Technical Education and Skills Development Authority

LABOR MARKET INTELLIGENCE REPORT

ISSUE NO. 2 | SERIES OF 2020

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FROM SEEDS TO SATELLITES

Revolutionizing Philippine Agriculture With Smart Farming

Issue no. 2 | Series of 2020

Technical Education and Skills Development Authority (TESDA)

I. Rationale

The agricultural sector is going to face enormous challenges in order to feed the 9.6 billion people that the Food and Agriculture (FAO) predicts are going to inhabit the planet by 2050. According to the FAO, food production must increase by 70% by 2050, and this has to be achieved in spite of the limited availability of arable lands, the increasing need for fresh water (agriculture consumes 70 per cent of the world's fresh water supply) and other less predictable factors, such as the impact of climate change. Climate change is in fact a crucial factor, which according to a recent report by the UN could lead, among other things, to changes to seasonal events in the life cycle of plant and animals.

One way to address these issues and increase the quality and quantity of agricultural production is using sensing technology to make farms more intelligent and more connected through precision agriculture, a growing trend in farming made possible by the Fourth Industrial Revolution (4IR). Sensors can gather data more efficiently, for instance, to tell farmers exactly how much fertilizer should be used for their crops, thereby reducing any adverse impacts to the environment.

The current COVID-19 outbreak highlights the importance of smart farming not just in the Philippines but also throughout the world. As large-scale food supply-chains become crippled due to global quarantines, more and more countries are now realizing the value of investing in food security. Small-scale farms can be augmented by smart farming technologies, like smart greenhouses, to become self-sufficient and even more productive. This makes it possible for individual farmers to provide food at a local level, perhaps focused solely on their own communities, and potentially produce more food than their small farms can suggest.

All of these, among others, are the key features of Smart Farming that Philippine TVET may wish to explore.

II.Overview of Smart Farming

Smart Farming as key for agriculture's future

Smart Farming is defined as a farming management concept using modern technology to increase the quantity and quality of agricultural products. Farmers in the 21st century have access to the Global Positioning System (GPS), soil scanning, data management, and IoT ("Internet of Things") technologies. By precisely measuring variations within a field and adapting the strategy accordingly, farmers can greatly increase the effectiveness of pesticides and fertilizers, and use them more selectively. Similarly, using Smart Farming techniques, farmers can better monitor the needs of individual animals and adjust their nutrition correspondingly, thereby preventing disease and enhancing herd health.

Smart farming is also defined as an emerging concept that refers to managing farms using technologies like IoT, robotics, drones and AI to increase the quantity and quality of products while optimizing the human labor required by production.

Among the technologies available to current farmers are the following (see Figure 1):

- Sensors - soil, water, light, humidity, temperature management
- Software - specialized software solutions that target specific farm types or use case agnostic IoT platforms
- Connectivity - cellular, LoRa, etc.
- Location - GPS, Satellite, etc.
- Robotics - Autonomous tractors, processing facilities, etc.
- Data analytics - standalone analytics solutions, data pipelines for downstream solutions, etc.

Equipped with such tools, farmers can monitor field conditions without even going to the field and make strategic decisions for the whole farm or for a single plant. The driving force of smart farming is the "Internet of things" (IoT) - connecting smart machines and sensors integrated on farms to make farming processes data-driven and data-enabled.

Figure 1. Technologies Involved in Smart Farming

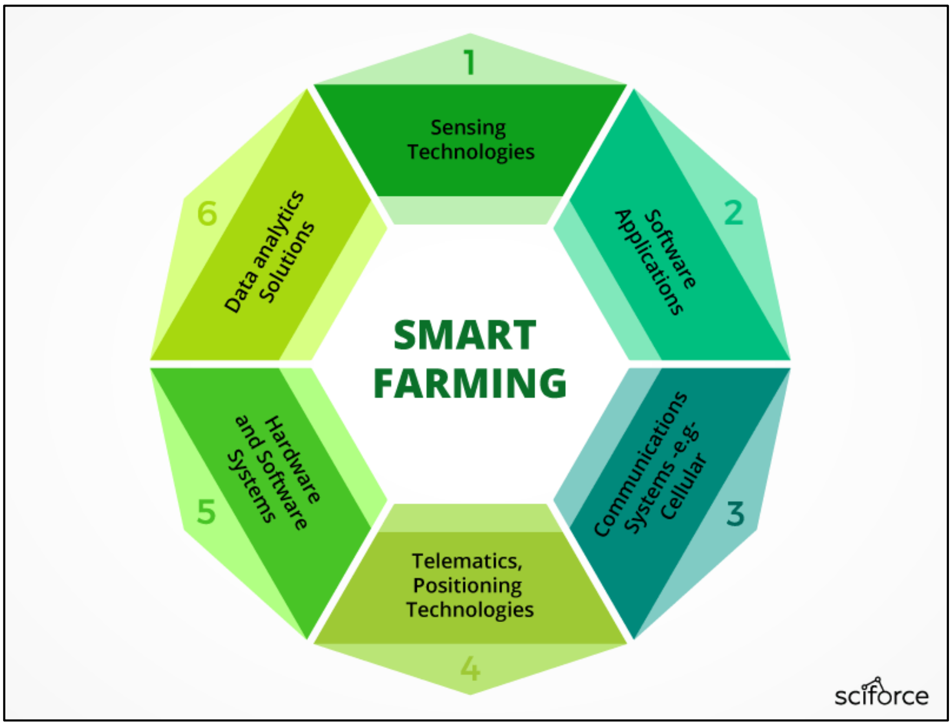


Image Credit: Beecham Research

The IoT-Based Smart Farming Cycle

The core of IoT is the data you can draw from things ("T") and transmit over the Internet ("I"). To optimize the farming process, IoT devices installed on a farm should collect and process data in a repetitive cycle that enables farmers to react quickly to emerging issues and changes in ambient conditions. Smart farming follows a cycle like this one:

- Observation- Sensors record observational data from the crops, livestock, soil, or atmosphere.
- Diagnostics- The sensor values are fed to a cloud-hosted IoT platform with predefined decision rules and models—also called "business logic"—that ascertain the condition of the examined object and identify any deficiencies or needs.
- Decisions- After issues are revealed, the user, and/or machine learning-driven components of the IoT platform determine whether location-specific treatment is necessary and if so, which.
- Action- After end-user evaluation and action, the cycle repeats from the beginning.

IoT Solutions to Agricultural Problems

Many believe that IoT can add value to all areas of farming, from growing crops to forestry. Two major areas of agriculture that IoT can revolutionize include:

A. *Precision Farming*

Precision farming, or precision agriculture, is an umbrella concept for IoT-based approaches that make farming more controlled and accurate. In simple words, plants and cattle get precisely the treatment they need, determined by machines with superhuman accuracy. The biggest difference from the classical approach is that precision farming allows decisions to be made per square meter or even per plant/animal rather than for a field.

By precisely measuring variations within a field, farmers can boost the effectiveness of pesticides and fertilizers, or use them selectively.

B. *Precision Livestock Farming*

As in the case of precision agriculture, smart farming techniques enable farmers better to monitor the needs of individual animals and to adjust their nutrition accordingly, thereby preventing disease and enhancing herd health.

Large farm owners can use wireless IoT applications to monitor the location, well-being, and health of their cattle. With this information, they can identify sick animals, so that they can be separated from the herd to prevent the spread of disease.

