Photo: Mitr Phol

The **Fourth Industrial Revolution:** benefits and threats for commodity-dependent developing countries

Introduction

With the development of new technologies such as artificial intelligence, advanced robotics, and genetic editing, humankind is considered to have entered the fourth industrial revolution[1] (Figure 1). This provides the world with opportunities to tackle challenges such as climate change, dwindling natural resources, a growing population (projected at 9.8 billion people by 2050 (FAO, 2017), and an increase in the demand for food of 50% (FAO & OECD, 2018). However, the disruptive impact of wide-spread technological change combined with the vulnerabilities of commodity dependent developing countries (CDDCs) may also result in the emergence of a new technological divide which could further constrain the competitiveness and affect the rising aspirations of CDDCs to sustainable development.

The emergence of integrated cyberphysical systems combining existing elements of commodity value chains with numerous new technological breakthroughs in Information Technology (IT) space has the potential to make agricultural production and commodity chains more efficient, sustainable and transparent. For example, satellite and drone imagery is being used to detect problems (e.g. pests, disease, nutrient and water deficiency, etc.) in crops to allow farmers to act fast to mitigate the issue. The internet of things creates a possibility of setting up a decentralized grid of smart soil sensors reporting in real time on the status of the soil, the weather conditions, and other relevant parameters, supplying all this information to a central "cyber agronomist" computer which will analyze and predict crop condition and advise the farmer on the best use of water, fertilizer and other inputs. Similarly, trackers worn by cattle can record the exact location and health of the animals from birth. Blockchain, another disruptive and much hyped technology, is already revolutionizing logistics, enabling, inter alia, simple and effective tracking of food from farm to plate to allow consumers to make more conscious decisions about food and driving the whole food chain to adopt more sustainable and ethical practices.

[1] The Fourth Industrial Revolution is a term coined at the World Economic Forum in Davos by Klaus Schwab, Founder and Executive Chairman of the World Economic Forum. This Fourth Industrial Revolution "is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres". https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

