SEAMEO SEARCA
Policy Paper 2018-1

Digitalization and Food Security Amidst the Changing Landscape of Asian Agriculture[1]

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The United Nations (UN) Committee on World Food Security (1996) defines food security as the condition in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Food insecurity exists when people do not have adequate physical, social, or economic access to food as defined above. Meanwhile, the United States Department of Agriculture (USDA 2012) estimates that a whopping 870 million people globally do not have access to a sufficient supply of nutritious and safe food.

Due to the observed population growth and rising incomes, USDA estimates that the demand for food will rise by 70 to 100 percent by 2050. The middle class, who normally have more money available for food leading to assumed greater demand, could reach five billion people by 2030. Roughly three quarters of the world's hungry people live in rural areas and face distinct structural challenges compared to those living in urban areas; most of them are in Asia.

The latest report by the Food and Agriculture Organization (FAO 2017) titled *The Future of Food and Agriculture—Trends and Challenges*, warned of the need to significantly increase investments in agriculture to meet the anticipated 50 percent rise in food demand by 2050. With this, the UN estimates that food production in developing countries, which mostly occurs in Asia, will need to double up.

This state should be achieved over the coming years despite challenges brought about by climate change, degradation of natural resources, booming population growth, and escalating food prices.

Push for Food Security

The concept of food security originated in the mid-1970s during an international forum discussing food problems as a result of the global food crises of the 1960's. The initial focus was primarily on food supply problems—of assuring the availability of basic foodstuffs and to some degree the stability of food prices at the international and national levels. In 1974, the World Food Conference was held and a new set of institutional arrangements were discussed covering information, resources for promoting food security, and policy issues.

Since then, the international community has accepted varied and increasingly broad statements of common goals and implied responsibilities about food security—from the highly influential World Bank report on Poverty and Hunger (1986), UNDP Human Development Report (1994), and discussions during World Food Summits (1996 and 2001).

The primary objective was to push for organized international and national public action to significantly reduce hunger, malnutrition, and poverty. The 1996 World Food Summit exemplified this direction of policy by assuring that food security will be achieved by the reduction of the number of hungry or undernourished people by half by 2015. In September 2015, all 193 member states of the UN agreed to end hunger in all countries by 2030. This was one of the 17 headline objectives established under the Sustainable Development Goals deliberately targeting international policy efforts to promote food and nutrition security (Kharas and McArthur 2016).

According to Teng and Vas (2017), today's global food system is an inter-linked relationship between countries, with surplus production and high agricultural productivity premised on technology-enabled farming and countries that regularly experience food deficit. Food deficit countries are not necessarily food insecure countries. Singapore, for example, imports more than 90 percent of its food but less than 10 percent of household income is spent on food. With its advanced economy, the country is considered to be one of the most food secure countries in the world.

Digitalization in agricultural sectors of developed countries

Digital agriculture or precision agriculture is one of the agricultural innovations currently available to lessen problems related to malnutrition and hunger. Digitalization aims to improve yield to increase farm productivity and farm profitability, and address the growing demand for food for an ever increasing global population. Coupled with this is the promise of lower environmental impact due to reduced water wastage, chemical run-off, and CO_2 emissions. It also plays a critical role in fostering sustainable farming practices.

In developed countries, the agriculture sector has started to invest in these digital technologies and combined them with the Internet of Things (IoT) with its big data analytics, visualization capabilities, and industry knowledge. By using digital technologies, large farms can harness and make sense of a wide range of relevant data to increase the amount of food they produce from the same hectarage, while potentially improving their financial performance. The total market size for digital-based services in developed countries is expected to grow at a CAGR (compound annual growth rate) of 12.2 percent between 2014 and 2020 to reach USD 4.55 billion (MarketsandMarkets 2014).

Digital agriculture spans a wide range of technologies such as systems to support farmers in precisely dosing the water and fertilizer they apply to their fields to sensors that record parameters such as temperature, pH, and soil humidity. These systems can also control the valves in automatic irrigation systems, thereby reducing water consumption by 30 to 50 percent, on the average. Similarly, they can reduce fertilizer consumption by up to 30 percent. Furthermore, these technologies also help farmers optimize climate conditions in their stables and silos. The systems, thus, help prevent animal diseases that can be triggered by rapid temperature fluctuations.

Another technology is facial recognition, not necessarily new when used with humans, but a cutting-edge concept in animal agriculture because of imaging sensors that have recently become cheap, along with data storage, and transfer. Facial recognition is used for lameness detection. Facial

recognition allows for 24/7 monitoring to spot animals that show signs of lameness. Feed efficiency and general behavioral analytics are two other examples of data being collected.