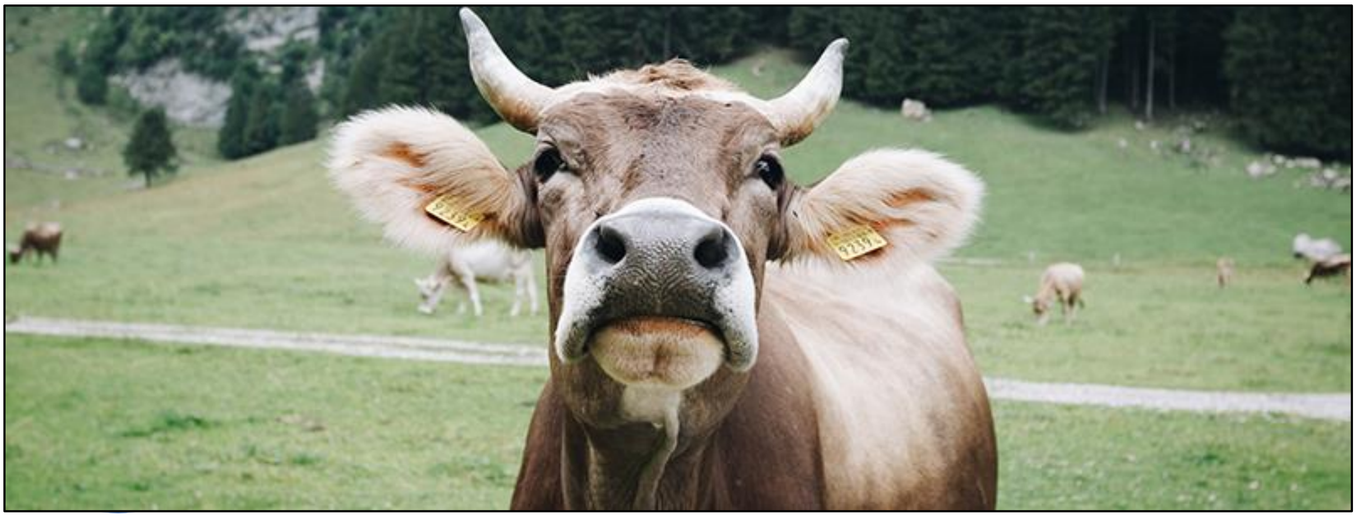


Image Credit: unsplash.com

Automation in Smart Greenhouses

Traditional greenhouses control the environmental parameters through manual intervention or a proportional control mechanism, which often results in production loss, energy loss, and increased labor cost.

IoT-driven smart greenhouses can intelligently monitor as well as control the climate, eliminating the need for manual intervention. Various sensors are deployed to measure the environmental parameters according to the specific requirements of the crop. That data is stored in a cloud-based platform for further processing and control with minimal manual intervention.

Agricultural Drones

Agriculture is one of the major verticals to incorporate both ground-based and aerial drones for crop health assessment, irrigation, crop monitoring, crop spraying, planting, soil and field analysis and other spheres.

Since drones collect multispectral, thermal and visual imagery while flying, the data they gather provide farmers with insights into a whole array of metrics: plant health indices, plant counting and yield prediction, plant height measurement, canopy cover mapping, field water pond mapping, scouting reports, stockpile measuring, chlorophyll measurement, nitrogen content in wheat, drainage mapping, weed pressure mapping, and so on.

Importantly, IoT-based smart farming doesn't only target large-scale farming operations; it can add value to emerging trends in agriculture like organic farming, family farming, including breeding particular cattle and/or growing specific cultures, preservation of particular or high-quality varieties etc., and enhance highly transparent farming to consumers, society and market consciousness. These efforts would prove useful for smaller farms, as technology could therefore be used to make them even more self-sufficient and competitive in the market, while employing less labor themselves.

III. Smart Farming in Other Nations

Thailand

Agriculture sits at a peculiar spot in Thailand's economy. On the one hand, this sector only contributes to about 10% of the country's GDP, but on the other hand agriculture employs roughly 40% of Thailand's total workforce. The sector itself is even said to be in decline, as more and more young Thais leave the countryside to seek employment in the cities. Luckily, continuous government support for current Thai farmers has helped them stay afloat and keep up with the times, specifically in the use of smart farming technologies.

One of these systems is precision farming, which Thai farmers employ to maximize crop yield per square meter. Their version of precision farming consists of:

- *Precision fertilization* – farmers match and regulate fertilizer usage depending on soil properties, thereby ensuring that their land is not oversaturated with chemicals, and is given enough time to recover between crops. Precision fertilization also ensures that farmers can plant/replant crops faster after each harvest.

- *Precision spraying* – farmers identify parts of the land where weeds congregate, then prioritize them for highly-concentrated pesticide spraying. This ensures pesticides are deployed as efficiently as possible without harming the environment (i.e. maximizing gains while minimizing use). In Thailand, farmers reported as much as 60% reduction in overall pesticide use thanks to precision spraying.

- *Data processing centers* – farmers access data from drones and satellites to customize their own farming and harvesting operations. Data processing centers also allow them to access real-time meteorological and geological information to influence their harvests. Thailand seeks to incorporate artificial intelligence in the future, to make their data processing requests much faster and more seamless.

As of 2017, some 12.7 million Thai farmers have availed of precision farming and other smart farming technologies. These are not 'smart farmers' per se, however; the term is reserved for those who have successfully integrated such technologies into almost every aspect of their farming operations. The Thai government seeks to develop more

than 100,000 smart farmers by 2021, and increase the income of every farmer to approximately Bt390,000 (or about 12,000 USD) per year. See Figure 2 for more information:

Higher crop yields and income aren't the only benefits that smart farming provides to Thai farmers. Through technology, farmers gained knowledge about sustainable agricultural practices and about how they can promote their produce too consumers. The latter is especially useful for farmers who wanted to maximize their profits on certain crops that have a small market, which is exactly what happened on a case study of a black pepper farmer in Tambon. The experience could also teach the farmers other non-farming skills like networking and product promotion.

