poverty, it is estimated that 2.1 billion people are still living in poverty, out of whom 700 million live in extreme poverty<sup>21</sup>. A total of 75 percent of the world’s poorest people live in rural areas and depend on agriculture and related activities for their livelihood. Even in countries where poverty has been reduced, pervasive inequalities remain between rural and urban areas, between regions, between ethnic groups, and between men and women. Poverty, hunger and malnourishment are closely connected; in 2018, 807 million undernourished people and 154 million stunted children under the age of five lived in low- and middle-income countries<sup>22</sup>, of whom about 515 million chronically undernourished are in Asia alone<sup>23</sup>. Hunger and malnutrition seem to have acute gender and socio-

<sup>18</sup> Global Panel on Agriculture and Food Systems for Nutrition. 2016. *Food systems and diets: Facing the challenges of the 21st century*. London, UK. 93 pp. Available at <https://www.glopan.org/wp-content/uploads/2019/06/ForesightReport.pdf>.

<sup>19</sup> FAO. 2017. *The future of food and agriculture: trends and challenges*. Rome, Italy. 163 pp. Available at <http://www.fao.org/3/a-i6583e.pdf>; HLPE. 2014. *Food losses and waste in the context of sustainable food systems*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome, Italy. Available at <http://www.fao.org/3/a-i3901e.pdf>.

<sup>20</sup> FAO. 2011b. *Food wastage footprint and Climate Change*. 4 pp. Available at [http://www.fao.org/fileadmin/templates/nr/sustainability\\_pathways/docs/FWF\\_and\\_climate\\_change.pdf](http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/FWF_and_climate_change.pdf).

<sup>21</sup> FAO. 2017. *The future of food and agriculture : trends and challenges*. Rome, Italy. 138 pp. Available at <http://www.fao.org/3/a-i6583e.pdf>.

<sup>22</sup> FAO, IFAD, UNICEF, WFP & WHO. 2019. *The State of Food Security and Nutrition in the World : Safeguarding against economic slowdowns and downturns*. Rome, Italy. 64 pp. Available at <http://www.fao.org/3/ca5162en/ca5162en.pdf>.

<sup>23</sup> The Hunger Project. 2019. *Know Your World: Facts about World Hunger & Poverty*. Available at <https://www.thp.org/knowledge-center/know-your-world-facts-about-hunger-poverty/>.



economic bias too, 60 percent of the world's hungry are women and girls<sup>24</sup>, while in terms of their livelihoods, 50 percent of hungry people are farmers.<sup>25</sup>

21. Gender inequity is a key factor in the poverty-hunger-malnutrition nexus. On average, women make up about 43 percent of the agricultural labour force in developing countries<sup>26</sup>. Evidence indicates that if these women had the same access to productive resources as men, they could increase yields on their farms by 20 to 30 percent, raising the total agricultural output in these countries by 2.5 to 4 percent. This would reduce the number of hungry people in the world by around 12 to 17 percent.<sup>27</sup>

22. Agriculture can play an important role in pro-poor growth.<sup>28</sup> Reducing rural poverty requires measures to increase productivity and profitability, link farmers to markets, and provide efficient extension and agricultural advisory services, all of which require digital tools to overcome some of the physical barriers that exist in many countries, thereby supporting achievement of SDGs 1, 2, 5, 8, 10 and 14.

## Digital disruptions and Agriculture 4.0 (fourth agriculture revolution)

### *Digital disruption and digital pathways*

23. Increased mobile connectivity and wide availability and affordability of computers and smartphones have made it possible for the new generation of people to experience the transformative power of digital technologies from an early age. This generation, also called the “digital-natives”, prefer to interact with the world digitally rather than physically; giving rise to more and more digital services and platforms in every aspect of life. In the coming decades, technologies such as 5G, Internet of Things (IoT), remote sensing, big data analytics, artificial intelligence and machine learning, blockchain, 3D/4D printing and farm robotics will be increasingly used in the food and agriculture sector and many of these technologies are considered to disrupt the food and agriculture systems.

24. However, to take advantage of this digital revolution in the agriculture sector, it is important to understand how technologies can bring in changes that alter the fundamental structures and orders of the existing food and agriculture systems, or in other words cause ‘digital disruption’, within the larger context of human behaviour, socio-economic factors, infrastructural and policy environments, etc. giving rise to a concept that can be called the ‘digital pathways’ of disruption.

### *Agriculture 4.0*

25. Agriculture 4.0 can be understood as the equivalent of Industry 4.0, which is about automation and data exchange in manufacturing technologies and includes cyber-physical systems, IoT, hyperconnectivity and cloud-computing to transform production units into “smart factories”. Hence, Agriculture 4.0 also talks about “datafication” of food and agriculture systems, underpinned by artificial intelligence, hyperconnectivity, IoT and automation, thereby creating a network of connected farms, machines and factories and achieving a high level of system optimization at the supply side (food production) and demand side (food consumption).<sup>29</sup>

<sup>24</sup> WFP. 2009. *WFP Gender Policy*. Rome, Italy. 3 pp.

<sup>25</sup> World Food Program USA. Available at <https://www.wfpusa.org/explore/wfps-work/wfp-programs/small-scale-farmers/>.

<sup>26</sup> FAO. *The Female Face of Farming*. Available at <http://www.fao.org/gender/resources/infographics/the-female-face-of-farming/en/>.

<sup>27</sup> FAO. 2011. *The State of Food and Agriculture: Women in agriculture: closing the gender gap for development*. Rome, Italy. 6 pp. Available at <http://www.fao.org/3/a-i2050e.pdf>.

<sup>28</sup> FAO. 2017. *The future of food and agriculture : trends and challenges*. Rome, Italy. 138 pp. Available at <http://www.fao.org/3/a-i6583e.pdf>.

<sup>29</sup> Kovács, I., Husty, I. 2018. *The role of digitalization in the agricultural 4.0 – how to connect the industry 4.0 to agriculture?*. Hungarian Agricultural Engineering, 7410(33): 38–42. Available at <https://doi.org/10.17676/hae.2018.33.38>.

## Examples of digital technologies that may disrupt the agriculture sector

### *Mobile telephony*

26. As of 2018, two-thirds of the world's 7.6 billion inhabitants own mobile phones.<sup>30</sup> Smartphone (mobile phones with some functionalities of a computer, such as web browsing) ownership in the developing economies of Asia and the Pacific region is projected to become 77 per cent, by 2025. Smartphone ownership is very significant in socio-economic transformation, especially in developing economies, since smartphones are practically the only (and in most cases the first) digital device that gives people access to the digital world.

27. Increasing penetration of mobile phones makes it a potential tool to overcome social development barriers such as technology, literacy and gender that cause inequality and the digital divide.

28. Mobile telephony has disrupted the conventional agriculture extension system by connecting farmers directly with researchers and other critical information service providers, thereby creating a new order of remote farm advisors with different skills and work processes than the conventional extension agents.

29. Mobile phones also change the workflows of institutions, such as banks, insurance providers and agriculture markets, as farmers can receive money on their mobile wallets, buy crop insurance online and sell their produce online on e-commerce platforms, making many of the erstwhile actors obsolete.

30. It is estimated that mobile-based services could help farmers to grow 500 million more tonnes of food and reduce wastage by 65 million tonnes, resulting in an additional income of USD 200 billion by 2030.<sup>31</sup>

### *5G and Hyperconnectivity*

31. 5G is already a reality in Asia and the Pacific region. Many operators are already looking to expand beyond their traditional telecom businesses and explore new revenue streams from services through 5G networks. However, the degree of 5G adoption varies from country to country. While the developed markets such as Australia, Japan and Republic of Korea have a high proliferation of 5G, many developing economies, where 4G itself is relatively new, will continue to remain a primarily 4G market for some time.<sup>32</sup>

32. 5G-based services are expected to boost the GDP in the Asia and the Pacific region by USD 212 billion by 2034.<sup>33</sup>

### *Internet of Things (IoT)*

33. IoT has many applications in agriculture, ranging from *in situ* sensors that monitor soil, plant and animal health in real time, to tracking the details about a product's provenance, environmental impact and storage environments through the supply chain. The technology forecast tells that by 2030, IoT will evolve into something termed as 'Internet of Action'<sup>34</sup>; where sensors and machines, using in-built artificial intelligence and data analytics capacity, will be able to do more than just measuring data (what they can do today) but will be capable of self-optimizing and initiating activities on their own, without any input from humans.

<sup>30</sup> Hootsuite and We are social. 2018. *Global Digital Report 2018*. Digital In 2018. 153 pp. Available at <https://digitalreport.wearesocial.com/>.