RFID (radio frequency identification) technology, on the other hand, is used for contactless data collection at short ranges. The Veterinary Department of Malaysia's Ministry of Agriculture introduced a livestock-tracking program in 2009 to track an estimated 80,000 cattle all across the country. Each cattle is tagged with the use of RFID technology for easier identification, providing access to relevant data such as: bearer's location, name of breeder, origin of livestock, sex, and dates of movement. Said to be the first of its kind in Asia, it is expected to increase the competitiveness of the Malaysian livestock industry in international markets by satisfying the regulatory requirements of importing countries like the United States, Europe, and the Middle East. Tracking by RFID also help producers meet the dietary standards by the halal market, and provide improvements in controlling disease outbreaks in livestock.

Robotics is another example of the use of digitalization in agriculture. In the United States, there is a six-legged robot named Prospero roaming test fields and planting individual kernels of corn in exactly the right spot for the plant to take root. And for several years now, Bonirob (another robot) has been wandering the fields of Germany unassisted, testing the ground and picking weeds that threaten the main crop (Walter 2016).

Simpler systems are computer controlled stand alone systems that milk dairy cattle. The complete automation of the milking process is controlled by a robot, a complex herd management software, and specialized computers. Automatic milking allows farmers more time for supervision of the farm and herd. Farmers can also improve herd management by using the data gathered by the computer. By analyzing the effect of various animal feeds on milk yield, farmers may adjust accordingly to obtain optimal milk yields.

Wireless technologies have likewise numerous applications in agriculture. The use of Global Positioning System (GPS) provides benefits in geo-fencing, map-making, and surveying. Geographic information systems (GIS) are also extensively used in agriculture, especially in precision farming. Land is mapped digitally, and pertinent geodetic data such as topography and contours are combined with other statistical data for easier analysis of the soil. GIS is also used in decision-making, such as what to plant and where to plant using historical data and sampling.

Looking a gift horse in the mouth

Many farms in emerging markets in Southeast Asia are small—comprising only a few hectares. Majority of smallholder farmers continue to follow traditional farming practices because some lack access to knowledge about current farm practices. Big data (digitalization) and ICT (information and communication technologies) can revolutionize the fight against hunger and malnutrition in developing countries, and more specifically digitalization can feed people in developing countries, but there are concerns that need to be addressed first.

According to Teng and Vas (2017), Asia is the main food importing region of the world in terms of food volume. Yearly, its hunger for higher protein diets means that Asia uses over two-thirds of the world's surplus soybeans (an essential component to make animal feed for poultry, hogs, and fish) and over a quarter of the world's surplus corn production. Most of these imports come from the Americas, in particular the United States, Brazil, and Argentina. Ironically, Asia is also the main producer of rice, vegetable oils, and seafood, especially Southeast Asia. But trade data shows that the ASEAN region exports more to countries outside the region than between member countries, for reasons of infrastructure, protectionism, and policies.

For developing countries in Southeast Asia, the question is not whether digitalization can feed people or solve issues pertinent to food security, but whether digitalization or the use of such technologies can increase and stabilize food production, hence, addressing concerns of food and nutrition security. Concerns may point to these three factors: scientific know-how pertaining to digital technologies at the farm level; corporate farming, agri-tourism, and urban/peri-urban farming; and public acceptance of new technologies.

Scientific know-how pertaining to digital technologies at the farm level

One question regarding scientific know-how is what will farmers do when agriculture is digitalized and automated in Southeast Asia? The assumption is that farmers will primarily assume other roles such as those of technically skilled researchers when new diseases emerge, for example. But the story of prescriptive planting is also a cautionary tale about the conflicts that may arise between data entrepreneurs and local businessfolk. Farmers might be expected to have mixed feelings about the technology—although it boosts yields, it reduces the role of discretion and skill in farming—their core competence.

In Asia, smallholder farmers rely more on the use of ICTs for agriculture and rural development in agriculture. These alternative technologies offer a wide range of solutions to some agricultural challenges. In this context, ICT is used as an umbrella term encompassing all information and communication technologies including devices,

networks, mobiles, services, and applications, which could range from innovative Internet-era technologies and sensors to other pre-existing aids such as fixed telephones, televisions, radios, and satellites. The use of mobile technologies as a tool of intervention in agriculture is also becoming increasingly popular. The reach of smartphones even in rural areas extended the ICT services beyond simple voice or text messages. Several smartphone apps are available for agriculture, horticulture, animal husbandry, and farm machinery.