Figure 2. Thailand's Smart Farming Policy

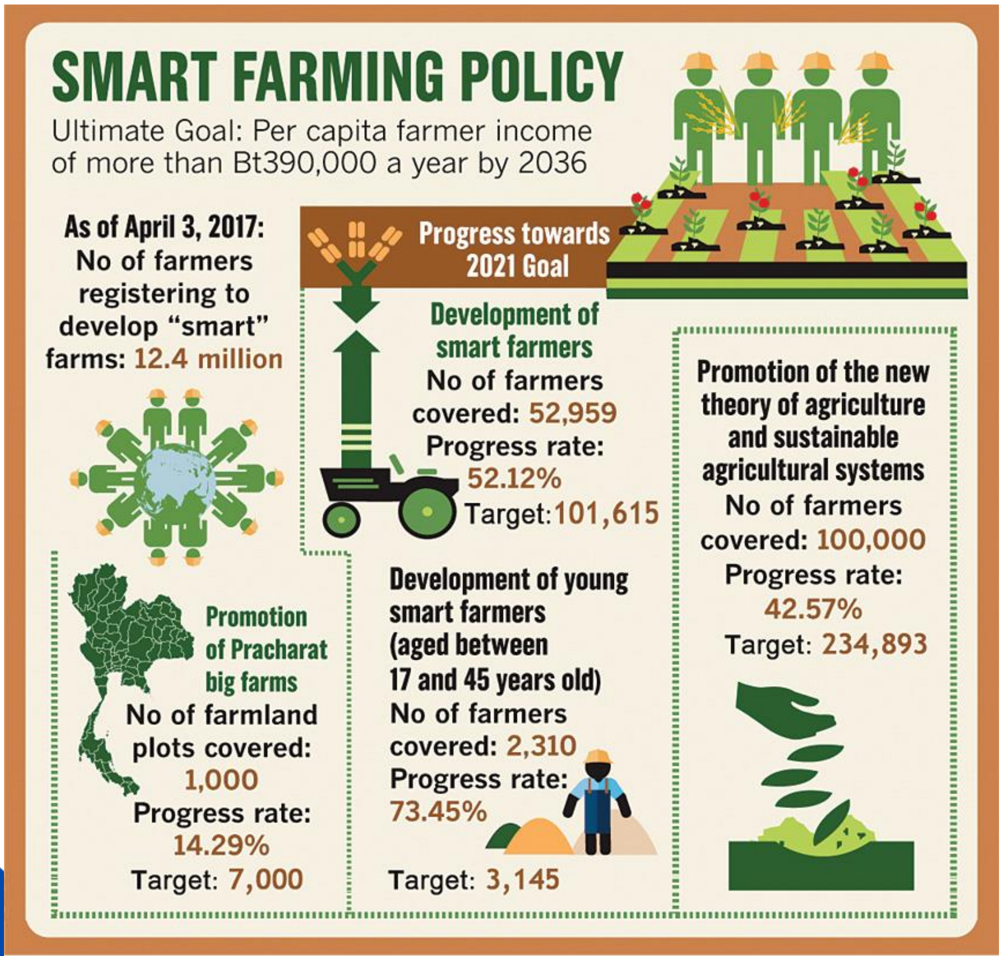


Image Credit: Thailand Agriculture and Cooperatives Ministry

Vietnam

Agriculture is a very important economic sector in Vietnam, considering that rice is one of the country's prime commodities for rural employment and foreign trade. Rice, as a matter of fact, accounts for about 50% of the country's gross production for food crops, a number that has increased steadily thanks to continuous practice of input-sensitive crop management techniques. As the 4IR draws near, Vietnam has started several initiatives to improve its current rice farming methods and incorporate "smarter" technologies in this regard.

One example of such technologies is the "Rice Crop Manager" (RCM) smartphone application developed by the International Rice Research Institute that guides farmers in nutrient management for crops. The RCM also allows agricultural extension workers to help poor farmers in observing cost-efficient crop management practices. The app was field-tested among farmers in the Mekong River Delta and Red River Delta in 2014, and it proved helpful in improving their crop yields and net income in almost every part of the farming season (see Figure 3 and 4).

Figure 3. Added net Benefit from Field-Pilot RCM Application

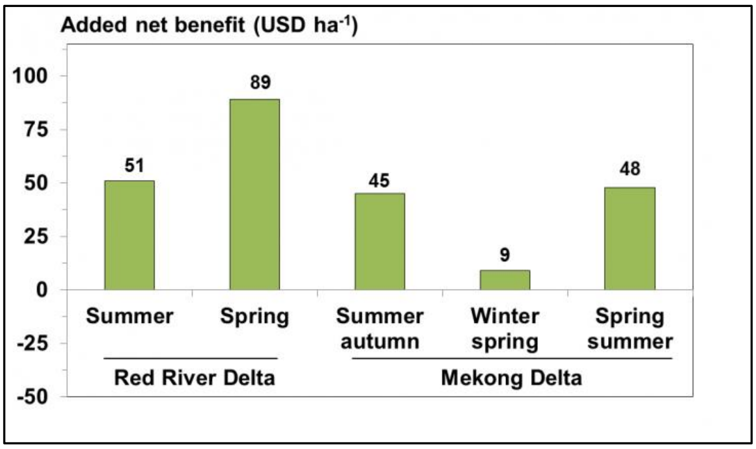
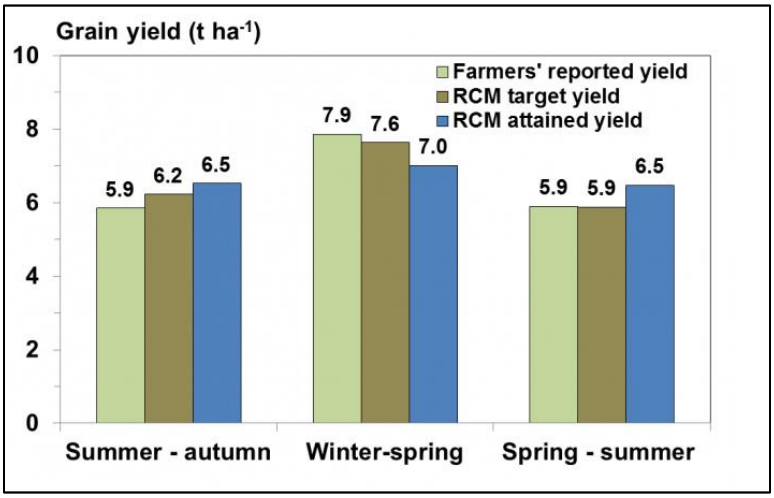


Figure 4. Rice Grain Yield Comparison at Field-Pilot RCM Application



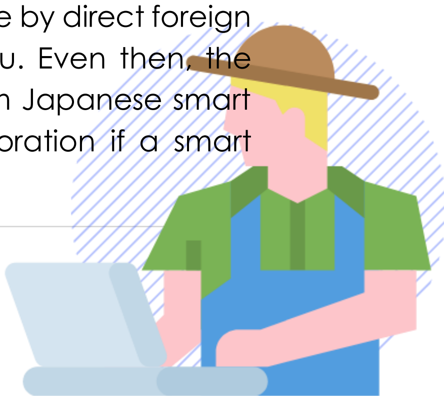
As seen in Figure 4, the RCM also established target yields for every cycle, most of which proved higher than the farmers' previous (pre-RCM) yields. Only the winter-spring cycle saw lower than normal yields, but this was likely due to the lower fertilizer rates that the RCM recommended. Nevertheless, RCM proved quite helpful for Vietnamese farmers that many of them have replaced their old rice cultivation methods with those prescribed by the app, maximizing efficiency and minimizing waste.

Another example of smart farming technology devised by Vietnam is the 'smart greenhouse' which seeks to create optimum environments that can cultivate 'ready-to-eat' tomatoes, lettuce, and the like without having to wash them first. Proponents of this technology claim that lettuces grown in smart greenhouses have one-fifth the potassium content of those sold in the supermarket, making them an excellent choice for diabetics.

One particular smart greenhouse was designed and constructed by FPT-Fujitsu in Hanoi in 2014, which featured sophisticated environmental control systems that prevent bacteria and viruses from sticking to the produce. In theory, this system will enable a 1000 square-meter plot of land to cultivate between 4,000 to 6,000 individual crops all year-round, all of which are completely safe for immediate consumption. It will also elevate Vietnam into a top producer of world-class food crops, which in turn will help improve the lives of Vietnamese farmers all throughout with additional revenue.

Image Credit: Hortibiz.com

While the technology is promising, it is not without its limitations. For one thing, the huge expense and technical cost needed to manage a smart greenhouse is enormous enough to dissuade common farmers from getting it. The Vietnamese acknowledged this, saying that the Hanoi smart greenhouse was only made possible by direct foreign investments and a partnership with the aforementioned FPT-Fujitsu. Even then, the systems implemented in the smart greenhouse were adapted from Japanese smart farming technologies, which further stresses the need for collaboration if a smart farming venture can be successful.



Japan

Japan is one of the leading countries in Asia when it comes to smart farming. Through its National Agriculture and Food Research Organization (NARO), the country produced one of the first autonomous rice planters in 1998. NARO sees technology as a necessity in this regard since foreign and domestic demands for agricultural products from Japan are steadily increasing every year, yet the workforce is in decline. As of 2018, the average age of Japanese farmers is 65 years old, and a common challenge they face is the difficulty of finding a successor, let alone farmhands, for their farms.

The Japanese government has since launched several initiatives to address these issues, which have the following objectives:

- Enhance the base of agricultural production
- Promote the development of farm management through innovative technologies
- Achieve vigorous productivity in paddy-field farming, upland farming and livestock production by taking advantage of regional conditions

Among these initiatives is an effort to improve the current Global Positioning System, i.e. the one that is currently used across the world, in order to create a 'local version' specific to the steep and densely-populated features of Japan's natural terrain. This Quasi-Zenith Satellite System (QZSS) was created by sending multiple satellites into orbit as part of a new network, with the first launch conducted September 11, 2010. The improved telemetry afforded by the QZSS has opened the way for new technologies to enter the agricultural sector - so far, it has been used to provide automated farm systems with precise geological data, in addition to meteorological data for planting.