CFC common fund for commodities
KIT Royal Tropical Institute
CHIPSAFER

Figure 1: The four industrial revolutions

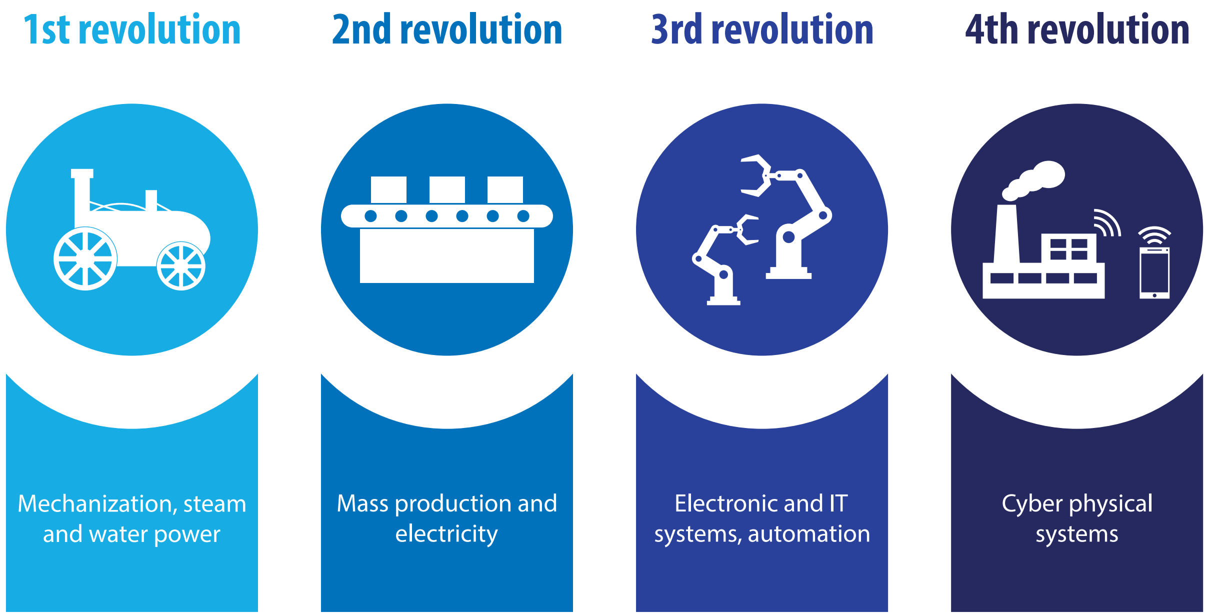


Photo: Adobe Stock

Despite their overall positive economic and development impact, every new technological breakthrough has always created both winners and losers. Unemployment, loss of sources of income, economic migration and other major social changes have been routinely witnessed in every industrial revolution. The fourth industrial revolution will likely not be an exception. Indeed, there are concerns that this new industrial revolution can increase inequality, as the majority of the world is still not connected to the internet[2] or do not have access to new technologies. In the absence of suitable mitigation strategies, CDDCs may face significant social challenges in the coming years resulting from the global expansion of new technological models, undermining the competitiveness and sources of income of the most vulnerable people in CDDCs. This article explores the potential of the fourth industrial revolution for CDDCs and its potential threats.

Technologies and their potential benefits for agriculture

A large number of new technologies are already being used in agriculture, including CDDCs. A selection of technologies is presented below.

Satellite and unmanned aerial vehicle (UAV) imagery

UAVs are a specialized tool in precision farming as they capture very high resolution imagery (e.g. 5-10 cm). High resolution satellites have the advantage of instantaneous measurement for large areas but the resolution is lower (e.g. 0.5 – 2.5 m). UAVs can also be equipped with motion video cameras for close-up visual inspections, or with a LiDAR (Light Detection and Ranging) sensor to detect the height of trees or crop canopy. LiDAR can also be used to create a 3D model of the farm or forest, which can be very useful for environmental projects and better farm planning. Satellites and UAVs equipped with multispectral sensors are able to cover entire farms and at high resolution. In addition to providing views of the farm, these images provide remote-sensing data and can be used to map crop health.

Satellite and UAV imagery can also be used to detect changes over time by processing imagery acquired on multiple dates over a particular period. This allows farmers to determine variability in crop health and make timely management decisions to increase the efficiency of input use, crop yield, quality, and farm profitability.

Satellite and UAV imagery, can also be used for index-based insurance. This is starting to become an important mechanism for farmers to manage the risks of circumstances outside of their control such as weather, pests, and diseases. For example, sensors can be used to determine the amount of rainfall in a certain region over a whole season. If the amount of rainfall is less than a certain threshold then the farmer gets paid by the insurance company. This will allows farmers to reduce their exposure to risk and feel more comfortable making investments into their

[2] https://www.voices360.com/technology/the-fourth-industrial-revolution-threatens-more-global-inequalities-17438938

farms. Satellite data can also be used to determine vegetation levels and to use it as an index.[3]

Global navigation satellite systems (GNSS)

Global navigation satellite systems are satellite constellations that provide world-wide positioning, navigation, and timing information. GNSS can be used for increased accuracy in farm management and agricultural planning, leading to added efficiency in land use. For example, due to the precise navigation capabilities, these systems are being used in machinery to precisely measure the distance in planting crops more efficiently. Farmers and crop consultants can also use GNSS-based applications to do crop scouting and to determine the exact location where pesticide, fertiliser or irrigation needs to be applied for improving resource utilisation, maximise output and land use.[4]

Unmanned aerial vehicle (UAV) transportation (drone-driven logistics)

UAVs can also be utilised to transport small goods to places that are not easily reachable. In case of an emergency, a drone can be used to transport emergency equipment to a remote location and provide fast action. Generally, electric drones are capable of reaching places around half an hour from the base station. UAV charging stations could enable drones to reach longer distances in the future. Drone-driven logistics is already being used in Rwanda ("Zip-line") and aims to transport high value products, such as blood or medication, within half hour to any location within over 100 km from the base station. The use of AI eliminates the need to piloting the drones, which drop supplies by parachute within 3 meters from the GPS target spot in any reasonable weather conditions. The technology is economically efficient because it eliminates the need to maintain local hospital stocks of medicine, with all the costs, losses and poor storage conditions. The experience of the operation demonstrates that a technology based solution is entirely viable in a developing country.[5]

Internet of things (IoT)