Some useful ICT resources are the World Bank's e-sourcebook, *ICT in Agriculture—Connecting Smallholder Farmers to Knowledge, Networks, and Institutions* (2017); and Food and Agriculture Organization of the United Nations (FAO)'s *ICT Uses for Inclusive Agricultural Value Chains* (2013). According to the World Bank (2017), the types of ICT-enabled services that are useful for improving the capacity and livelihoods of poor smallholders are quickly growing. Examples of these are the use of mobile phones as a platform for exchanging information through short messaging services (SMS). The World Bank e-sourcebook (2017) cites the case of Reuters Market Light, which services over 200,000 smallholder subscribers in 10 different states in India. The farmers receive four to five messages per day on prices, commodities, and advisory services from a database with information on 150 crops and more than 1,000 markets for the cost of USD 1.50 per month.

According to Mehra (2010) as cited in the World Bank report, this service may have generated USD 2–3 billion in income for farmers, while over 50 percent of them may have reduced their spending on agriculture inputs. The World Bank report states that resource-poor farmers in developing countries need to be empowered with information and communication assets and services that will increase their productivity and income as well as protect their food security, and livelihood.

Another example of ICTs at the farm level are the different tools that the International Rice Research Institute (IRRI) uses towards impact acceleration. At present, IRRI works closely with its local partners in delivering advice to rice farmers to help them increase their income. ICT mechanisms employed are: Rice Crop Manager, Rice Doctor, Rice Knowledge Bank, and WeRise. In the Philippines, the Department of Agriculture Agricultural Training Institute (DA-ATI) has its own e-Learning and e-Farming platforms to further enhance its agricultural extension delivery systems in the provinces and other key stakeholders.

In 2015, the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) in partnership with the French government though its embassy in the Philippines, the Delegation for Regional Cooperation-ASEAN and the United Nations Organization for Education, Science and Culture (UNESCO) Regional Science Bureau for Asia and the Pacific, hosted and co-organized a seminar-workshop as a research collaboration platform between French and Asian researchers on the application of ICT in agriculture, science, and technology. ICT-Asia 2015 focused on four themes: Climate Change Modeling and Monitoring, Disaster Risk Reduction, ICT Applications to Food Security, and Urban and Rural Informatics. The regional event was attended by ICT experts from France, ASEAN Member States, Japan, South Korea, Nepal, Pakistan, and Sri Lanka. From this meeting, multilateral research teams and network partnerships were

formed to address ICT issues earlier identified. The event also enabled the interaction between French and Asian scientists to further facilitate future scientific collaboration.

At present, SEARCA also supports smallholder farmers in Asia and the Pacific Islands through an International Fund for Agricultural Development (IFAD)-funded project, which promotes the use of ICTs in agricultural extension services. Through this initiative, resource-poor farmers are developed to take on and assume bigger roles in the entire value chain.

Corporate farming, agri-tourism, and urban/peri-urban farming

Smallholder and resource-poor farmers may be concerned that they would never be able to recover the necessary investments for digital technologies. Because modern harvest equipment is expensive to rent, purchase, and operate, such efficiency translates directly to cost-efficiency for farmers. A state-of-the-art combine can easily cost up to half a million euro, and disruptions in logistics chains can quickly cost farmers 1,000 euro per hour.

The solution is for farmers to cooperate on ventures, such as purchases of high-tech tractors that open the way to the benefits of digital agriculture. In Southeast Asia, because of the ASEAN Economic Community (AEC) and the limited production and lack of competitive edge of smallholder farms, the strategy of farm consolidation and formation of cooperatives and farmer associations to run consolidated farms as business enterprises is beginning to gain momentum. Because of economies of scale, these consolidated farms will find it economically feasible in going into modern farm technologies and equipment or digitalization.

As regards capital and inputs normally beyond their reach, cooperatives could enter into contracts with both private and public entities under a contract growing scheme, which not only solves the capital requirements of their farms, but also extension and technology, and most importantly, the market linkage because these partners are automatic buyers of their produce.

One way to guarantee reliable supply chains within the ASEAN region is to develop mutually beneficial alliances that guarantee the integrity of supply chains (Teng and Vas 2017). Specifically, contract farming in countries such as Australia, which have aspirations to be Asia's food bowl, but which require investments, offer much more potential than contracted farming in countries that are not robust in their food security.