As a result, more and more Japanese farmers are taking advantage of QZSS-dependent systems such as drones and smart farms to make themselves more productive despite their shrinking manpower. In 2016, these so-called 'farming robots' constituted only 2% of the entire smart agriculture market in Japan, but more machines are being tested and developed every year. In 2017, a Japanese tech company unveiled one of the country's first driverless tractors; more of such machines could be developed as long as government support (which includes legislation) keeps up with the demand. It is expected that sometime in 2020, Japanese legislators would have come up with laws that could help create/support fully-autonomous farms.

Image Credit: Science and Technology Office Tokyo

Despite the prevalence of such kinds of advanced technologies, NARO still acknowledged the value farmers' wisdom as useful input that were considered during development. The introduction of self-driving tractors, for instance, was done in phases in this regard. During planting season, the farmers were still expected to drive behind or alongside the automated vehicles in order to gauge their efficiency. According to NARO, such kind of 'supervised self-driving' lightened the farmers' workload, yet also improved their work efficiency by 30%.

Unfortunately, such advantages are off-set by their cost. The self-driving tractors alone, for example, could cost upwards to 30,000 USD (or about 3 million Yen) more than conventional tractors that are readily available to farmers. Such an investment is infeasible for an individual farm, which is why the Japanese government is also eyeing the idea of establishing collectives and farming corporations to shoulder expenses such as this. Expertise and skills requirements can be met with training programs or consultations via remote-access video conferencing, the latter of which features farmers directly talking with online industry experts.

The end goal of these initiatives is the creation of a 'smart supply value chain' which, according to NARO, will calculate every factor that comes into the conception, growth, harvesting, and distribution of agricultural products, thus ensuring maximum efficiency is achieved in time, resources, and money. Such a scheme is perhaps the only way that Japan could hope to meet the growing demand for its agricultural products, both at home and abroad, in the light of the aging farmer population. As of 2019, NARO is still continuing its research and development on smart farming technologies, fully intending to realize "the agriculture and food industry sector of Society 5.0" as illustrated in Figure 5. Society 5.0 correlates to the Fourth Industrial Revolution or 4IR.

The following are NARO's objectives in this regard, which are expected to be achieved from 2021 to 2030:

- Creation of a data-driven, innovative, smart agriculture
- Development of a smart breeding system and cooperation with the private sector in breeding new cultivars
- Construction of a smart food value chain that includes exports
- Utilization of biological functions to create new industries and enhance health care through food
- Development of essential agricultural knowledge and technologies, such as the NARO Genebank
- Advancement of fundamental technologies by the Agricultural Information Technology Research Center, such as robotics

Figure 5. Japan's Agriculture and Food Industry Sector in Society 5.0

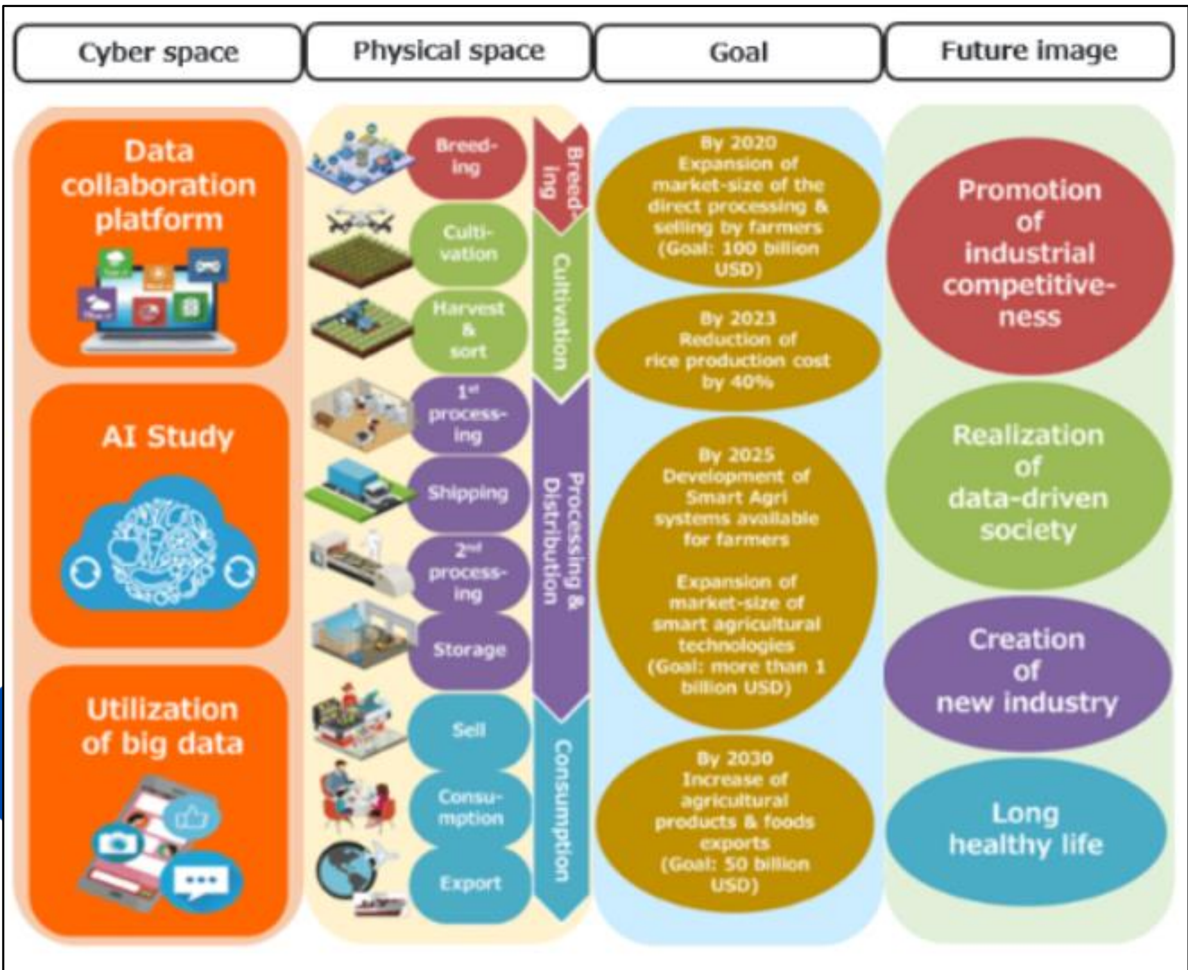
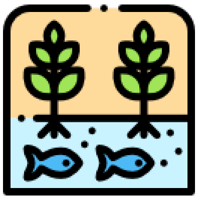


Image Credit: National Agriculture and Food Research Organization



IV. Smart Farming in the Philippines

Like other Asian countries, the Philippines is heavily reliant on its agriculture for both sustenance and trade. As such, the context for smart farming in Asia also applies to Filipino farms and farmers: digital technology needs to be integrated into current farming practices if the agriculture sector hopes to thrive in the 4IR. That being said, the push for smart farming in the Philippines isn't undertaken purely for economic reasons - many experts believe that adopting a more efficient and technology-based approach to farming will be necessary to combat the adverse effects of climate change and to promote social equity amongst farmers, who still represent the poorest of the poor in the Philippines.

In terms of climate, the Philippines is prone to natural hazards given its geographic location in the Western North Pacific Basin, where 66% of the world's annual cyclones originate. As a result, the country is constantly plagued by storms, to the point that flooding is constantly one of the biggest problems for farmers since 2000. What's more, the country's 17000km coastline is susceptible to high-tidal waves and its location in the Pacific Ring of Fire make it susceptible to earthquakes. Climate change, therefore, is a serious concern to any kind of agricultural development project, which is already hampered by rapid urbanization and environmental degradation.