The internet of things consists of devices connected to the internet and there are many new technologies being used in agriculture. For example, sensors can be placed across fields to measure soil moisture, air pressure, temperature, wind, among

Colombian fruit farmer using his hand-held GPS device for planting decisions

Photo: Neil Palmer (CIAT)

[3] https://ccafs.cgiar.org/es/themes/index-based-insurance
[4] https://www.gps.gov/applications/agriculture/
[5] https://flyzipline.com (accessed December 2018)

Photo: Mitr Phol

Sugarcane production in Thailand supported by AI and Internet of Things (IoT) to assess crop health, soil moisture, and pest and disease infestation risk

other things to maximise analytical data opportunities. Livestock can also use wearable technology, such as collars, that transmit information about the exact position and health of the animals starting from the day they were born. In addition, tablets and smartphones enable data to be gathered. A farmer or crop consultant can do crop scouting with a hand-held device and upload pictures of the field, and write notes about field conditions. All the information transmitted by the sensors can then be correlated and translated into actionable information that the farmer can use to improve production.

Weather modelling

Being able to predict the weather is essential for farmers' planning. Through the use of weather satellites that transmit weather data, there are weather modelling systems that correlate this information with weather stations and sensors on the ground to predict weather patterns and warn farmers about conditions such as hail. Weather models are tools that can also be used to foresee how the next season will be and use that information to plan for the amount of irrigation that will be needed.

Irrigation systems

Water usage must be strategically utilised to maximise appropriate coverage. New irrigation systems can be automatically and remotely controlled to ensure uniform water delivery throughout the crop field. The irrigation system can also be set to irrigate in the right amount and in the right places, preventing water wastage. Satellite and UAV imagery can help detect if there is a problem in the irrigation system, like having a micro-sprinkler clot, so that fast remedial action can be taken.

Gene editing

The traditional way of breeding crops may take many years and a crop may be generated that is improved in one trait but worse in another. New gene editing techniques using Artificial Intelligence for the analysis of genetic traits has the potential of accelerated, more precise breeding programmes producing plants specifically adapted to climate, soils, or nutrient composition. This amounts to significant productivity improvements.

Blockchain and traceability

Tracking and tracing the history of food products allows consumers to make more informed decisions about the products they buy. Active traceability, via blockchain technologies, provides open information and transparency to the whole food supply chain, which helps improve food safety and decreases the chances of illegal activities, such as deforestation due to land appropriation for agriculture.

Artificial intelligence (AI) and machine learning

Satellite and UAV data, field data gathered by sensors, and weather modelling may all be correlated to generate actionable information. Machine learning and AI are then being used to determine specific problems in the field and suggest recommendations on how to solve it. These technologies can also be used to predict crop yield and even estimate prices based on global data.

Box 1: The case of Santos Lab in Brazil

There are many small companies in CDDCs that focus on agriculture technology (AgTech). For example, Santos Lab, a Brazilian company which was established in 2006 by a young entrepreneur who was passionate about UAVs and their use to benefit the Brazilian economy. Santos Lab started as a research and development company for the Brazilian armed forces, developing mainly unmanned aerial systems and integrating intelligence software. In 2014, with the airspace opening for civilian drones and with Brazil's huge demand for technology in the agricultural sector, the company decided to focus their expertise and technology to address issues in the agricultural sector. Since then, the company has been creating, developing and integrating diverse technologies in order to provide better solutions for farmers and their activities.

Gabriel Klabin, founder and CEO of Santos Lab says that "one of the many issues farmers face, and the one Santos Lab is trying to address, is lack of precise information about what is happening with their crops so that they can better manage and avoid the many issues that happen during the crop season and soil preparation". The company uses UAV and satellite imagery, together with soil and leaf-sampling to determine crop health, pest infestation, yield forecasting, and multispectral maps, among other things. After analysing all the data, they provide the farmer with recommendations on water, fertiliser and other input applications, thus reducing resource consumption and increasing productivity and profitability. They also monitor pasture quality in cattle grazing. If the soil is not degraded, it can sequestrate the greenhouse gas emissions produced by the cattle. Besides, the animal's manure also helps to fertilise the soil.