<sup>31</sup> World Economic Forum and McKinsey. 2018. *Innovation with a Purpose*. 42 pp. Available at [http://www3.weforum.org/docs/WEF\\_Innovation\\_with\\_a\\_Purpose\\_VF-reduced.pdf](http://www3.weforum.org/docs/WEF_Innovation_with_a_Purpose_VF-reduced.pdf).

<sup>32</sup> GSMA. 2019. *The Mobile Economy, Asia Pacific*. GSMA Intelligence. Available at <https://www.gsmainelligence.com/research/?file=fe8735424e3058f98c3a83bc57bc2af5&download>.

<sup>33</sup> GSMA and TMG. 2018. *Study on Socio-Economic Benefits of 5G Services Provided in mmWave Bands*. London, UK. Available at <https://www.gsma.com/spectrum/wp-content/uploads/2019/10/mmWave-5G-benefits.pdf>.

<sup>34</sup> Kite-Powell, J. 2017. *The Next Technology Shift: The Internet of Actions*. Forbes. Available at <https://www.forbes.com/sites/jenniferhicks/2017/12/29/the-next-technology-shift-the-internet-of-actions/#84020e232270>.



34. It is predicted that by 2025, there will be as many as 75 billion IoT devices in use, generating a total potential economic gain of up to USD 11.1 trillion a year for the industry and with the potential to prevent 10-50 million tonnes of food waste.<sup>35</sup>

### ***Artificial Intelligence, machine learning and cognitive computing***

35. The major applications of artificial intelligence, machine learning and cognitive computing in agriculture are in the areas of automation and smart machines, remote surveillance and diagnosis, predictive analytics and supply chain optimization, among others.

36. Technology analysts predict that artificial intelligence can potentially affect 70 million farmers globally and create additional farming income of USD 9 billion by 2020.<sup>36</sup>

### ***Big data***

37. Big data and analytics improve decision-making by their predictive modelling ability. The most significant use of big data in agriculture and food systems is in agro-insurance. Studies show that, in addition to providing a safety net, farmers' adoption of insurance products can have a positive impact on investments, efficiency, nutrition and income.<sup>37</sup>

38. By 2030, big data-enabled insurance solutions could provide crop insurance solutions to an additional 200-300 million farmers worldwide, generating 40-150 million tonnes of additional food and USD 15-70 billion in additional farming income. Indirectly, farmers would also benefit from improved nutrition and health.<sup>38</sup>

### ***Blockchain***

39. Blockchain can serve a multitude of roles in agriculture and food systems, ranging from provenance of goods, traceability of food, reduction of transaction cost, secure digital payments or even tracking of land tenure.

40. The global blockchain technology market is estimated to be USD 23 billion in 2023.<sup>39</sup> By 2030, using blockchain technology to monitor the information of even half of the world's supply chains, could lead to a reduction in food loss by 10-30 million tonnes.<sup>40</sup>

## **Digital technology use by the smallholder, marginal and women farmers**

41. Although the roots of many digital technologies are in advanced industrial economies, it is increasingly being discovered that the smallholder, marginal and women farmers are also using and benefiting from many of these technologies.

42. Mobile telephony is one such exemplary use case, which benefits farmers and rural women. For example in India, a study by the International Maize and Wheat Improvement Center (CIMMYT) in 2011 noted that about 67 per cent of the smallholders and marginal farmers were using mobile phones

<sup>35</sup> Particle. 2019. *2019 State of IoT Report*. 1–34 pp. Available at <https://cdn2.hubspot.net/hubfs/2833873/WhitePapers/Particle-IoT-Survey.pdf>; World Economic Forum and McKinsey. 2018. *Innovation with a Purpose*.

42 pp. Available at [http://www3.weforum.org/docs/WEF\\_Innovation\\_with\\_a\\_Purpose\\_VF-reduced.pdf](http://www3.weforum.org/docs/WEF_Innovation_with_a_Purpose_VF-reduced.pdf).

<sup>36</sup> Nayak, A., Akshatanayak and Huchaiah, L., Mahinsharif and Khan, M. 2019. *The Economics of Applications of Artificial Intelligence and Machine Learning in Agriculture*. International Journal of Pure & Applied Bioscience, 07(1): 296–305. Available at <https://doi.org/10.18782/2320-7051.7324>.

<sup>37</sup> Castillo, M.J., Boucher, S., Carter, M., Jose, M. 2016. *Index Insurance: Using Public Data to Benefit Small-Scale Agriculture*. International Food and Agribusiness Management Review, 19(A): 93–114. Available at <http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=116615769&lang=pt-br&site=ehost-live>.

<sup>38</sup> World Economic Forum and McKinsey. 2018. *Innovation with a Purpose*. 42 pp. Available at [http://www3.weforum.org/docs/WEF\\_Innovation\\_with\\_a\\_Purpose\\_VF-reduced.pdf](http://www3.weforum.org/docs/WEF_Innovation_with_a_Purpose_VF-reduced.pdf).

<sup>39</sup> Markets and Markets. 2019. *Blockchain Market Insights, Scope, Service Providers, Verticals & Growth Factors*. Markets and Markets Research Private Ltd. Available at <https://www.marketsandmarkets.com/Market-Reports/blockchain-technology-market-90100890.html>.

<sup>40</sup> World Economic Forum and McKinsey. 2018. *Innovation with a Purpose*. 42 pp. Available at [http://www3.weforum.org/docs/WEF\\_Innovation\\_with\\_a\\_Purpose\\_VF-reduced.pdf](http://www3.weforum.org/docs/WEF_Innovation_with_a_Purpose_VF-reduced.pdf).

for market price alerts and about 71 per cent of the smallholders and 63 per cent of the marginal farmers, who were using mobile phones, reported to have obtained a better price for their product.<sup>41</sup>

43. Mobile advisory services in Bangladesh and Sri Lanka have helped women farmers to access information on agriculture, nutrition and health. Although the gender gap is still large, evidence from these countries indicated that 20 to 30 per cent of total subscribers of these services were women farmers.<sup>42</sup>

44. Digital technologies, such as blockchain, has already proven to help in digital inclusion of the smallholders. In Kenya, over 4 000 smallholders benefited from using a blockchain-enabled digital wallet and mobile financial tool for the agricultural sector providing a business account for farmers, which they can use to save, buy and earn.<sup>43</sup>

45. Similarly, in India, Microsoft together with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), has developed an artificial intelligence-based sowing app that enables smallholder subsistence farmers to receive precision agro-advisories based on the weather and other parameters. In 2017, the service was provided to 3 000 farmers during the Kharif crop cycle (rainy season) for a host of crops including groundnut, *ragi*, maize, rice and cotton. The increase in yields ranged from 10 to 30 per cent across crops.<sup>44</sup>

46. Other technologies such as machine-to-machine communication and IoT, help in natural resource conservation; for example farmers in India used mobile phones to remotely operate irrigation pumps, thereby saving wastage of water.

47. Although it is sometimes argued that digital technologies may not be affordable for poor farmers or technology adoption may be hindered because of lack of literacy, the reality is different. It is well known that the cost of technology reduces over time, following a principle known as Moore's law, which states that technology capacity doubles itself every two years,<sup>45</sup> or in other words, the cost of technology increasingly lowers over time, making it more affordable to ordinary people.

48. Similarly, increased use of social media by farmers indicates that in spite of the literacy gap, farmers and rural people themselves find ways to learn using new digital technologies. For example, one of the largest agriculture groups on Facebook is "Digital Farmers Kenya", with 336 000 members.<sup>46</sup> Farmers also share and learn new technologies by watching YouTube videos; a search on YouTube with the keyword "agricultural extension" gives over 10 000 results.<sup>47</sup>

49. Such evidence indicates that farmers, especially the younger generations, are not impeded by the literacy gap or affordability of digital technologies and when they realize benefits from using them, they themselves find ways and means to learn and adopt. This trend can be seen all over the world; in both developing and low developed countries and with time, this will only grow making digital technologies a key driver and influencer in both smallholder and large farming systems.

<sup>41</sup> Mittal, S., Mehar, M. 2012. *How mobile phones contribute to growth of small farmers? Evidence from India*. Quarterly Journal of International Agriculture, 51(3): 227–244.

<sup>42</sup> GSMA. 2017a. *Govi Mithuru/Uzavar Tholan*. London, UK. Available at <https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/06/govi-mithuru-mobile-agriculture-service-dialog-sri-lanka.pdf>; GSMA. 2017b. *Grameenphone Krishi Sheba: A mobile agriculture service in Bangladesh*. London, UK. Available at <https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/07/gp-krishi-sheba-mobile-agriculture-service-grameenphone-bangladesh.pdf>.

<sup>43</sup> Bolt, J. 2019. *Agri-wallet, a wallet for smallholder farmers*. CTA Blog. Available at <https://www.cta.int/en/digitalisation/all/article/agri-wallet-a-wallet-for-smallholder-farmers-sid00f60f624-f62a-4b58-bd27-bd2c838b724f>.