In terms of agricultural mechanization, the Philippines is lagging behind. 2011 data presented by then-TESDA NCR Director Conrado Bares revealed that the country only had a 1.27 hp/ha (horsepower per hectare), which is used by the Department of Science and Technology as a measure for mechanization given that this is the amount of mechanized power available in a plot of farm land. In other countries, their hp/ha was higher, with India having 2.2, Thailand with 4.2, China with 8.42, Korea with 9.38, and Japan with 18.87.

Studies conducted by the Department of Agriculture indicate that Filipino farmers are already employing some 'climate-smart' practices in their lands. These need only be augmented by mitigation and adaptation techniques, as well as technology, to make them even more effective in the long run. Some of these practices include:

- Planting climate resilient rice
- Reviewing and adjusting their cropping calendars
- Using SALT (Sloping Agricultural Land Technology) to promote soil conservation and contour farming in sloping lands
- Observing farm diversification (i.e. producing different crops)

- Practicing integrated farming for rice and vegetable components, which is also known as 'rice intensification'
- Rain water harvesting
- Employing the SRI (System of Rice Intensification) to produce the productivity of irrigated rice through more careful management of plants, soil, water, and nutrients.
- Mitigating methane emissions
- Farming with biotechnology, mainly through genetically modified crops
- Promoting organic agriculture
- Establishing Enhanced Farmers Field Schools (EFFs) to capacitate farmers with better production systems and skills
- Practicing 'aquasilviculture', or integrating mangrove ponds and pens for fish and crabs, thus improving the health of the farming ecosystem
- Supporting researches into livestock feeds
- Practicing 'agroreforestation', or integrating perennial and annual crops in a two canopy or multi-canopy production system to reduce carbon emissions in farms
- Employing non-conventional irrigation systems

Such a kind of 'climate-smart' agriculture is the primary focus of the Department of Agriculture's Agri-Pinoy Program, which in turn strives to establish food security and self-sufficiency, sustainable resource management, support services from farm to table, and expand broad-based local partnerships among farmers. More importantly, the drive to create such mechanisms in the sector has already been instituted by Republic Act No. 10601, or the "Agricultural and Fisheries Mechanization Law".

Among other things, this Law seeks to hasten the mechanization of Philippine agriculture and fisheries for food sufficiency (see Figure 6). Perhaps more importantly, the Law instructs relevant government agencies, like TESDA and the Department of Agriculture, to provide training for these farmers in order to prepare them for mechanization in the future. Such efforts should have the intended goal of making farmers more productive and knowledgeable, particularly about the use of advanced farming machines.

Figure 6. Research Agenda for the National Agriculture and Fisheries Mechanization Program (2017-2020)

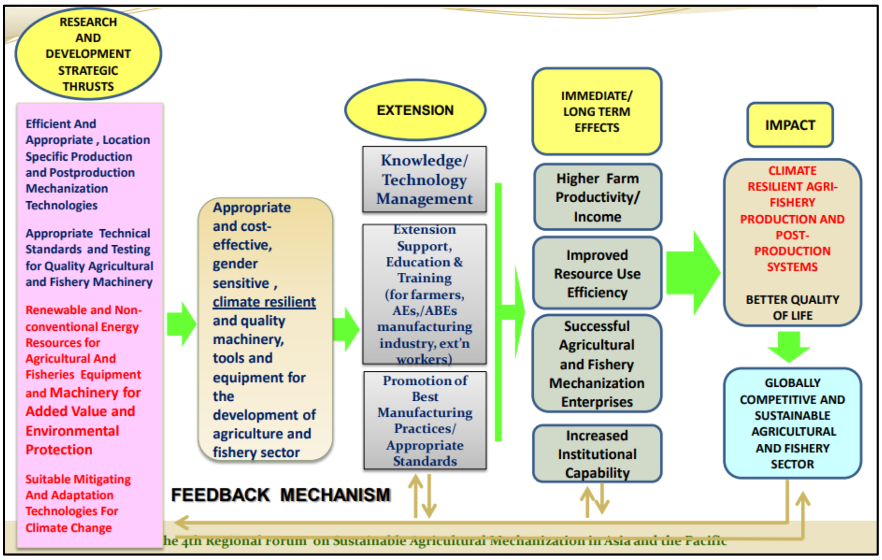


Image Credit: United Nations Economic and Social Commission for Asia and the Pacific

The country's vulnerability to natural calamities is also seen as a reason for agriculture to mechanize. In times like this, some authors argue that mechanization could make small-scale farms to be even more productive in times of great need if ever or whenever the larger value chain is disrupted. Perhaps the biggest consideration in this mindset is identifying what kinds of farming technologies must be converted to create agroecological (i.e. farming with ecological principles taken into account) environments. Practices that adversely affect the environment must also be replaced with those that promote more diverse crop rotations, organic fertilizers, and integrated pest management.

Another initiative from the Department of Agriculture is the Digital Farmers Program, which is aimed at tech-savvy youths to capacitate them into helping small-scale Filipino farmers embrace the digital space. This initiative is a partnership with Smart Communications Inc. for capacity development and technology inclusion in the agriculture sector. Among the skills taught in this Program are smartphone usage, visual media, and interpersonal communication, particularly online communication. The latter skill is essential to help farmers reach out to relevant experts, exchange ideas, and share age-old farming practices to the younger generation. As of 2018, the Program has established about 24 Program sites throughout the Philippines and involved 720 youths and rural farmers working in pairs.

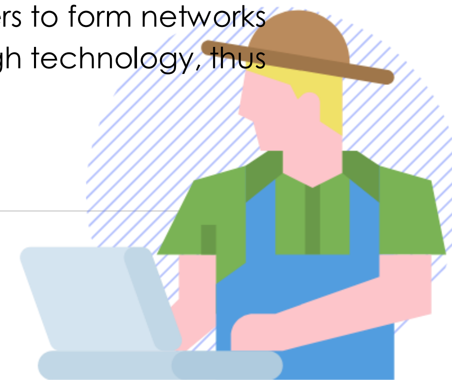
V. Skills Needs

Such small steps to integrate technology into basic agricultural practices will go a long way to prepare farmers for smart farming, and the 4IR by extension. It is acknowledged that any initiative to transition into smart farming will revolve around several factors, but the fact remains that these initiatives should impart valuable knowledge and skills about the following:

Agriculture 4.0 – among the biggest hurdles farmers face when transitioning to smart farming is learning how to use 4IR technology. Typically, this translates to smartphones, given that they are portable, readily-available, and relatively easy to use. Smart apps like the RCM in Thailand and the Philippines' Smart Farmer Program provide farmers with valuable geological, meteorological, and agricultural information to help them make more-informed decisions about their farming activities. The apps also act as a valuable communication channel between farmers, government agencies, and experts, which allow all actors to have the best idea on what happens on the ground. It is hoped that familiarizing farmers with this technology will ease their transition automated machine, drones, and the like, which is where smart farming is inevitably headed to.

Specific 4IR technologies for agriculture include:

- Internet of Things or IoT, which combines all machines and devices to create a data-driven agriculture sector.
- Automation, which lightens the physical burden involved in traditional farming practices.
- Chatbots, which provide answers and recommendations to farmers for specific or day-to-day problems.
- Drones, which can spray crops, analyze soil properties, monitor crop progress, and even facilitate irrigation.
- Blockchains, which can make the farmers' financial network more robust and secure, as well as allow for more efficient bookkeeping.
- Nanotechnology, which allow farming practices to be more precise, introducing machines to facilitate crop fertilization, protection, and analysis.
- Foodsharing and crowd farming, which allows farmers to form networks where they can share resources and surpluses through technology, thus reducing waste.



- Green Technology and Green Practices – it is important for all actors in the agriculture sector to remember that smart farming is ultimately intended to maximize farm efficiency and promote food sufficient without adversely harming the environment at the same time. After all, one of the key features offered by smart farming apps is access to accurate and up-to-date information about weather, topology, and soil nutrients, thereby advising how farmers should go about with their planting practices. Choosing the wrong crop for a particular type of land or using the wrong kind/amount of fertilizer will have long-term impacts in farmlands.