Santos Lab is an example of social entrepreneurship, since the company is a business and generates a positive impact at the same time. The new technologies of the fourth industrial revolution bring great opportunity for startups and small and medium enterprises (SMEs) to solve pressing problems in agricultural production and commodity chains. These companies thereby also generate employment in the region and boost the economy.

Photo: Santos Lab

Gabriel Klabin, founder and CEO of Santos Lab next to one of his UAVs

Challenges to widespread adoption of new technologies

These new technologies promise to make agriculture more efficient, improve food security, mitigate climate change and reduce poverty, but, at the same time, numerous challenges of practical implementation exist which may result with the fourth industrial revolution leading to more inequality.

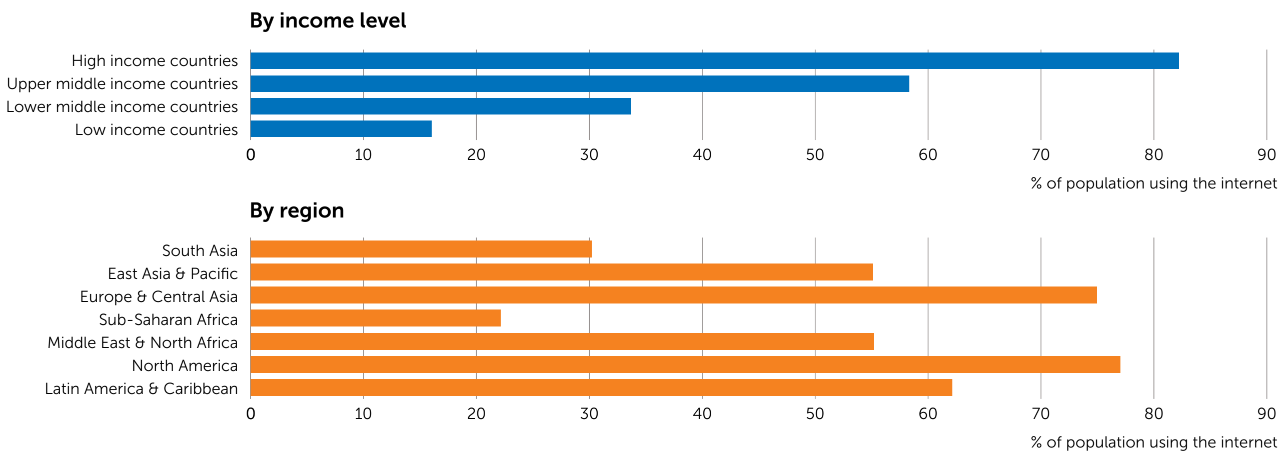
Internet connectivity

While many of the new technologies are based on real-time data and broadband internet, the ability to adopt these technologies differs a lot across the globe. Data on internet use show that there is a major difference in the use of the internet, between lower and higher income countries, and between regions (Figure 1). Access to broadband internet in particular, has even larger variations between countries; for example only 0.1% of the population in Myanmar and Afghanistan had a fixed-broadband subscription in 2016, while in Japan and New Zealand more than 30% did[6]. Where internet cannot be used due to a lack of connectivity, the adoption and development of the key cyberphysical technologies, such as AI, will be uneven.

Access to finance

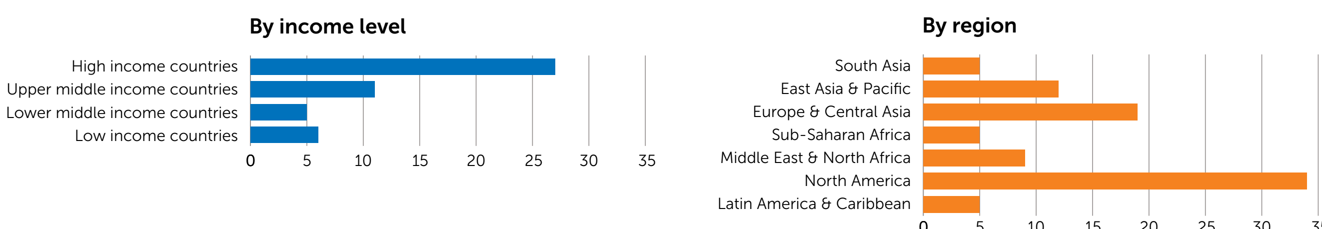
Another issue that may exacerbate inequality as a result of the fourth revolution is unevenness in access to finance to afford these new technologies. A lack of access to credit and financing has long been a major impediment for smallholders to invest and innovate, as they are more likely to be unable to fulfil lenders' requirements (e.g. minimum incomes, collateral), or are unable to pay the often high interest rates. There are major differences between countries in the ability of people to borrow money for farming or business innovation (Figure 2). The agricultural sector is considered high-risk by financial institutions, as farm production and incomes are variable. Digital technology (i.e. mobile phones and digital financial services) has the potential to improve people's access to finance, and a potential virtuous circle may exist with technology improving access to finance, which, in turn, will further improve access to technology. However, such virtuous circle will also likely amplify inequalities and vulnerabilities because the unbanked may have greater difficulties in making the first few steps as they are also relatively less likely to have both a mobile phone and access to the internet (Demirgüç-Kunt et al., 2018). In addition, there are gender gaps as women are less likely to have a mobile phone.

