The Emergence of Disruptive Smart Farming Technologies in the Philippine Agriculture Under the New Normal

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Abstract: - As the COVID-19 pandemic entered and disturbed activities in every nation, managing manual agricultural practices are slowly shifting towards automation such as the use of the Internet of Things (IoT) and machine learning. This trend can be seen both in the global and local setting, which they termed precision agriculture or commonly known as smart farming. The purpose of this study was to explore the role of smart farming technologies both in urban and rural areas especially in the Philippines. The results showed that the impact on agriculture in terms of the economic aspect expanded by about 1.6% in its GDP despite the pandemic, that is experienced all over the globe. Furthermore, key performance indicators in aspects of economic, industry/manufacturing including labor and social were determined, which yielded out to be positive despite some barriers or constraints identified. In the end, there were - going programs and projects under precision agriculture that will support labor and employment, human development through government laws/policy, and research and development/innovation until the post-pandemic era or the new normal.

Key Words— ***Smart farming technologies, rural and urban areas, precision agriculture, new normal.***

I. Introduction

The effect of the COVID-19 pandemic had drastically changed the whole sector in the society from transportation, education, entertainment and refreshment, manufacturing, power, and above all in agriculture, where the supply chain of food is the primordial source of every nation. The trend on smart farming is a transformation from traditional to intelligent agriculture with the involvement of the Internet of Things and Wireless Sensor Network, which changes the said sector under the new normal. The advancement of technology, despite several challenges in the sector, has greatly driven the growth of precision agriculture. It also combines information from many sources to enhance crop output and boost the cost-effectiveness of crop management methods, including the input of fertilizers, irrigation management, and the application of pesticides, which integrates the science of improving crop yields. While definitions of precision agriculture vary, the term is generally applied to tools and strategies relevant locally at subfield scales.

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Distance sensing has been pushed for decades as a crucial source of information to help precise farming, but acceptance was slow for several reasons. Crop status is monitored in modern agriculture by observing and measuring variables such as soil condition, plant health, fertilizer and pesticide effect, irrigation, and crop yield. Managing all these factors is a significant challenge for crop producers. The rapid improvement of precise monitoring of agricultural growth and its health assessment is critical for prudent farming resource management and crop yield management (Rubio, V.S. & Mas, F.R., 2019). The implementation of remote sensing methods, such as hyperspectral imaging, can address such issues to produce precise biophysical indicator maps across crop growth cycles. Precision agriculture systems rely on hardware components, primarily wireless sensors, which serve as a source of real-time data. Automation in agriculture is accomplished using a decision-based system based on real-time data retrieved by sensors. Also, it improves productivity by ensuring crop sustainability by delivering what the crop requires based on new techniques and software platforms (Gill, R. & Chawla, P., 2021).

The paper describes the trends of smart farming technology both in the global and local setting, facilitating factors, barriers in the adoption, and policy recommendations in the Philippines.

II. Trends in Smart Farming Technology

Agriculture 4.0, the forthcoming revolution in agriculture, is focused on science and green technology. It had to look both at the demand side and the supply or value chain of the food using technology to better the consumer's real demands and to revise the value chain. Every link, from seed to fork, is the beginning to convert technological breakthroughs in the food chain. Digital technologies and analytics are increasing insight and efficiency in industrialized countries.

Global Setting

In both research and the marketplace, it is clear that smart farming is evolving at a rapid pace. However, end-user adoption still lags behind the said technology (Balafoutis, A.T., Evert, F.K., and Fountas, S., 2020)

The United Nations Sustainable Development Goal, which is to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" (SDG2) recognizes the interdependence of continuing to support sustainable farming, empowering small farmers, gender equality, ending rural poverty, ensuring healthy lifestyles, addressing climate change, and other issues addressed in the Post-2015 Development Agenda's set under the 17 Sustainable Development Goals. Moreover, the area designated as resilient and profitable agriculture encompasses all three aspects of sustainable production namely, environmental, economic, and social. Farm surveys as a measurement tool will allow countries to raise a series and obstacles within the three pillars of sustainability. Farms and associated agricultural land areas that meet the sustainability criteria of the sub-indicators selected across all three dimensions will be classified as productive and sustainable agricultural land (FAO, 2022).

Based on the report from the Food and Agriculture Organization of the United Nations, it was predicted that the world population would increase to 10 billion by 2050, food demand is anticipated to rise anywhere from 59 to 98 %. This will have a profound impact on agricultural markets that we have never seen before. Farmers around the world will need to improve crop production, either by expanding the quantity of agricultural land available for crop production or by improving productivity on existing agricultural lands with fertilizer and irrigation, as well as embracing new methods like precision farming (Elferink, M. and Schierhon, F., 2016).