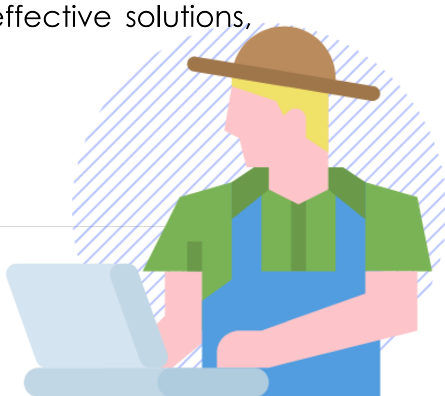
- 21st Century Skills – These refer to the skills that are not directly related to the sector, but are seen as vital for any prospective worker to thrive in the 21st Century. Usually these are "soft skills" that do not necessarily involve manual labor or physical activity. 21st Century Skills are a major feature of TESDA's 2018-2022 National Technical Education and Skills Development Plan (NTESDP), integrated in the agency's training programs and other initiatives. Such Skills include:

    - Entrepreneurial Skills, as with the amount of autonomy small-scale farmers are afforded because of smart farming, it should be no surprise if they wanted to promote and sell their produce on their own. Such activities are made even easier with digital technology thanks to smart apps and social media. By using these technologies, farmers can gain a better understanding on market trends, allowing them to forge business opportunities on their own.

    - Marketing Skills, since entrepreneurship and marketing tend to go hand in hand, but the latter is particularly seen as one of the areas where the tech-savvy youth can play a part in. The Philippines' Digital Farming Program imparts video editing, photography, and other similar skills to rural farmers for this very reason.

    - Communication Skills, seeing as smart farming has the potential to bridge farmers and agriculture experts together, it is vital for both parties to understand each other clearly so that they could address any issue that may arise in the farmlands. Writing and numeracy are key topics in this regard, but interpersonal communication also goes a long way in improving farmer relationships.

    - Critical Thinking and Problem Solving, given that farmers will likely face complex situations that require them to formulate effective solutions, especially when there is no outside help available.



Caution and careful planning are strongly-advised before any learning program could be initiated. A study published by the UNESCO in 2016 said that rural farmers generally become averse to learning programs if these are deemed 'inaccessible' (i.e. too far from their homes, too expensive for their annual income, etc.) and/or 'pointless'. The latter is worth mentioning because farmers may already know specific farming techniques and technologies that they are satisfied with, and introducing a new idea could quickly alienate it from them.

The UNESCO study also highlighted the importance of helping farmers think about the long-term, which tackles both the economic and environmental consequences of their current practices. To illustrate, the UNESCO study delved into the rise of eucalyptus tree-farming in a region in Ethiopia. Ethiopian farmers proclaimed that they shifted to planting eucalyptus trees because of the immediate financial gains they could get, unaware that the oils from the plant are highly-flammable, which is quite concerning for a country with hot climes, and that the plant itself is a poor food source to many animals and birds.

VI. TVET Situation

The agriculture sector is declared as the priority sector of the agency. Sec. Isidro S Lapeña, PhD, CSEE initiated the development of various programs for the sector such as the development of organic farms and allocating bulk of the scholarship provision to the agriculture sector.

Furthermore, the agency is working with the Department of Agriculture and other relevant organizations/associations in the operationalization of agriculture related programs and realization of relevant Laws.

Section 19 of Republic Act No. 10601, also known as the Agricultural and Fisheries Mechanization Law, obliges other government agencies like TESDA to assist in all efforts to mechanize Philippine Agriculture. The agency performs this function by implementing and regulating various training regulations (TRs) that produce a highly-skilled, internationally-recognized workforce for industries. Through these TRs, TESDA annually produces certified workers for the country's various industries, which include the agriculture and fisheries sector.

As of February 2020, TESDA offers the following TRs are directly related to this sector:

- Agricultural Crops Production NC I
- Agricultural Crops Production NC II
- Agricultural Crops Production NC III
- Agricultural Machinery Operations NC II
- Agricultural Machinery Servicing (4-Wheel Tractor) NC III
- Agroentrepreneurship NC II

- Agroentrepreneurship NC III
- Agroentrepreneurship NC IV
- Animal Health Care and Management NC III
- Animal Production (Poultry-Chicken) NC II
- Animal Production (Swine) NC II
- Animal Production (Ruminants) NC II
- Artificial Insemination (Large Ruminants) NC II
- Artificial Insemination (Swine) NC II
- Aquaculture NC II
- Bamboo Production NC II
- Bamboo Processing (Engineered-Bamboo) NC II
- Drying and Milling Plant Servicing NC III
- Grains Production NC II
- Fish Capture NC I
- Fish Capture NC II
- Fishport/Wharf Operation NC I
- Fishing Gear Repair and Maintenance NC III
- Horticulture NC III
- Landscape Installation and Maintenance (Softscape) NC II
- Organic Agriculture Production NC II
- Milking Operation NC II
- Pest Management (Vegetables) NC II
- Pressurized Irrigation System Installation and Maintenance NC II
- Rice Machinery Operations NC II
- Sugarcane Production NC II
- Seaweeds Production NC II
- Rubber Processing NC II
- Rubber Production NC II

In addition to these, a TR for Solar Powered Irrigation System (SPIS) Operation and Maintenance NC II was also developed during the first quarter of 2020.

Of these TRs, only a handful such as Agricultural Machinery Operations NC II, Rice Machinery Operations NC II, Drying and Milling NC III, and Milking Operation NC II are directly related to mechanization, which is a prerequisite for smart farming technologies. Despite this, the agriculture and fisheries sector consistently see a high student enrollment rate every year.

TESDA also developed the following competency standards during the first quarter of 2020:

- Mango Production Level II
- Sonar Deep Sea Fishing Level II
- Net Making Level II
- Beekeeping (Apiculture) Level II

- Fish Finder Equipment Servicing Level III
- Fish Finder Operation Level III
- Net Construction and Maintenance Level II
- Seamer Operation Level II
- Sonar Equipment Servicing Level I

As seen in Annex A, the number of TVET enrollees and graduates in agri/fishery skills have been steadily increasing since 2017, culminating to about 184,000 and 157,000 (respectively) in 2019. The numbers reported for the first quarter of 2020 also look promising, as Annex B demonstrates, with around 14,400 enrollees and almost 20,000 graduates in the sector. However, the growing clamor for smart farming will likely see a crosscutting of competencies between agriculture and various other sectors, particularly the information and communications technology (ICT) sector. Thus, it is also worth considering the number of ICT enrollees and graduates for TVET, in this regard. ICT students seemed to fluctuate in numbers, coming in at about 202,000 and 185,000 (respectively) in 2017, but only about 78,000 and 71,000 in 2019. This drop could be attributed to incomplete student data, as TVET schools still report more numbers as they come in 2020. For the first quarter of 2020, about 5,600 TVET enrollees and 6,800 graduates in ICT were reported.

TESDA has also taken note of the aforementioned skills needs for smart farming and is currently studying how to incorporate other TRs into the agriculture and fisheries sector, as technologies and practices start to change. Annex C provides a brief rundown of emerging skills in Philippine agriculture that currently have or don't have an equivalent TR to instruct students with. This Annex was created with information gleamed from the Department of Labor and Employment's Jobsfit 2022 Labor Market Information Report, the Department of Trade and Industry's, and other sources. As seen from this list, ICT is envisioned to become even more prominent in the future once the automation and artificial intelligence becomes integrated in farming machinery. Marketing and entrepreneurship are also given importance, as smart farming will incentivize small-scale farmers to grow and promote their own produce without the auspices of a larger corporation.