Figure 2: Individuals using the Internet (% of population, 2017)



Source: https://data.worldbank.org/indicator/it.net.user.zs

Figure 3: Borrowed to start, operate, or expand a farm or business (% age 15+)



Source: https://globalfindex.worldbank.org/

[6] https://www.unescap.org/sites/default/files/06Chapter4.pdf

Photo: USDA by Lance Cheung

Technological capabilities

A major factor in the adoption of new technologies are access to knowledge, skills and technological capabilities. This in itself is a huge source of inequality because the CDDCs face impediments to knowledge access which are most acute in areas constituting the key innovations of the cyberphysical revolution. This includes limited skills available for technology adoption, brain drain from commodity dependent economies, weak linkages from commodity based industries to academia, as well as limited availability of vocational education and training. Technological capabilities in a country can also be hampered by a lack of investment in national technology development, and national capacity to innovate. CDDCs are likely to have limited resources available to invest in Research and Development, and regulatory frameworks for AI are also more likely to be weak (ESCAP, 2018).

The technological divide and inequality

The inequality in the adoption of the technologies of the fourth industrial revolution as a result of a different starting point with regard to access to the internet, access to finance and technological capabilities, could result in further unevenness in economic growth. These technologies impact productivity and are therefore strongly linked to long-term economic growth, although the growth can also be a result of non-technological innovations. Furthermore, financial globalization, digitization and monopolies on intellectual property rights, may mean that the profits of certain technologies may be captured by a few large companies (ESCAP, 2018).

Inequality can also be created by the effect of new technologies on the composition and nature of jobs and the wages being paid. This effect was also apparent during earlier industrial revolutions. Technology has the potential to increase labour productivity, but it can also substitute jobs for workers altogether. New technologies will also create new employment, although these are likely to be jobs that require different kinds of skills. With past industrial revolutions unemployment effects have however usually been most apparent in the short term (ESCAP, 2018).

The way forward

The technologies of the so-called fourth industrial revolution such as AI, have a major potential to increase efficiency and transparency in agricultural production and commodity chains. With an enabling policy environment, such technologies can reduce inequality in opportunities. For example, solar panels have provided access to electricity for many who are not connected to the grid. Digital technologies have increased access to information and finance, and have provided farmers access to online platforms to sell their products. However, these technologies also carry the potential threat of creating more inequality, leaving CDDCs behind. As this article has highlighted, there are a number of factors that create or exacerbate these inequalities, such as a lack of access to fast and reliable internet, and finance, as well as limited technological capabilities.

Therefore, policymakers in CDDCs need to work with farmers and the private sector in creating an enabling environment so that technologies can be adopted. This needs to consist of a number of key elements (ESCAP, 2018):

- Ensuring the availability of ICT infrastructure, by investing in broadband internet.
- Development of appropriate skills to identify and use technologies by updating existing curricula and developing new vocational education programs, and making sure that both men and women find their way into these programs.
- Develop a better understanding of potential impacts on employment and wages of new technologies and develop policies to mitigate these impacts.
- Develop policies that create a conducive environment for the development and adoption of new technologies, and ensure that wealth generated by new technologies is not accumulated by only some.
- Invest in and promote the development of technologies that address the needs of low-income and vulnerable groups, including women, and promote adoption and dissemination of such technologies.

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