There is a growing generation of digital-native, tech-savvy customers who have expectations based on their previous experiences in digital-first industries. Meanwhile, consumer preferences and behaviours are changing, with millennials driving demand for organic products, sustainable retail supply chains, and zero-deforestation pledges.

Retailers face the challenge of increased seed and crop protection sector concentration and shifting requirements from digitally native clients. Traders lack prospects for crop volumes and experience severe price volatility and the digitization of farmers' domestic storage across the value chain disrupts their fundamental business model. Precision farming and technological developments throughout the supply chain can assist in addressing these difficulties and meeting the increasing global demand for food, fueling the next agricultural revolution.

Under this umbrella, three main technological themes shape the fourth agrarian revolution.

Robotics Farm: Robotics are improving and exploring their feasibility throughout the agricultural value chain, from plants through harvesting, to meat production and food logistics. Agricultural robots must operate in unstructured environments while maintaining current work quality. In terms of objectives, structures, methods, techniques, and sensors, agricultural robot designs, developments, and evaluations are diverse. For comparing robot performance and technological progress, standardization of terms, system-performance measures and methodologies, and the adequacy of technological requirements are crucial (Bechar, A. and Clement, V., 2016).

As an illustration, John Deere invested 305 million dollars on the acquisition of Blue - River Technology, a start-up capable of enabling robots to identify and spray undesired plants, reduce input costs, and improve efficiency. There is also increasing demand as a service for robot technology, particularly in fruit collection. By 2024, robots should sail through the ag-bot business to an anticipated $5.7 billion five times the size of the market in 2016.

Remote Sensing: Many remote sensing techniques, ranging from field sensors, drones to satellite imaging, allow farmers to view their plants in a variety of ways. Farmers can now have access to large, high-speed coverage with detail on the field by improving computing or sensor technology. These all provide farmers with up–to–date information in real-time, allowing them to make changes to their crops accordingly. According to Weiss, M., Jacob F., and Duveiller, G. (2020), remote sensing is a non-invasive method of monitoring vegetation in both space and time, and it appears to be an unavoidable tool in achieving these objectives. It can help with the detection of new varieties that are better suited to challenging environments such as phenotyping, the tracking of agricultural land use, the projections from within crop yields, the enhancement of relatively brief production, and the allocation of environmental services concerning soil or aquatic ecosystems, as well as plants or animals' wildlife habitat.

*Machine Learning and Analytics***:** In a broad sense, the goal of a machine learning algorithm is to optimize the performance on the job by leveraging illustrations or previous experiences. In

particular, it can develop effective connections between different inputs and regenerate a comprehension scheme. The more data used in this data-driven methodology, the better machine learning performs This is comparable to how well a human accomplishes a specific task as they gain knowledge and experience (Lopez, I., 2020).
In every sector, machine learning and advanced analytics are used to mine trend data and agriculture is no exception. They can be used with plant breeders before seed planting. Machine education can predict which characteristics and genes will best serve the crops, giving farmers the best location and climate for the crop. On the field level, satellite data are used to distinguish crops, such as maize and soy, plants to weeds, and to provide valuable information on crop, logistics, and commodity insurance markets. This trend will be even more accelerated by the intersection of robotics and data from a more connected farm.

TESDA (2020) and Despommier, D. (2019) cited some notable countries, that adopt smart farming technologies in agriculture including:

2.1 Thailand

Agriculture occupies an unusual position in Thailand's economy. On the one hand, agriculture accounts for only around 10% of Thailand's GDP, while it employs roughly 40% of the country's overall workforce. The industry is also considered to be in decline, as an increasing number of young Thais leave the rural in search of work in the metropolis. Fortunately, ongoing government assistance for present Thai farmers has allowed them to stay afloat and keep up with the times, particularly when it comes to the adoption of smart agricultural technologies. Precision farming is one of these technologies, which Thai farmers use to increase crop yield per square meter. Some of their smart farming technologies include:
Precision fertilizing: is part of their interpretation of precision farming. Farmers match and manage fertilizer application based on soil conditions, ensuring that their land is not oversaturated with chemicals and has enough time between crops to recuperate. Precision fertilization also allows farmers to produce and replace crops more quickly after each harvest.
Precision spraying: Farmers select areas of the land where weeds collect and spray highly concentrated pesticides there first. This ensures that pesticides are used as efficiently as possible while causing little environmental harm (i.e., maximizing gains while minimizing use). Precision spraying has resulted in a 60 percent reduction in overall pesticide use in Thailand, according to farmers.
Centers for data processing: Farmers may modify their agricultural and harvesting operations using data from drones and satellites. They can also use data processing centers to get real-time meteorological and geological information to help them plan their harvests. Thailand plans to include artificial intelligence into its data processing processes in the future to make them considerably faster and smoother.