Agro-industrialists seem to share a similar point of view. In a Skills Needs Assessment Forum conducted by TESDA in January 2018, a number of TRs were deemed vital for the agriculture and fisheries sector in the short-term (see Figure 7). Other skills currently do not have corresponding TRs, but they were nonetheless mentioned during the Forum, explicitly labelled as NTRs (No Training Regulations), as seen in Figure 8. Many of these qualifications are not at all directly related to the sector, such as Shielded Metal Arc Welding (SMAW) and Heavy Equipment Operation. Thus, it can be surmised that such skills will also be necessary for workers to adapt to the smart farming labor landscape.

Figure 7. Top WTR Qualifications as Identified by Agro-Industrialists (2018)

Rank	WTR Qualifications	Respondents
1	SMAW NC II	11
2	Agriculture Crops Production NC II	10
3	Aquaculture NC II	8
	Electrical Installation and Maintenance NC II	8
4	Instrumentation and Control Servicing	3
	Heavy Equipment Operation NC II	3
5	Agricultural Crops Production NC I	2
	Animal Production NC II	2
	Automotive Servicing NC II	2
	Chemical Process Operations NC III	2
	Machining NC II	2
	Mechatronics Servicing NC II	2
	Organic Agricultural Production NC II	2
	Refrigeration and Air Conditioning (RAC) Servicing NC II	2
	Trainers Methodology I	2

Original Source: Labor Market Information Report: Developing Philippine Agriculture Through Agribusiness (TESDA, 2018)

Figure 8. Top NTR Qualifications as Identified by Agro-Industrialists (2018)

Rank	NTR Qualifications	Respondents
1	Plant Operations	3
	Leadership / Organizational Management	3
2	Product Packaging	2
3	Ricemill Operation	1
	Product Upgrading Enhancement	1
	Refresher Seminar on Leadership	1
	Tunnel Farming Technology	1
	Shelling Machine Operations	1
	Parer Operations	1
	Mechanical Technician	1
	Electricians / Mechanic / Electronics Operations	1
	Corrugating Machine Operation	1
	Heavy Equipment Troubleshooting (Mechanical and Electronic)	1
	Boiler / Filtering Operations	1
	Steam Generation Operation	1
	Lathe Machine Operations	1
	Use of PLCs in operating new machine shop equipment	1
	Mechanical Technician	1

Original Source: Labor Market Information Report: Developing Philippine Agriculture Through Agribusiness (TESDA, 2018)

Compare and contrast these lists of competencies with Annex B, which also featured several non-agriculture skills as essential for the sector's future. Both placed importance on operation of heavy equipment, automation, and other forms of farming. However, only the latter mentioned ICTs and similar competencies as emerging skills for the agriculture and fisheries sector. This could be evident of the minimal perception of ICTs in Filipino farms, and the whole notion of transitioning to smart farming as a whole.

Such a notion should change if TESDA seeks to increase ICT participation in the agriculture and fisheries sector. As of February 2020, TESDA offers the following ICT TRs:

- 2D Animation NC III
- 3D Animation NC III
- Animation NC II
- 2D Game Art Development NC III
- 3D Game Art Development NC III
- Broadband Installation (Fixed Wireless Systems) NC II
- Cable TV Installation NC II
- Cable TV Operation and Maintenance NC III
- Contact Center Services NC II
- Game Programming NC III
- Medical Coding and Claims Processing NC III
- Medical Transcription NC II
- Programming (.Net Technology) NC III
- Programming (Java) NC III
- Programming (Oracle Database) NC III
- Telecom OSP and Subscriber Line Installation (Copper Cable/POTS and DSL) NC II
- Telecom OSP Installation (Fiber Optic Cable) NC II
- Visual Graphic Design NC III
- Web Development NC III

With a handful of exceptions such as Programming and Web Development, these TRs are not directly related to smart farming technologies such as soil scanning, data management or the IoT. Take note that in Annex B, competencies related to the use of "e-commerce technologies" and "geographic information systems" are sought after for the industry. That said, the existing TRs could be used as a baseline or an introduction for students to familiarize themselves with digital technologies.

VII. Way Forward

The current TVET situation shows that while there is a solid foundation for farmers and agriculture workers to learn skills for smart farming, there are plenty of opportunities for improvement in terms of learning and their access to it. Higher-level qualifications may have to be created or certain competencies from the existing TRs may have to be revisited in order to accommodate the skills deemed necessary before the Philippines could establish a data-driven, technology-based agriculture and fisheries sector.

Below are some of the ways TESDA could go with in order to prepare its learners for this kind of future:

- Partner and cooperate with the Department of Agriculture in their efforts to mechanize the Philippine agriculture and fisheries sector. The Department has already launched several initiatives related to this, such as the Agri-Pinoy Program, but TESDA has to determine which among the programs needs intervention from the agency.

- Review existing TRs related to Agriculture/Fisheries and ICT to see which competencies could be adapted to smart farming. In a similar vein, TESDA may also want to consider creating higher competencies to accommodate the foreseen skills needs. This will entail the need to determine basic and common competencies that should be considered to be included in the training programs.

  Likewise, given the criticality of ICT as the agriculture is moving towards mechanization, pre-requisite programs and even entry requirements of trainees should be carefully analyzed.

- Consider the allocation of budget not only on programs with existing TR but also to new and emerging programs in the agriculture sector that would have an impact to current situation of the country under the COVID-19 pandemic, especially in the food security of the country.

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ANNEX A **Number of TVET Enrollees and Graduates, by Sector and Sex (2017-2019)**

SECTOR	2017						2018						2019					
	Enrolled			Graduates			Enrolled			Graduates			Enrolled			Graduates		
	FEMALE	MALE	TOTAL	FEMALE	MALE	TOTAL	FEMALE	MALE	TOTAL	FEMALE	MALE	TOTAL	Female	Male	Total	Female	Male	Total
Agriculture Forestry and Fishery	61,142	50,006	111,148	55,675	45,796	101,471	67,232	68, 977	136,209	64,733	67,522	132,255	96,296	88,570	184,866	82,403	75,018	157,421
Automotive and Land Transportation	17,628	155,389	173,017	15,008	134,753	149,761	22,235	119,891	142,126	19,222	110,205	129,427	23,959	133,758	157,717	21,890	120,396	142,286
Chemicals / Plastics / Petrochemicals	428	541	969	420	530	950	207	76	283	200	77	277	204	45	249	153	40	193
Construction	14,443	82,564	97,007	12,990	70,659	83,649	12,640	87,469	100,109	11,957	86,316	98,273	12,065	89,888	101,953	10,334	76,801	87,135
Decorative Crafts	3,616	1,341	4,957	3,556	1,320	4,876	1,288	579	1,867	1,127	513	1,640	4,443	1,090	5,533	4,339	1,015	5,354
Electrical and Electronics	40,620	114,847	155,467	36,738	99,426	136,164	64,455	122,755	187,210	58,892	112,008	170,900	63,822	137,389	201,211	55,302	116,984	172,286
Footwear and Leathergoods	1,324	504	1,828	1,479	621	2,100	276	151	427	268	147	415	344	175	519	340	167	507
Furniture and Fixtures	239	456	695	238	425	663	1	93	94	38	244	282	232	830	1,062	224	747	971
Garments	40,257	5,884	46,141	35,459	5,079	40,538	42,768	9,355	52,123	40,694	8,545	49,239	35,061	6,736	41,797	31,826	6,315	38,141
Heating, Ventilation, Airconditioning and Refrigeration	364	8,773	9,137	270	7,038	7,308	1,004	7,318	8,322	917	6,188	7,105	531	8,321	8,852	420	7,370	7,790
Human Health / Health Care	100,587	37,616	138,203	89,242	33,875	123,117	101,270	36,760	138,030	101,074	36,393	137,467	96,604	47,630	144,234	84,704	43,146	127,850
Information and Communication Technology	107,235	95,455	202,690	97,345	87,856	185,201	66,040	56,982	123,022	63,745	54,561	118,306	44,246	34,636	78,882	39,802	31,317	71,119
Logistics							117	70	187	42	38	80	237	132	369	66	37	103
Maritime	654	6,690	7,344	553	5,508	6,061	601	6,979	7,580	517	5,157	5,674	881	10,191	11,072	641	8,246	8,887
Metals and Engineering	16,041	124,304	140,345	13,926	105,165	119,091	13,145	100,417	113,562	12,760	102,543	115,303	13,813	102,581	116,394	11,793	87,038	98,831
OTHERS							254,157	205,681	459,838	234,005	190,586	424,591	321,520	208,719	530,239	303,159	194,509	497,668
Processed Food and Beverages	76,419	25,210	101,629	73,180	23,777	96,957	50,044	21,568	71,612	47,007	20,399	67,406	54,840	20,324	75,164	51,390	18,695	70,085
Social, Community Development and Other Services	336,353	187,886	524,239	321,447	182,820	504,267	172,562	60,904	233,466	163,787	57,788	221,575	167,362	66,388	233,750	155,338	61,197	216,535
Tourism (Hotel and Restaurant)	385,461	171,742	557,203	334,147	149,956	484,103	394,183	191,531	585,714	373,877	174,899	548,776	383,406	188,121	571,527	348,387	168,755	517,142