<sup>44</sup> Microsoft News. 2017. *Digital Agriculture: Farmers in India are using AI to increase crop yields*. Microsoft News Center, India. Available at <https://news.microsoft.com/en-in/features/ai-agriculture-icrisat-upl-india/>.

<sup>45</sup> Moore, G.E. 1965. *Cramming more components onto integrated circuits*. Electronics Magazine, 38(8): 4. Available at <http://www.cs.utexas.edu/~fussell/courses/cs352h/papers/moore.pdf>.

<sup>46</sup> Trendov, N.M., Varas, S., Zeng, M. 2019. *Digital technologies in agriculture and rural areas - Status report*. Rome, Italy. 152 pp. Available at <http://www.fao.org/3/ca4985en/ca4985en.pdf>.

<sup>47</sup> Bhattacharjee, S., Saravanan, R. 2016. *Social Media: Shaping the Future of Agricultural Extension and Advisory Services*. GFRAS Interest Group on ICT4RAS discussion paper. Lindau, Switzerland.

## The key drivers of digital technology proliferation

50. Some of the key drivers that are spurring proliferation of digital technologies are: falling hardware prices (e.g. mobile phones, micro-processors and sensors), availability of higher computing capacity at cheaper cost (e.g. cloud computing), wider availability and increasing network capacity (e.g. 4G/5G)

51. The cost of computer hardware has reduced drastically. In 1992, the average cost of data storage was USD 569 per gigabyte. In 2012, the same was only USD 0.02.<sup>48</sup>

52. Along with computer hardware, the cost of mobile phones (both basic and smartphones) has reduced largely. Globally, the average price of smartphones decreased from USD 348.60 in 2011 to USD 214.70 in 2019, making smartphone ownership more widespread.<sup>49</sup> On the other hand, basic mobile phones with some web browsing capability are available in some countries of Africa, for as low as USD 33.<sup>50</sup>

53. Between 2008 and 2017, the global average monthly ownership cost of mobile phones almost halved, from USD 21.50 to USD 12.60. Mobile ownership is cheapest in Asia and the Pacific region, especially in India and China at USD 1.88 and USD 2.91 per month, respectively.<sup>51</sup>

54. Cloud computing has made possible digital services that need high level of computing power (e.g. big data, image analysis etc.) available through simple devices such as smartphones, which in turn has catalysed innovations around these technologies.

55. Mobile-broadband prices as a percentage of gross national income (GNI) per capita halved between 2013 and 2016 worldwide. The most significant decrease was registered in the low developed countries where prices fell from 32.4 to 14.1 percent of GNI per capita<sup>52</sup>. Digital platforms underpinned by high speed internet are creating new opportunities for entrepreneurs all over the world to start new technology-based companies, and for both start-ups and existing small and medium enterprises to reach global markets.

56. An important caveat here, however, is that in the less developed countries, internet penetration be more pervasive and of better quality in urban and peri-urban areas compared with remote rural areas and even though smartphones have become inexpensive, it may still not be affordable for the absolute “last mile” population. This poses a challenge to bring in digital technologies to the ‘base of pyramid’ (BoP) population in low developed countries, who otherwise would need such technologies the most in order to reap benefits that would help them in ending poverty and hunger.

## The impact of digital technologies on food and agriculture systems

57. Digital technologies are impacting food and agriculture systems at both macro and micro levels. At macro level, digital technologies primarily help to better understand the anthropogenic impacts on the Global Commons (e.g. the climate, oceans, landscape) while at micro level, their impacts are mainly in optimizing and harmonizing food value chains.

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<sup>48</sup> World Bank. 2016. *World Development Report 2016: Digital Dividends*. Washington DC, USA. 359 pp. Available at <https://www.worldbank.org/en/publication/wdr2016>.

<sup>49</sup> Statista. 2019. *Average smartphone price 2019*. Available at <https://www.statista.com/statistics/484583/global-average-selling-price-smartphones/>.

<sup>50</sup> Trendov, N.M., Varas, S., Zeng, M. 2019. *Digital technologies in agriculture and rural areas - Status report*. Rome, Italy. 152 pp. Available at <http://www.fao.org/3/ca4985en/ca4985en.pdf>.

<sup>51</sup> ITU. 2019a. *ICT Prices*. Available at <https://www.itu.int/en/ITU-D/Statistics/Pages/ICTprices/default.aspx>.

<sup>52</sup> Trendov, N.M., Varas, S., Zeng, M. 2019. *Digital technologies in agriculture and rural areas - Status report*. Rome, Italy. 152 pp. Available at <http://www.fao.org/3/ca4985en/ca4985en.pdf>.

## *Digital technologies and the Global Commons*

### Climate

58. Monitoring and analysing the impacts of human activities on climate is critical for climate change mitigation. Sensor technologies, big data analytics and blockchain technologies are increasingly being used to monitor and analyse climatic conditions and initiate mitigation measures.

59. The Landsat and MethaneSAT programmes help in monitoring a range of climate-related parameters, including methane emissions, almost anywhere on the planet and identify climate change trends and hotspots, critical for policy and strategic interventions. FAO's GeoNetwork produces a large number of Geographic Information System (GIS) datasets for monitoring, assessment and analysis of environmental and socio-economic factors that cause poverty and food insecurity. FAO's digital solutions, such as Open Foris and SHARP, help researchers, policy-makers and farmers to assess and manage climate change impacts. Global collaborations, such as the Radiant Earth Foundation, are applying machine learning for Earth observation in efforts to meet the SDGs.

60. Digital technologies not only help in monitoring and analysing climate change but also helps in climate change mitigation through preventive measures. One such approach is The Climate Ledger initiative, which is systematically strengthening the intersection between climate change and blockchain/distributed ledger technology. Specialized blockchain-based private cryptocurrency exchanges are helping businesses to offset their carbon emissions and create demand for their carbon-neutral products and services through their platforms.

### Ocean and other water resources

61. Ocean acidification, biogeochemical contamination and overuse of freshwater are some of the consequences of human activities affecting the oceans. Digital technologies such as sensors and remote sensing, together with big data analytics, can support monitoring and conservation of Earth's water resources.

62. ARGO uses a global array of 3 800 free-drifting profiling floats that continuously monitor the temperature, salinity and velocity of the upper ocean, while GEBCO database provides bathymetric (depth of ocean floors, as measure of rising or falling sea level) data of all the oceans; together these digital tools are enabling researchers to collect data about subsurface ocean temperature, salinity, currents and, increasingly, biochemical parameters in real time.

63. Water Accounting, AQUASTAT/AQUAMAP, WAPOR and AQUEDUCT are examples of how digital systems are helping to collect, analyse and disseminate data and information, by country, on water resources, water use and agricultural water management.

### Sustainable landscapes

64. Sustainability of landscapes requires that biodiversity and conservation be mainstreamed into policies, strategies and practices of key public and private actors that have an impact or rely on biodiversity, so that it is conserved and sustainably used.

65. Digital technologies such as remote sensing, spectral analysis and blockchain are helping researchers, policy-makers and businesses to monitor, analyse and initiate investments/actions to conserve and manage landscapes and resources such as forests.

66. The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (UN-REDD) leverages Planet Lab's satellite imagery to track forest degradation, predict future deforestation and alert businesses to preventive actions. FAO's Global Information and Early Warning System on Food and Agriculture (GIEWS) monitors water availability and vegetation health during the cropping seasons to assess the Agricultural Stress Index, an indicator for dry spells, or drought in extreme cases.

67. Innovative internet search engines support climate change actions by using part of their profits to plant trees; more than 73 million trees have been planted so far through this process. Drones are being used to plant trees and restore 100 000 hectares of mangrove forest in Myanmar.

68. Innovative private businesses support environmental sustainability by rewarding customers with cryptocurrencies for buying sustainable and eco-friendly products, or by rewarding people with tradable cryptocurrencies for planting trees. The REDD-Chain project, promoted by UNFCC REDD+ and Cleantech21, aims to use blockchain, artificial intelligence and IoT to create a new “forest finance ecosystem”.

### ***Digital technologies and food value chains***

69. Food value chains consist of all the stakeholders that participate in the coordinated production and value-adding activities that are needed to make food products. A sustainable food value chain is one that is profitable throughout all of its stages (economic sustainability), has broad-based benefits for society (social sustainability), and has a positive or neutral impact on the natural environment (environmental sustainability).<sup>53</sup>

70. Digital technologies can be an important means to achieve sustainable food value chains by acting as a bridge between the social good and business interests.