2.2 Vietnam

Agriculture is a crucial economic sector in Vietnam, as rice is one of the country's most essential commodities for rural employment and international trade. Rice accounts for over half of the country's gross food crop production, a figure that has consistently risen thanks to the continued use of input-sensitive crop management techniques. As the 4IR approaches, Vietnam has begun several projects to upgrade its current rice farming methods and include “smarter” technologies, including:
Rice Crop Manager (RCM): The International Rice Research Institute developed the Rice Crop Manager (RCM) smartphone application to assist farmers with crop nutrition management. Agricultural extension personnel can also use the RCM to assist disadvantaged farmers in following cost-effective crop management strategies. In 2014, the application was field-tested among farmers in the Mekong River Delta and the Red River Delta, and it proved to be beneficial in practically every aspect of the farming season.
Smart greenhouse: This aims to establish ideal conditions for growing ready-to-eat tomatoes, lettuce, and other vegetables without the need to wash them first. Proponents of this technology claim that lettuce grown in smart greenhouses has one-fifth the potassium concentration of retail lettuce, making them a good alternative for diabetics. This method will allow a 1000 square meter plot of ground to grow between 4,000 and 6,000 different crops all year long, all of which are safe to eat right away. It will also help Vietnam become a leading producer of world-class food crops, which will assist improve the lives of Vietnamese farmers around the country by providing additional cash.

2.3 Japan

When it comes to smart farming, Japan is one of Asia's leading countries. In 1998, the government built one of the first independent rice planters through its National Agriculture and Food Research Organization (NARO). Because foreign and domestic demand for agricultural products from Japan is gradually expanding year after year, NARO regards technology as a requirement in this regard. The average age of Japanese farmers is 65 as of 2018, and one of the most common challenges they encounter is finding a successor, much alone farmhands, for their farms.
Global Positioning System: To build a "local version" specific to the steep and densely populated features of Japan's natural topography, researchers used the Global Positioning System (GPS), which is currently in use around the world. The Quasi-

Zenith Satellite System (QZSS) was developed by launching a new network of satellites into orbit, with the first launch taking place on September 11, 2010. The QZSS's better telemetry has paved the path for new agricultural technologies to emerge; so far, it has been used to give automated farm systems with precise geological data as well as climatic data for planting.

Vertical Farming: Vertical farms have exploded in popularity when the Japanese government began to provide significant support for them. Several hundred commercial vertical farms, such as Spread Co., are operating across Japan's islands as of 2018. Leafy green vegetables, which are especially simple to cultivate in this type of environment, have become a staple of Japanese cuisine.

2.4 South Korea

In terms of the technological approaches utilized to cultivate food plants indoors, vertical farms essentially differ from one another. South Korea was the second country to engage in vertical farming. It began with an experimental seed bank complex in Suwan and subsequently grew to include agricultural instruction so that others might emulate the model. As a result, there is now a thriving industry that has spread across the country.

2.5 Local Setting

Global agriculture is already engulfing technology, and the Philippines should not be left behind. The Philippines is adapting various techniques to ensure sustainable production of crops and increasing farmers' incomes by applying different technology-induced techniques in agriculture, given the problems of improving the agricultural sector around the world to secure food production.

According to studies conducted by the Department of Agriculture (2016), Filipino farmers are already implementing some "climate-smart" practices on their farms. These only need to be supplemented with mitigation and adaptation techniques, as well as technology, to be more effective in the long run. Among these practices include planting rice that is resistant to climate change; SALT (Sloping Agricultural Land Technology) is being used to promote soil conservation and contour farming on sloping land; using the SRI (System of Rice Intensification) to increase irrigated rice productivity by carefully managing plants, soil, water, and nutrients; biotechnological farming, primarily using genetically modified crops; employing "agroreforestation," or combining perennial and annual crops in a two-canopy or multi-canopy production system, to reduce farm carbon emissions and using non-traditional irrigation methods.

Digitalization efforts here in the Philippines, through *e - Kadiwa* initiative of the Department of Agriculture, do not just include the *e - Kadiwa* Initiative as the ICTS has begun upgrading the information system management of the agency, including the Farmers and Fisherfolk's Registry System (FFRS), and Farmers' Intervention Monitoring System (FIMS). Both the FFRS and FIMS is online surveillance system designed to facilitate the listing and monitoring of beneficiaries using the interventions provided by various Department of Agriculture programs. This is a further tool for confirming and monitoring the distribution on the ground and providing a quick review of what is happening to the Secretary and various Department of Agriculture offices. The program of digitalization then makes it possible to record agri-fishery information in real-time and efficiently and to monitor and evaluate the reports of various Department of Agriculture projects (Department of Agriculture, 2020). It was highlighted the emergence of the COVID -19 pandemic the flaws of various food systems in the world but also emphasized one vital thing that has been ailing the farm sector, that is neglecting food production. The disruptions in domestic trade caused by lockdowns have resulted in an imbalance in the food supply, resulting in the shortage of food products in certain areas like the metropolis while having a glut in food-production areas. That's why Filipinos engaged in smart urban farming to what they called "hydroponics."