TVET	10,639	7,700	18,339	6,392	4,665	11,057	9,592	7,498	17,090	9,965	7,791	17,756	10,175	8,242	18,417	8,870	7,095	15,965
Utilities	3	107	110	0	84	84	432	1,192	1,624	419	1,255	1,674	464	582	1,046	403	439	842
Visual Arts	421	1,084	1,505	364	884	1,248	360	833	1,193	328	799	1,127	302	428	730	262	359	621
Wholesale and Retail Trading	2,920	3,851	6,771	2,967	4,064	7,031	2,306	1,284	3,590	1,565	931	2,496	1,692	1,117	2,809	1,489	1,033	2,522
Pyrotechnics							156	39	195	137	27	164	295	235	530	302	194	496

Source: Annual Reports on Enrolled and Graduated TVET Students (TESDA Planning Office)

ANNEX B Number of TVET Enrollees and Graduates by, Sector and Sex (Q1 of 2020)

SECTOR	ENROLLED				GRADUATED			
	Male	Female	Total	% Dist	Male	Female	Total	% Dist
Agriculture Forestry and Fishery	6,899	7,522	14,421	7.86%	9,222	10,690	19,912	9.25%
Automotive and Land Transportation	8,672	1,763	10,435	5.68%	10,818	2,271	13,089	6.08%
Chemicals / Plastics / Petrochemicals	25	49	74	0.04%	24	42	66	0.03%
Construction	6,151	851	7,002	3.81%	11,261	1,508	12,769	5.93%
Decorative Crafts	31	162	193	0.11%	23	109	132	0.06%
Electrical & Electronics	11,014	5,287	16,301	8.88%	15,345	6,937	22,282	10.35%
Footwear & Leathergoods	21	23	44	0.02%	16	12	28	0.01%
Furniture and Fixtures	3		3	0.00%	17	8	25	0.01%
Garments	463	2,441	2,904	1.58%	556	3,316	3,872	1.80%
Heating, Ventilation, Air conditioning and Refrigeration	439	20	459	0.25%	407	15	422	0.20%
Human Health / Health Care	1,776	4,659	6,435	3.51%	2,764	7,142	9,906	4.60%
Information and Communication Technology	2,757	2,881	5,638	3.07%	3,092	3,800	6,892	3.20%
Logistics	5	28	33	0.02%	0	0	0	0.00%
Maritime	2,013	86	2,099	1.14%	1,520	62	1,582	0.74%
Metals and Engineering	7,974	1,120	9,094	4.95%	15,292	1,827	17,119	7.95%
Others	21,388	30,927	52,315	28.50%	19,487	29,149	48,636	22.60%
Processed Food and Beverages	1,243	4,002	5,245	2.86%	1,267	3,878	5,145	2.39%
Pyrotechnics	16	63	79	0.04%	16	63	79	0.04%
Social, Community Development and Other Services	5,475	11,964	17,439	9.50%	4,972	11,937	16,909	7.86%
Tourism (Hotel and Restaurant)	10,294	20,616	30,910	16.84%	10,418	23,281	33,699	15.66%
TVET	981	1,219	2,200	1.20%	1,032	1,389	2,421	1.12%
Utilities	4		4	0.00%	20	5	25	0.01%
Visual Arts	95	89	184	0.10%	42	43	85	0.04%
Wholesale and Retail Trading	17	35	52	0.03%	33	100	133	0.06%

Source: 2020 Student Data (Q1) from TESDA's Regional Operations Management Office – Management Information Technology Division (ROMO-MITD)

ANNEX C List of Emerging Skills in Agriculture (by TR if applicable)

With TR	Without TR
Agricultural Crops Production NC I	Abacca Production/ Processing
Agricultural Crops Production NC II	Bag Making (Abaca/Piña)
Agricultural Crops Production NC III	Bamboo Chips Making (Food Group)
Agricultural Machinery Operations NC II	Bamboo Weaving (Amakan, Tabig)
Agricultural Machinery Servicing (4-Wheel Tractor) NC III	Bamboo Yam Development
Agroentrepreneurship NC II	Banana Production
Agroentrepreneurship NC III	Bastry/Trays Using Bamboo
Agroentrepreneurship NC IV	Beekeeping
Animal Production (Poultry-Chicken) NC II	Chemical Waste Process
Animal Production (Swine) NC II	Climate-Smart Farming Data Analysis
Aquaculture NC II	Coco Coir Geonet Installation And Maintenance
Fish Capture NC I	Coco Coir Production
Fish Capture NC II	Coffee Plant Propagators
Fish Products Packaging NC II	Dredging
Food Processing NC I	Drip Irrigation Technology
Food Processing NC II	Duck Raising And Value-Adding Of By-Products
Food Processing NC III	Evisceration Processor
Food Processing NC IV	Farm Automation
Heavy Equipment Servicing (Mechanical) NC II	Farm Implement Fabrication
Horticulture NC III	Farm Tour And Technology Transfer
Motorcycle/Small Engine Servicing NC II	Fruit And Vegetable Dehydration
Seaweeds Production NC II	Genomicist
Slaughtering Operations (Large Animal) NC II	Ginger Production And Processing
Slaughtering Operations (Swine) NC II	Green House Technician
	Guinea Fowl Production And Value-Adding Of By-Products
	Halal Slaughtering Operation
	Hand Embroidery (Visayan) On Piña, Silk, Abaca
	Handmade Paper For Home Furnishing
	Herb Cubes And Fruit Juice Processing
	Herbal Production (Herbalist)
	Hydrophonics
	Installation And Management Of Smart Farming Systems
	Land Surveyor

	Marine Biologist
	Marketing Officer
	Marketing Specialist
	Mushroom Culture And Production
	Mushroom Production
	Natural Dye Development (Indigo, Etc.)
	Operation And Maintenance Of An Automated Agriculture System
	Organic Farm Landscaping
	Purchaser
	Quail Farming And Value Adding Of By-Products
	Quality And Safety Control (Production Process)
	Quality Control Technician
	Repair And Servicing Of Smart Farming Equipment
	Sales Representative/Sales Officer
	Soil Conditioner Making
	Telescopic Crane
	Tramp Installation
	Use Of E-Commerce Technologies
	Use Of Geographic Information System
	Value Adding Of Agricultural Crops (Focus Commodity)
	Wine Making

Source: 2019 Consolidated Skills Map (TESDA Planning Office), with data from the 2017-2022 Philippine Development Plan, JobsFit 2022, NTESDP 2018-2022, and TESDA Regional/Provincial Offices

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