71. Technologies can help both the private and public sectors to work together in a win-win Relationship, bringing in new business opportunities worth USD 2.3 trillion annually for businesses by 2030 while helping to achieve the SDGs.<sup>54</sup>

### **Poverty and inequality**

72. A total of 570 million smallholder and family farmers contribute 80 percent of the world’s agriculture production.<sup>55</sup> The livelihoods of many of these smallholder farmers are, however, perpetually at risk owing to the lack of market access and the absence of safety nets such as crop insurance or access to easy credit, thus hampering their resilience and often forcing them into debt and poverty.

73. Digital technologies, such as mobile applications, blockchain and big data analytics, are increasingly being used by many private businesses in countries such as China, India, Indonesia, Myanmar, Nepal, and the Philippines to help farmers gain access to capital and insurance, buy and sell inputs and farm produce online, and form and manage farmer producer groups, thereby ensuring better market access, availability of capital and provision of safety nets.

### **Climate change and sustainable consumption of natural resources**

74. One of the greatest challenges of the sustainable development agenda is how to feed a growing population without additional environmental degradation and deforestation.

75. Precision agriculture technologies such as on-farm sensors, remote sensing, IoT and big data analytics could effectively reduce greenhouse gas emissions by 5-20 megatons, reduce water use by 50-180 billion cubic metres, and reduce the cost of production by USD 40-100 billion by 2030.<sup>56</sup>

76. FAO, in collaboration with Telefónica, launched a partnership in February 2018 to assist smallholders in Colombia, El Salvador and Peru with climate-resilient agriculture technologies, innovative irrigation water management, and maintenance of soil conditions close to optimum for crop growth, to contribute to climate change mitigation. Technologies included IoT and a mobile app called

<sup>53</sup> FAO. 2014. *What is sustainable food value chain development?*. Sustainable Food Value Chains Knowledge Platform. Available at <http://www.fao.org/sustainable-food-value-chains/what-is-it/en>.

<sup>54</sup> Business and Sustainable Development Commission. 2016. *Valuing the SDG prize in food and agriculture: Unlocking business opportunities to accelerate sustainable and inclusive growth*. London, UK. 48 pp. Available at <http://s3.amazonaws.com/aws-bsdc/Valuing-SDG-Food-Ag-Prize-Paper.pdf>.

<sup>55</sup> (Dalglish, T., Williams, J.M.G., Golden, A.M.J., Perkins, N., Barrett, L.F., Barnard, P.J., AuYeung, C., Murphy, V., Elward, R., Tchanturia, K., et al. 2011. *Save & Grow. A policymaker’s Guide to the sustainable intensification of smallholder crop production*. Rome, Italy. 23-42 pp. Available at <http://www.fao.org/3/a-i2215e.pdf>); Lowder, S.K., Skoet, J., Raney, T. 2016. *The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide*. World Development, 87: 16–29. Available at <https://doi.org/10.1016/j.worlddev.2015.10.041>.

<sup>56</sup> World Economic Forum and McKinsey. 2018. *Innovation with a Purpose*. 42 pp. Available at [http://www3.weforum.org/docs/WEF\\_Innovation\\_with\\_a\\_Purpose\\_VF-reduced.pdf](http://www3.weforum.org/docs/WEF_Innovation_with_a_Purpose_VF-reduced.pdf).

Smart Agro 4.0. Initial results indicated up to a 77 percent increase in crop yields and a 44 percent reduction in production costs.<sup>57</sup> In Myanmar, a mobile app from a telecom operator has helped 150 000 farmers with climate-smart agro-advisory services.<sup>58</sup>

77. In India, Malaysia, the Philippines and Viet Nam, Agtech companies are using *in situ* sensors, remote sensing, spectral analysis and big data analytics to support farmers with precise information to optimize inputs and crop yields, thereby not only increasing productivity and profitability, but also contributing to better environmental protection through sustainable farming.

#### Food loss and waste

78. Without reducing food loss and waste, which is currently estimated to be at 14 percent of total production,<sup>59</sup> it will not be possible to supply 70 percent more food to meet demand by 2050.<sup>60</sup> This is why reducing food loss and waste is a critical issue in the food and agriculture systems and SDG Target 12.3 calls for halving per capita global food waste at the retail and consumer levels and reducing food loss along production and supply chains (including post-harvest losses) by 2030.

79. Poor farming practices, lack of good post-harvest management, inefficient processing and supply chains, and lack of awareness at retail/consumer level are some of the major issues that cause food loss and waste.

80. Digital or e-extension can help farmers in developing countries, where conventional extension systems are inadequate and burdened with a poor extension-farmer ratio,<sup>61</sup> to rapidly acquire knowledge and skills in better farming practices and catalyse the adoption of new agriculture technologies,<sup>62</sup> resulting in improved farm productivity<sup>63</sup>. In Indonesia, Myanmar, Nepal, Pakistan and Sri Lanka, public and private extension services are providing mobile phone-based e-extension solutions that are helping farmers to gain knowledge and receive agro-advisory services from agriculture experts.

81. Crop pest incidences are increasing, and changing climatic conditions are bringing new pests to previously unaffected areas. Using image analytics, coupled with artificial intelligence and big data, agriculture applications such as the Fall Armyworm Monitoring and Early Warning System (FAMEWS) from FAO can help farmers to diagnose pests in real time and take necessary actions to minimize crop loss.

82. Digital technologies such as artificial intelligence and machine learning is used by leading retailers in Europe to introduce ‘dynamic discounting’ to motivate consumers to buy near expiry foods at discounted prices<sup>64</sup>, thereby significantly reducing food loss at retail level. Such technologies can as

<sup>57</sup> FAO. 2018. *Smart Agro 4.0*. Rome, Italy. 2 pp. Available at <http://www.fao.org/3/ca5673en/ca5673en.pdf>.

<sup>58</sup> GSMA. 2017c. *Site Pyo : A weather and agriculture app by Ooredoo Myanmar*. London, UK. Available at <https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/07/Site-Pyo-A-weather-and-agriculture-app-by-Ooredoo-Myanmar.pdf>.

<sup>59</sup> FAO. 2019d. *The State of Food and Agriculture 2019: Moving forward on food loss and waste reduction*. Rome, Italy. 275-284 pp. Available at <http://www.fao.org/3/ca6030en/ca6030en.pdf>.

<sup>60</sup> Cole, M.B., Augustin, M.A., Robertson, M.J., Manners, J.M. 2018. *The science of food security*. *Science of Food*, 2(1): 1–8. Available at <https://doi.org/10.1038/s41538-018-0021-9>.

<sup>61</sup> Swanson, B.E., Rajalahti, R. 2010. *Extension and Advisory Systems: Procedures for Assessing, Transforming, and Evaluating Extension Systems*. World Bank Agriculture and Rural Development Discussion Paper 45. Washington DC, USA. Available at

<http://documents.worldbank.org/curated/en/873411468159312382/pdf/565870NWP0ARD0110Stren1combined1web.pdf>.

<sup>62</sup> Mwangi, M., Kariuki, S. 2015. *Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries*. *Journal of Economics and Sustainable Development*, 6(5): 208–216. Available at [www.iiste.org](http://www.iiste.org).

<sup>63</sup> Casaburi, L., Kremer, M., Mullainathan, S., Ramrattan, R. 2019. *Harnessing ICT to Increase Agricultural Production: Evidence From Kenya*. Harvard Business School Working Paper. 1-33 pp. Available at [https://scholar.harvard.edu/files/kremer/files/sms\\_paper\\_with\\_tables\\_20190923\\_merged.pdf](https://scholar.harvard.edu/files/kremer/files/sms_paper_with_tables_20190923_merged.pdf).

<sup>64</sup> Renda, A., Reynolds, N., Laurer, M., Cohen, G. 2019. *Digitising Agrifood: Pathways and Challenges*. Available at <https://www.ceps.eu/ceps-publications/digitising-agrifood/>.



will be adopted in other developing countries, as food retailing will become more organized and the number of supermarkets increase.

83. Cities have a unique opportunity to spark a transformation towards a circular economy for food, given that 80 percent of all food is expected to be consumed in cities by 2050.<sup>65</sup> Companies have started using computer vision, machine learning and big data analytics to monitor, analyse and redistribute food surplus to the hungry. Social enterprises in India and Indonesia are using big data analytics together with mobile technology to counter food waste at consumer end by relocating excess food to the urban poor, thus reducing hunger and malnutrition in big cities.

#### Changing food systems as result of growing urbanization

84. Persistent and widespread hunger and malnutrition, together with obesity and micronutrient deficiency, remain a huge challenge in many parts of the world. Increasing urbanization and changing dietary habits are further compounding this problem.

85. Automated micro-urban farming is gaining popularity in Asian countries such as India and Indonesia. Using a controlled atmosphere growing environment (e.g. a container or a polyhouse) and IoT devices (e.g. actuators for pumps, or artificial lighting), which are remotely controlled by a mobile application, these farms can operate in small urban spaces, such as rooftops and provide nutritious foods (primarily vegetables, but could be all crops in future) to city dwellers, irrespective of growing season or prevailing weather conditions.