Agri-tourism is also one way of generating additional income for farmers and showcasing best practices for sustainable agriculture. In Southeast Asia, because of the uniqueness of the landscape and culture, the fruits and products from agri-tourism are becoming a sunrise industry. In the Philippines, agri-tourism may come in the form of small family farms that are opened to the public for experiencing the leisure of farming. These family farms also help their host communities by creating jobs and offering livelihood programs. This set-up is attractive to people in the urban areas—which now see agriculture as not being a labor intensive activity, but also as a potential source of leisure and relaxation. Maybe this is one area where higher education institutions, with regard to food security, can help developing countries and foster development cooperation.

The need to address concerns about food security also comes at a time when most of Asia is experiencing rapid urbanization, where by 2050, more than 50 percent of the region's people will live in cities (Teng and Vas 2017). Asia is home to more than 60 percent of the world's population. This is concurrently accompanied by a declining farmer population, which is fast ageing and farming less land each year.

Consequently, a promising way to boost food supply is to harness unused space in urban environments to grow food, or space in the periphery of cities, i.e., peri-urban space, for agriculture (Teng and Vas 2017). In most cities, there is much unused or under-utilized space, which can be turned into productive food areas for farming vegetables. Examples of these are rooftops, public space between buildings, underground space, and even the waters around small islands for aquaculture.

FAO (2017) estimates that currently urban peri-urban agriculture (UPA) contributes up to 20 percent of the world's food supply. Asian countries like South Korea, Japan, Singapore, and even mainland China have embraced this. However, more could be done to make this sector an important complement to rural farming, especially with respect to fresh supplies of vegetables and dairy products. City states like Singapore are developing the beginnings of a vibrant UPA sector, with commercial farms based on vertical vegetable farming and indoor artificial lighted farms. The Philippines has likewise encouraged residents in urban areas to start their own vertical vegetable gardens, and those in the suburban communities to have backyard vegetable gardens for personal consumption.

Public acceptance of new technologies in Asia

According to The Economist (2014), some say that digitalization could be the biggest change to agriculture in rich countries since genetically modified (GM) crops. This is proving nearly as controversial, since it raises profound questions about who owns the information on which the service is based. It also plunges stick-in-the-mud farmers into an unfamiliar world of big data and privacy battles.

The bigger problem is that some farmers (and the public at that) distrust the companies peddling this new method. They fear that the stream of detailed data they are providing on their harvests might be misused. Their commercial secrets could be sold or leaked to rival farmers. Prescriptive-planting firms might even use the data to buy underperforming farms and run them in competition with the farmers. Companies could use the highly sensitive data on harvests to trade on the commodity markets, to the detriment of farmers who sell into those markets.

In response to such worries, the American Farm Bureau, the United States' largest organization of farmers and ranchers, have drawn up a code of conduct, saying that farmers own and control their data; that companies may not use the information except for the purpose for which it was given; and

that they must not sell or give it to third parties. Some farmers in Texas have likewise banded together to form the Grower Information Services Cooperative to negotiate with the data providers (The Economist 2014).

According to Teng and Vas (2017), despite these hurdles, Asian governments must not shy away from using modern science and technology to rapidly increase both the potential and on-farm yields of important food crops, and accompany this with effective technology transfer systems. The FAO report (2017) indicates that new multi-billion dollar investments will be needed. Reports from a food security assessment index called the Rice Bowl Index (RBI) has further shown that consistently across Asia, farm level yields are an important factor in conferring food security robustness in agri-producing countries.

Conclusion

According to the USDA, establishing global food security is important in attaining sustainable economic growth of developing nations. Economic growth is only sustainable if all countries have food security. Without country-owned and country-driven food security strategies, there will be obstacles and additional costs to global, regional, and country-level economic growth.

Developing countries in Southeast Asia need to understand and manage tradeoffs such as balancing the use of agricultural innovations to ensure stable food production against the ecological costs of using such technologies. Adaptation strategies and policy response to such challenges are urgently needed. These policy responses are vital in improving the plight of farmers and the living conditions of rural folks in developing countries.

Governments in Southeast Asia can make digital technologies in agriculture more accessible to farmers. Thus, there is a need for government programs to provide support to access to technologies. Government must likewise help the conduct of research and public advocacy of these new technologies for increased public awareness and acceptance. The participation of smallholder farmers in Asia's food supply chains, especially through private-public sector partnerships, are likewise important.

International development cooperation efforts can support countries in Asia based on three factors: their needs, policies, and available resources. The fastest results can be achieved by supporting countries with high needs, strong domestic policies, and very limited resources. However, little can be gained by supporting countries with low needs, weak policies, and extensive resources.

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1 Paper presented at World Food Day Colloquium 2017 on 19 October, University of Hohenheim, Germany
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April 2018

EDITED BY: MARILIZA V. TICSAY | LAYOUT BY: ZARA MAE C. ESTAREJA

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