86. Community farming apps in India link rural farmers with urban consumers in a new model of digitally connected contract farming that provides safe and fresh foods to urban consumers.

87. Several digital technologies such as IoT, big data and artificial intelligence, coupled with mobile technology can provide information regarding authenticity, freshness, ripeness, shelf life, nutritional information such as food quality (e.g. existence of pathogens), and supply chain traceability.

88. In Papua New Guinea, Singapore and Thailand, blockchain and big data analytics technology-enabled applications are being used by farmers and food processors to ensure complete traceability of the food value chain, thus ensuring food safety.

#### ***Digital technologies in global agriculture trade and finance***

89. Digital technology changes the economics of doing business across borders, bringing down the cost of cross-border communications and transactions, creating a cascading impact on the overall economy, including the agriculture sector. If countries could reduce just two supply chain barriers, border administration and telecom/transport infrastructure, using digital technologies such as blockchain, global trade could improve by almost 15 percent facilitating about USD 1.1 trillion of new trade volumes globally.<sup>66</sup>

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<sup>65</sup> Ellen MacArthur Foundation. 2018. *Cities and circular economy for food*. Ellen Macarthur Foundation: 66.

<sup>66</sup> World Economic Forum. 2018. *Trade Tech: A New Age for Trade and Supply Chain Finance in collaboration with Bain and Company*. Geneva, Switzerland. 4–16 pp. Available at [http://www3.weforum.org/docs/WEF\\_White\\_Paper\\_Trade\\_Tech\\_.pdf](http://www3.weforum.org/docs/WEF_White_Paper_Trade_Tech_.pdf).

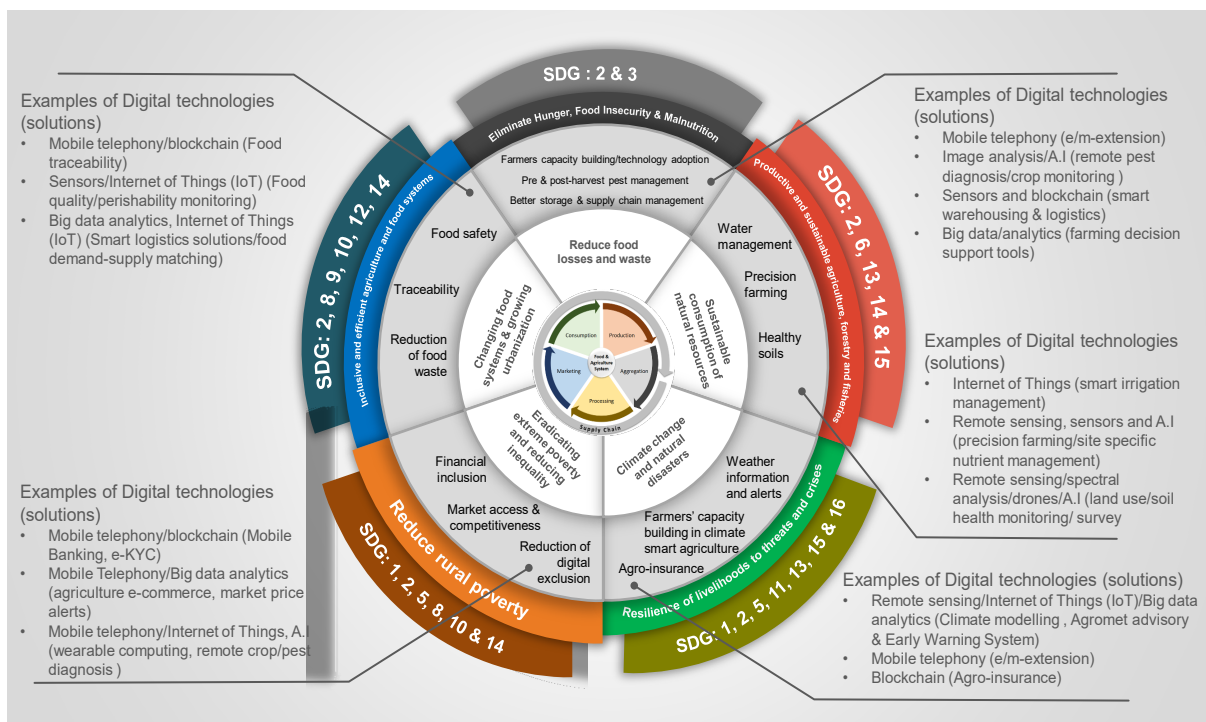


Figure 1: Examples of how digital technologies link solutions to the food and agriculture system challenges to SDGs

90. Figure 1 above illustrates how digital technologies link solutions to the food and agriculture system challenges to SDGs. In the centre of the diagram is the food value chain, comprising five of its broad stages – production, aggregation, processing, marketing and consumption. The food value chain is impacted by five key challenges (as discussed in this paper), which are depicted in the next layer. Each of these challenges needs many transformative actions or solutions as depicted in the next layer. Some of these solutions can be achieved by digital technology applications, which are described as specific use cases (e.g. remote sensing or early warning system) in the side of the diagram. The digital applications make possible achievement of the sectoral goals, such as eliminate hunger, food insecurity and malnutrition etc. (depicted in the next outer layer) and thus can also be attributed to achievement of one or more SDGs, as depicted in the outermost layer. However, this is not an exhaustive list of all possible digital technology applications, as there could be many more possible applications, as technology evolves and new challenges appear.

### An enabling agriculture innovation system

91. An enabling agriculture innovation system is critical for digital transformation of the food and agriculture sector. Such a system will be a network of cross-sectoral entities working together to define, build and execute consumer solutions and define (or redefine) markets. Such an ecosystem can be measured by the depth and breadth of potential collaboration among its actors, each delivering a piece of the solution, or adding a necessary capability.<sup>67</sup>

92. Infrastructure, investment and policies are the three key pillars of such an enabling ecosystem for agriculture innovation and digital disruption.

<sup>67</sup> Lyman, M., Ref, R., Wright, O. 2018. *Accenture Strategy Ecosystems-Executive Summary*. Accenture Strategy: 16. Available at [https://www.accenture.com/t00010101T000000Z\\_w\\_/gb-en/\\_acnmedia/PDF-77/Accenture-Strategy-Ecosystems-Exec-Summary-May2018-POV.pdf#zoom=50](https://www.accenture.com/t00010101T000000Z_w_/gb-en/_acnmedia/PDF-77/Accenture-Strategy-Ecosystems-Exec-Summary-May2018-POV.pdf#zoom=50).

### ***Infrastructure as enabling agriculture innovation system***

93. Digital products and services need to be connected at all times, among themselves and among the users. Without a high-quality and stable communication network, many digital solutions cannot operate.

94. In 2018, 2.8 billion or 65 per cent of the total population of Asia and Pacific region were mobile subscribers, which is expected to grow to 3.1 billion (72 per cent) by 2025, making this region one with most prospective for advancement of new digital technologies

95. Along with mobile telephony subscription, the penetration of mobile internet in the region is also impressive; an estimated 2.7 billion mobile internet subscribers and 68 per cent 4G coverage in 2025 will make this region one of the most connected regions in the world.

96. Telecom is a significant contributor to the socioeconomic development of the region. In 2018, mobile technologies and services in Asia and the Pacific generated USD 1.6 trillion of economic value (5.3 percent of regional GDP) – a contribution that will surpass USD 1.9 trillion by 2023.

97. By 2025, mobile operators in the region are expected to invest over USD 570 billion in building and upgrading networks; almost two-thirds will be on 5G.<sup>68</sup>

### ***Private sector venture capital investment in Agriculture technology (Agtech)***

98. Food and agribusiness is a USD 5 trillion global industry<sup>69</sup> and is going to grow bigger, fuelled by an increasing population and caloric demand.

99. Business opportunities in the implementation of the SDGs related to food could be worth over USD 2.3 trillion annually and create about 80 million jobs in the private sector by 2030. Ninety (90) percent of this would come from developing countries. The investment required to achieve these opportunities is approximately USD 320 billion per year.<sup>70</sup>

100. Rising opportunities in the agriculture and food sectors have attracted the interest of both private and public investors. During 2018, global total venture capital investment in the Agtech sector was USD 16.9 billion, and the largest deals were from Asia. Eleven (11) deals worth over USD 200 million from China and India, compared with eight from the United States of America.<sup>71</sup>

### ***Public sector investments and policy measures catalysing Agtech innovation and entrepreneurship***

101. ICTs can deliver socio-economic dividends when countries create an enabling policy environment in terms of regulations, legislations and human capacities. The importance of this enabling environment was recognized in the Declaration and Action Plan of the first phase of the World Summit on the Information Society, which emphasized that a trustworthy, transparent, and non-discriminatory environment was essential for the use and growth of ICTs in the developing world.<sup>72</sup>

102. The exponential surge of capital infusion in start-ups in Asia and Pacific region is made possible because of the favourable public policy environment in the region.

<sup>68</sup> GSMA. 2019. *The Mobile Economy, Asia Pacific*. GSMA Intelligence. Available at <https://www.gsmainelligence.com/research/?file=fe8735424e3058f98c3a83bc57bc2af5&download>.

<sup>69</sup> Goedde, L., Horii, M., Sanghvi, S. 2015. *Pursuing the global opportunity in food and agribusiness*. McKinsey Insights. 9 pp. Available at <https://www.mckinsey.com/industries/chemicals/our-insights/pursuing-the-global-opportunity-in-food-and-agribusiness>.

<sup>70</sup> Business and Sustainable Development Commission. 2016. *Valuing the SDG prize in food and agriculture: Unlocking business opportunities to accelerate sustainable and inclusive growth*. London, UK. 48 pp. Available at <http://s3.amazonaws.com/aws-bsdc/Valuing-SDG-Food-Ag-Prize-Paper.pdf>.

<sup>71</sup> AgFunder. 2019. *AgFunder AgriFood Tech Investing Report*. AgFunder. 67 pp. Available at [www.agrfunder.com](http://www.agrfunder.com).

<sup>72</sup> World Summit on the Information Society. 2003.

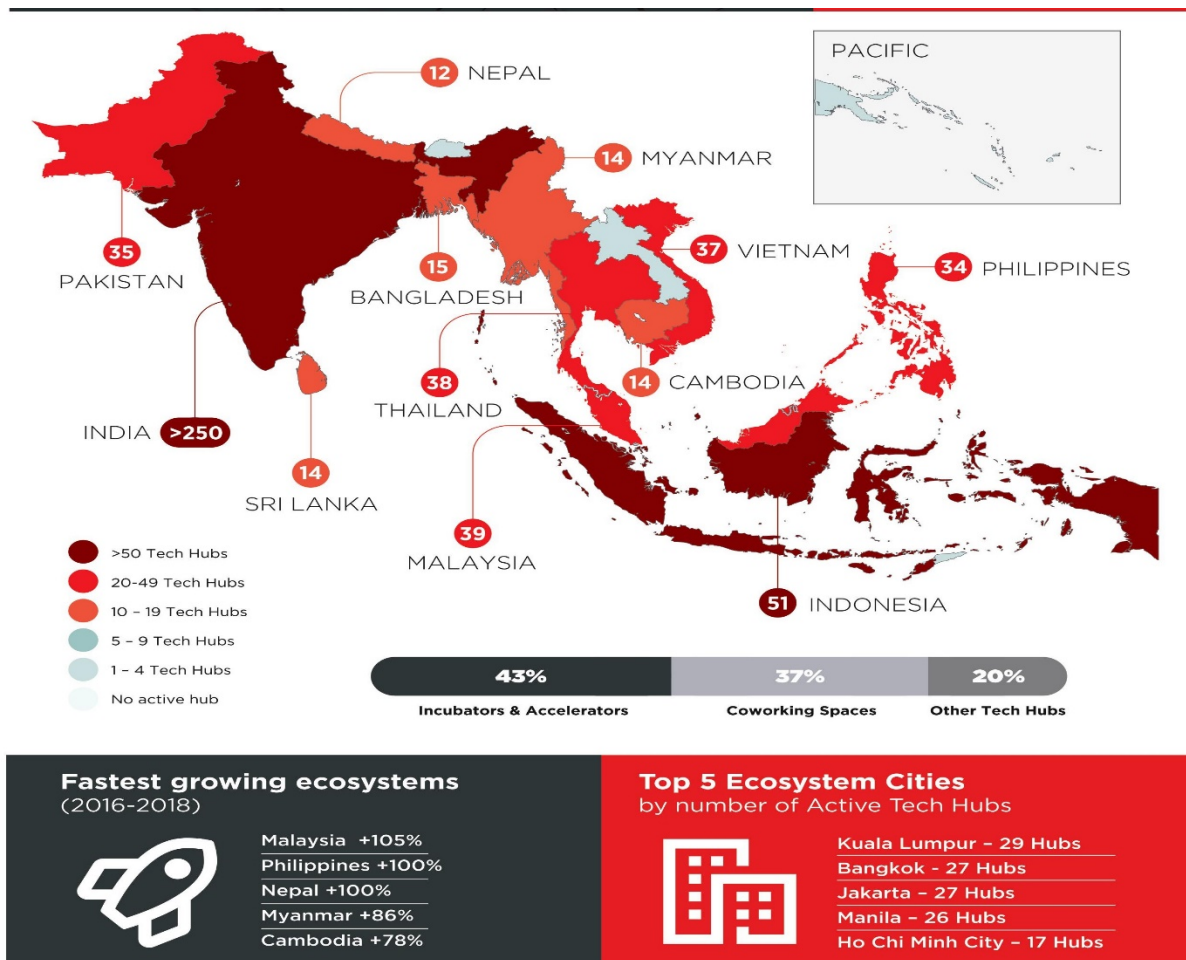


Figure 2: Tech Hubs in Asia and the Pacific region. Source: gsma.com/ecosystemaccelerator

103. For example, from 2016 to 2018 the number of technology hubs in the developing economies of the region almost doubled, from 287 to 565 – of which 250 are in India, followed by Indonesia (50+), Malaysia (39), Thailand (38), and Viet Nam (37).<sup>73</sup>

104. Asia-Pacific countries are taking an active interest in promoting technology innovations. The Government of India’s flagship *Digital India* and *Start-up India* programmes have created a support fund of USD 1.4 billion and 70 incubation centres for start-ups. As of 2018, there were 20 000 registered start-ups in India<sup>74</sup>.

105. With more than 50 active technology hubs, Indonesia represents the largest ecosystem across emerging markets in the region. Along with the government-promoted initiatives such as 1 000 Digital, BEKRAF and Kejora, a number of international accelerators, such as Founder Institute, Google, MaGIC, Microsoft, Microsoft, Plug and Play, and Telkomsel have launched programmes in the country.<sup>75</sup>

106. Under the overarching framework of indigenous innovations of the “Made in China 2025” strategy, the focus on and developmental funding for artificial intelligence are considered to be the

<sup>73</sup> GSMA. 2018a. *Asia Pacific: a look at the 565 active tech hubs of the region’s emerging economies*. GSMA Mobile for Development. Available at <https://www.gsma.com/mobilefordevelopment/blog-2/asia-pacific-a-look-at-the-565-active-tech-hubs-of-the-regions-emerging-economies/>.

<sup>74</sup> KPMG. 2018. *Startup ecosystem in India – Growing or matured?* 4 pp. Available at <https://assets.kpmg/content/dam/kpmg/in/pdf/2019/01/startup-landscape-ecosystem-growing-mature.pdf>.

<sup>75</sup> GSMA. 2018a. *Asia Pacific: a look at the 565 active tech hubs of the region’s emerging economies*. GSMA Mobile for Development. Available at <https://www.gsma.com/mobilefordevelopment/blog-2/asia-pacific-a-look-at-the-565-active-tech-hubs-of-the-regions-emerging-economies/>.

factors that will make the country “the front-runner and global innovation centre in artificial intelligence” by 2030.<sup>76</sup>

107. The Government of the Republic of Korea published its “Intelligence Information Society 4th Industrial Revolution Medium- to Long-term Comprehensive Response Plan” in 2016, which defines its strategy towards supporting digital innovations.<sup>77</sup>

108. In 2016, Prime Minister Abe launched Japan’s Artificial Intelligence Technology Strategy Council, which outlines some of the priority areas for Japan in the areas of artificial intelligence research and development.<sup>78</sup>

109. In 2015, the Government of Malaysia introduced 200 percent deduction of qualifying research and design (R&D) expenditure by companies for eligible R&D activities.<sup>79</sup>

110. With 37 active technology hubs, Viet Nam is a growing technology start-up destination. The Hi-tech Park at Da Nang recently received USD 62 million in investments. The country is home to regional programmes such as the Mekong Business Initiative, which runs MIST Accelerator and MATCh. Vietnam Innovative Start-up Accelerator (VIISA), Founder Institute’s Topica, and HATCH are some of the other prominent acceleration programmes in the country.<sup>80</sup>

111. Under the Philippine’s Innovation Fund, PHP 1 billion (around USD 20 million) will be set aside to engage private enterprises to aid in the development of innovative solutions which are to benefit the poorest of the poor.<sup>81</sup>

112. In Papua New Guinea, the National Development Bank has recently announced the opening of a new tech incubator in Port Moresby.<sup>82</sup>

113. In Fiji, the Government’s Youth Entrepreneurship Scheme is helping the start-up ecosystem to grow.

114. The establishment of Technology Institutes in Kiribati and Timor-Leste is positive evidence of the collective effort towards innovation and entrepreneurship support being made by the governments of the island states.

### **Challenges of digital transformation of food and agriculture systems**

115. Considered to be a catalyst for growth, digital technologies will have far-reaching effects on economies, employment and human well-being. However, together with creating new opportunities for countries, businesses (especially small and medium enterprises) and citizens, these technologies are also likely to disrupt the order by displacing workers, replacing human skills with machines, and opening the

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<sup>76</sup> United Nations Economic and Social Commission for Asia and the Pacific. 2019. *Financing for Development in Asia and the Pacific: Highlights in the Context of the Addis Ababa Action Agenda*. Available at [https://www.unescap.org/sites/default/files/Final Action Agenda 2019\\_Text\\_3.pdf](https://www.unescap.org/sites/default/files/Final%20Action%20Agenda%202019_Text_3.pdf).

<sup>77</sup> Ibid.

<sup>78</sup> Ibid.

<sup>79</sup> EY. 2017. *Catalyzing growth through incentives in Contents*. 28 pp. Available at <https://dokumen.tips/documents/catalyzing-growth-through-incentives-in-asia-growth-through-incentives-in-asia-pacific.html>.

<sup>80</sup> GSMA. 2018a. *Asia Pacific: a look at the 565 active tech hubs of the region’s emerging economies*. GSMA Mobile for Development. Available at <https://www.gsma.com/mobilefordevelopment/blog-2/asia-pacific-a-look-at-the-565-active-tech-hubs-of-the-regions-emerging-economies/>.

<sup>81</sup> United Nations Economic and Social Commission for Asia and the Pacific. 2019. *The Disaster Riskscape Across Asia-Pacific: Pathways for Resilience, Inclusion and Empowerment*. 130 pp. Available at <https://www.unescap.org/publications/asia-pacific-disaster-report-2019>.

<sup>82</sup> GSMA. 2018a. *Asia Pacific: a look at the 565 active tech hubs of the region’s emerging economies*. GSMA Mobile for Development. Available at <https://www.gsma.com/mobilefordevelopment/blog-2/asia-pacific-a-look-at-the-565-active-tech-hubs-of-the-regions-emerging-economies/>.



doors to many new challenges, resulting in new divisions, greater inequality and more vulnerability.<sup>83</sup> Some of the key challenges, foreseen as a consequence of digital disruption and pervasion of digitalization, are discussed in the paragraphs that follow.

### ***Infrastructure challenges for digital transformation of agriculture***

116. Due to wide differences in the stages of economic development and ICT development (GDP and ICT Development Index) in Asia and the Pacific region, countries face a number of challenges towards managing the ongoing development of the ICT industries within their jurisdictions and promoting long-term economic development and higher living standards.

117. Some of these challenges are: growing demand for broadband versus pricing (*network licensing*); promoting profitability in telecommunications (*regulations*) while maintaining competition to ensure benefits to consumers (open market); and focusing telecommunications investment for greatest impact on economic growth (*smart cities*) against the need to bring telecommunications services to groups in rural and remote regions (*mobile for development*).<sup>84</sup>

118. As a result of the wide variation in ICT development status, many people in least developed and developing countries will be unable to reap the benefits of digitalization of agriculture. This digital gap can be closed with multilateral cooperation and investment in ICT infrastructure. The Hand-in-Hand Initiative of FAO is a positive and pre-emptive step towards this goal.

### ***Investment challenges to digital transformation of agriculture***

119. Lack of investment is a key barrier to the uptake of new technology across the food and agriculture ecosystem. A number of key factors have driven this lack of investment. The food and agriculture industry is large, complex and diverse, creating a challenging investment environment but also significant opportunities for knowledgeable investors. Many emerging technologies are nascent, which means a longer payback period for investment. Specifically in the Asian context, there are a number of challenges, including the diversity of countries, levels of economic development, regulatory systems, currencies and dietary preferences. As a consequence, many innovations from other markets have proven less relevant in the Asian context.<sup>85</sup>

120. It is estimated that a cumulative investment of USD 800 billion until 2030 would be required in Asia and the Pacific region for digital transformation of the food and agriculture sector, implying annual investment of USD 290 billion until 2030. However, this investment could potentially unlock a market worth USD 8 trillion annually in 2030.<sup>86</sup>

121. Public sector investment in agriculture has yet to match what is required. In 2017, USD 18 billion was committed and USD 11 billion was disbursed as development assistance to the agriculture sector globally. The Asia and the Pacific region received about 40 percent of this development flow to agriculture.<sup>87</sup> However, only a part of this investment was directed towards digital agriculture.

122. Private sector investment in the agriculture sector has also been modest; since 2007, capital deployed by both private impact investors and development finance institutions in Southeast Asia has

<sup>83</sup> OECD. 2017. *Key Issues for Digital Transformation in the G20*. 163 pp. Available at <https://www.oecd.org/internet/key-issues-for-digital-transformation-in-the-g20.pdf>.

<sup>84</sup> ITU. 2019b. *Digital Infrastructure Policy and Regulation in the Asia-Pacific Region*. 72 pp. Available at [https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2019/RRITP2019/ASP/ITU\\_2019\\_Digital\\_Infrastructure\\_5Sep2019FNL.pdf](https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2019/RRITP2019/ASP/ITU_2019_Digital_Infrastructure_5Sep2019FNL.pdf).

<sup>85</sup> PWC, Rabobank, Teamasek. 2019. *The Asia Food Challenge: Harvesting the Future*. Available at <https://www.asiafoodchallenge.com/>.

<sup>86</sup> Ibid.

<sup>87</sup> FAO. 2019c. *Development flows to agriculture*. FAOSTAT, based on OECD-CRS data. Available at <http://www.fao.org/economic/ess/investment/flows/en/>.



amounted to nearly USD 12.2 billion, out of which 9 per cent was in the agriculture sector and about 12 per cent in ICT.<sup>88</sup>

### ***Policy challenges to digital transformation of agriculture***

123. Some of the key policy challenges to digital agriculture could be broadly classified as human development, data ownership and protection, and ethical use of data.

#### *Human development in the agriculture sector*

124. Developing human skills and organizational capacities to effectively deploy digital technologies and derive benefit is a key challenge for policy-makers.<sup>89</sup> For increased adoption of digital technologies, there should be concurrent changes in the demand or user side, such as enhanced digital literacy, availability of local digital facilitators who can raise awareness about new technologies and help in large-scale adoption, etc<sup>90</sup>. Also, some digital services may replace some manual tasks (e.g. pesticide spraying) making some blue-collar works redundant. There have to be systems in place to upskill this redundant workforce so that they can perform new jobs, without losing their livelihood.

#### *Data ownership, protection and interoperability*

125. With enhanced digital connectivity and more advanced communication media, there will be an enormous volume of data generated by digital systems. The flood of data collected on the internet brings many benefits to consumers but also raises the question of data ownership (open source, open access and restricted data-sharing), data security and abuse (through cybercrime, discrimination, or manipulation) and data ethics.

126. In the context of agriculture, the economic value of data in food systems increases as the data are aggregated. This economic value will create important policy and regulatory issues related to individual versus aggregate data ownership and use rights that are important for developers of digital applications as well as for farmers. Developing clearly defined policies with a win-win proposition for all stakeholders in the data ecosystem (creator, aggregators, processors and data storekeepers) would be critical.

127. Addressing data vulnerability is also important. According to the Global Information Security Survey 2018-19 by Ernst & Young, two billion records containing personal and other sensitive data were compromised between January 2017 and March 2018, causing an average global economic loss of USD 3.62 million every day.<sup>91</sup> As of 2014, out of 107 countries that had data-privacy laws, only 51 were developing countries,<sup>92</sup> which exposes a major hole in the legislative framework regarding data protection in the developing world.

128. Along with data, it is important to have standards to enact interoperability of information between systems. The agriculture sector traditionally has the weakest data standards and interoperability, so much so that different digital systems within the same country cannot exchange information among themselves. Without effective data standards, digital solutions such as big data analytics, IoT, artificial intelligence and blockchain will have very limited and localized applicability.

<sup>88</sup> GIIN, Intelicap. 2018. *The landscape for impact investing in Southeast Asia*. Available at [https://thegiin.org/assets/GIIN\\_SEAL\\_full\\_digital\\_webfile.pdf](https://thegiin.org/assets/GIIN_SEAL_full_digital_webfile.pdf).

<sup>89</sup> OECD. 2019. *Digital Opportunities for Better Agricultural Policies*. Available at [https://www.oecd-ilibrary.org/agriculture-and-food/digital-opportunities-for-better-agricultural-policies\\_571a0812-en](https://www.oecd-ilibrary.org/agriculture-and-food/digital-opportunities-for-better-agricultural-policies_571a0812-en).

<sup>90</sup> World Bank. 2019. *Future of Food: Harnessing Digital Technologies to Improve Food System Outcomes*. Washington DC, USA. 44 pp. Available at <http://documents.worldbank.org/curated/en/941601554962010560/pdf/Future-of-Food-Harnessing-Digital-Technologies-to-Improve-Food-System-Outcomes.pdf>.

<sup>91</sup> EY. 2019. *Is cybersecurity about more than protection?*. EY global Information Security Survey 2018-2019. 36 pp. Available at [https://www.ey.com/Publication/vwLUAssets/EY\\_Global\\_Information\\_Security\\_Survey\\_2018/\\$FILE/EY\\_Global\\_Information\\_Security\\_Survey\\_2018-19.pdf](https://www.ey.com/Publication/vwLUAssets/EY_Global_Information_Security_Survey_2018/$FILE/EY_Global_Information_Security_Survey_2018-19.pdf).

<sup>92</sup> ITU. 2019b. *Digital Infrastructure Policy and Regulation in the Asia-Pacific Region*. 72 pp. Available at [https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2019/RRITP2019/ASP/ITU\\_2019\\_Digital\\_Infrastructure\\_5Sep2019FNL.pdf](https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2019/RRITP2019/ASP/ITU_2019_Digital_Infrastructure_5Sep2019FNL.pdf).

FAO's Agriculture Information Management Standards Portal (<http://aims.fao.org/>) and Research Data Alliance's Agricultural Data Interest Group (<https://www.rd-alliance.org/>) are examples of pioneering work in developing data standards.

### *Ethical use of data*

129. The ethical use of data is also becoming an increasingly serious issue. A few big companies can monopolize all data created by digital systems developed by them or running on their platforms or using their proprietary technology, resulting in these companies having an unfair advantage over others. Today, popular social media, messenger and email service providers together are estimated to have data about almost half of the world's population. An artificial intelligence system together with big data analytics can use this huge volume of data and provide insights to these companies about anything from an individual user's next purchase decision or next place the user will visit, which would have serious ethical implications. Beyond ethics, there could be other serious issues such as an erroneous algorithm or compromised automation system, which could cause huge economic or property loss resulting in massive financial and social liability on the owners of such systems. Legislative frameworks in the countries need to evolve to cope with such new challenges.

### *Policy environment conducive to the new digital technologies*

130. A favourable policy environment is like the fertile ground in which new innovations take root and grow. As new digital technologies become ever more ubiquitous, a supportive policy environment can make the benefits delivered to the masses. A good example could be Digital India mission, which mobilized massive policy-level initiatives to popularize digital finance as a primary means to achieve financial inclusion in the country, which resulted in innovative digital platforms such as the universal payment interface (UPI), introduced by the Reserve Bank of India, and the Bharat Interface for Money, a mobile app that uses UPI for digital transactions. As of October 2019, 1.15 billion transactions had been conducted on these platforms. Furthermore, owing to such policy-level intervention, 176 million unbanked people were brought under a formal banking system through a special savings account called "Jan Dhan" bank accounts.<sup>93</sup>

131. At the same time, the pervasiveness of digital technologies could also result in hesitation and resistance among the regulators. In 2017, the national treasury of Kenya recommended that mobile money could be a "*plausible fiscal risk*" to the country, given the growing interlinkages with different sectors of the economy".<sup>94</sup> Since then, there has been some decline in mobile wallet use in Kenya.<sup>95</sup>

132. Innovators, businesses, regulators and policy-makers need to work together systematically and in tandem with technology experts in order to create a policy environment that enables technologies to prosper, while safeguarding the interest of the consumers.

## **Call for action**

133. The heterogeneity of the agriculture and food sectors in countries in Asia and Pacific region, together with the diversity and variability of their national policies and objectives and their preparedness to adopt digital technologies, calls for developing country-specific strategic policies that are aligned with the national, regional and global priorities, especially the SDG Targets.

### *Regional and global cooperation for digital agriculture*

134. The digital transformation of food and agriculture systems will not be homogeneous; countries with a better infrastructure, investment landscape and policy framework will be in a position to adapt and scale technology disruptions faster, while countries that are still at the lower rungs of ICT

<sup>93</sup> [www.ncpi.org.in](http://www.ncpi.org.in).

<sup>94</sup> The National Treasury of Kenya. 2016. *2017 Budget Policy Statement*. The Republic of Kenya. Available at [www.treasury.go.ke](http://www.treasury.go.ke).

<sup>95</sup> Sunday, F. 2019. *Mobile cash transfers fall 30 per cent*. The Standard Digital. Available at <https://www.standardmedia.co.ke/article/2001332332/mobile-cash-transfers-fall-30pc>.

development will need to build the base of sound infrastructure and policies and would require significant investment flows before entering this digital era.

135. Countries can find ways and means to work and grow together under regional or global cooperation (e.g. South-South, the Association of Southeast Asian Nations [ASEAN]) to achieve equitable progress and prosperity from the technology revolution. Countries at the higher rungs of ICT development can help countries with the highest poverty and hunger rates by providing policy and technical assistance that will substantially contribute to the achievement of the SDGs by these lesser developed countries and make it possible to close the hunger and poverty gap, support economic development, end malnutrition, and reduce environmental impact of agriculture at a global scale.

#### ***“Whole of government” approach for digitalization strategy and implementation***

136. It is also important for policy-makers to adapt a “whole of government” approach when planning digitalization of the agriculture sector. In doing so, countries will be able to take advantage of the inherent cross-cutting nature of digital technologies and derive maximum return on investment from the implementation of ICTs. FAO-ITU’s E-Agriculture Strategy Guide is an ambitious step towards realizing this goal, which has already supported several countries in Asia and Pacific region to successfully plan their own national strategy for digital agriculture.

#### ***Leveraging the private sector for ideas, innovations and investment***

137. The private sector can play a significant role in the digital transformation of the agriculture sector. In 2019 there were 1 600 Agtech start-ups that garnered about USD 16.9 billion in funding,<sup>96</sup> which shows the potential opportunity that lies with private businesses to catalyse digital transformation in the agriculture sector. Countries should leverage this potential by supporting private enterprises, creating fiscal incentives for investors, facilitating joint research and development between the private and public sectors and academia, increase ease of doing business, and adapt and evolve regulations and legislation in context of the emerging technologies. However, policy-makers should also be sensitive to and aware of how the private sector impacts can best be distributed across financial, social and environmental outcomes and channel private investments into adaptation actions that are profitable for businesses, equitable for the poor, and sustainable for all.

#### ***Bridging the “triple divide”***

138. As mentioned, the digital, rural and gender divides (the “triple divide”) still exists widely in most of the developing and LDC countries. Digitalization and the spread of ICTs have not ushered in benefits equitably to all strata of society; many poor, marginal and disadvantaged people have yet to gain and actualize any such digital dividends. Countries need to focus on building infrastructures in order to expand ICTs to the last mile and support businesses that offer affordable but innovative ICT solutions (i.e. a solution that will work on a basic mobile phone) through incentives and policies (e.g. preferential pricing for companies that provide mobile agro-advisory through SMS). BharatNet in India, considered to be the world’s largest rural broadband project, is an example of successful rural ICT infrastructure development. A mobile operator-led agro-advisory project in Sri Lanka uses SMS and automated voice calls to deliver critical information on nutrition-sensitive agriculture to about 600 000 farmers, and is supported by the Government’s agriculture department for content and advisory services, which is an example of government supporting private business in providing affordable ICT solutions. The Women ICT Frontier Initiative, launched by the Economic and Social Commission for Asia and the Pacific (ESCAP), will promote women’s entrepreneurship in eight countries in Asia and Pacific region by strengthening the capacities women entrepreneurs in ICT and entrepreneurship.<sup>97</sup> This is another good example of an initiative that could bridge the gender gap.

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<sup>96</sup> AgFunder. 2019. *AgFunder AgriFood Tech Investing Report*. 67 pp. Available at [www.agrfunder.com](http://www.agrfunder.com); Day, S. 2019. *AgTech Landscape 2019*. AgFunder News. Available at <https://agfundernews.com/2019-06-04-agtech-landscape-2019-1600-startups.html>.

<sup>97</sup> United Nations Economic and Social Commission for Asia and the Pacific. 2019. *The Women ICT Frontier Initiative (WIFI)*. APCICT. Available at <https://www.unapcict.org/flagship-programmes/wifi>.

139. In summary, technology can potentially answer some of the biggest challenges in the food and agriculture systems. Innovations in technologies together with policies, infrastructure and business models supported by public and private investment will be key to feeding a growing population in a safe and sustainable way.