In the early 1930s, Professor Willian Gericke describe the term hydroponics, which is a form of gardening that uses no soil, but instead, roots suspended in a solution of water and nutrients. Hence, this term was derived from the Greek word *hydro* for water and *ponos* for labor (Sharma, N., 2019). A hydroponic system can grow plants and vegetables faster than growing outdoors in soil, and hydroponic systems can be used year-round. Plants grown hydroponically often yield more, require less space and use less water than with conventional gardening. A hydroponic system also can be an ideal solution for apartment dwellers and urbanites who do not have an outdoor gardening plot. More advanced systems include the nutrient film technique and the aeroponic system. The easiest plants to start with are greens like lettuce, spinach, swiss chard, and kale; herbs like basil, parsley, oregano, cilantro, and mint; and fruiting plants like tomatoes, strawberries, and hot peppers. Similarly, vertical farming is the practice of producing food in vertically stacked layers, such as in a skyscraper, used warehouse, or shipping container. The modern ideas of vertical farming use indoor farming techniques and controlled-environment agriculture (CEA) technology, where all environmental factors can be controlled. As of this moment, urban farming is being practiced in some cities in the National Capital Region such as Las Piñas, Parañaque, Pasay, Quezon City, and Navotas launches the tallest indoor vertical urban farming structure.

III. FACILITATING FACTORS

The following facilitating factors for technology adoption are divided into three stages namely:

Access to technology requires knowledge about the technology's existence, its adequacy to an agricultural system, its potential risk, and its ability to obtain and finance technology.

The availability of information on new agricultural technologies is a prerequisite for their adoption. Extension agents, fellow farmers, or different media, such as mobile phones, TV, or radio, can provide this information. Farmers will also require the information necessary to assess the technology's suitability for their farming system and to understand the possible risks associated with its use. Another important factor for the adoption of technology is access to financial resources and services, where financial capital is required to obtain the technologies and related inputs. Richer farmers or off-farm farmers might be more willing to take on financial risks if technology is inadequate. Credits may also make available financial resources. For smallholder farmers, in particular, limited access to credit may constitute a major limit on technology adoption because lenders may not be prepared to support the high transaction costs of small disbursements. Banking facilities given via bank or mobile banking services may permit adoption of the technology by providing transmission services to pay for or to reimburse agricultural technology or inputs. Famers can also be more likely to embrace new technologies when their financial risk is minimized by insurance plans, such as drought or floods, to protect from crop failures. However, smallholder insurance plans have similar issues as credit. The insurance provider can be expensive to monitor and pay dispersed and minor claims (Poulton et al. 2006).

Farmers need to know, the ability to use them such as enough labor or other resources, and the ability to manage associated risk to be able to utilize the technologies.

To use the technology, farmers need the necessary knowledge and information. Some studies show that the adoption of new technologies has a positive relationship with the education of farmers. The more complex the technology will play an important role. Besides education, farmers will also benefit from the skills they can acquire during their lives to use the technology through training (Marra et al. 2003). As noted above, information and learning sources can include external sources, experimentation, and learning from others, including m-service. Some studies show that the adoption of new technologies has a positive relationship with the education of farmers. The more complex the technology will play an important role. Besides education, farmers will also benefit from the skills they can acquire during their lives to use the technology through training (Marra et al. 2003).

Additional agricultural resources such as labor, machinery, seeds, fertilization, pesticides, energy, storage, and irrigation will also be needed to use these technologies. Such resources will require workforce and input markets that are well - functioning which could be a grave constraint, especially in remote areas. In addition, where input demand is seasonal and small, the incentives to develop the market infrastructure necessary may not be sufficient. Collective input procurement, for example by mobile farming organizations and related services, could help address these weaknesses by reducing transactional expenses and creating economies of scale (Poulton et al. 2006).

The biophysical and agro-climatic environments could also be crucial to the success of new agricultural technologies, such as soil quality, availability of water, topography, changes in seasonal temperatures, or the presence of harmful pests and diseases. Observations and experiments have demonstrated that these environmental factors and particularly the availability and control of water resources are often the main reasons for differences in adoption patterns.

Farmers can generate income if surplus products can be profitably sold, and the return is saved and reinvested.

The ability to sell excess production profitably for income will depend on good market access. The ability to access various markets physically depending upon the proximity and transport infrastructure to reach the market is a prerequisite. Farmers may also be lacking in information or access to alternative buyers or markets. In many poor areas, farmers are often forced to sell their products to intermediaries or to sell them to their creditors at prearranged prices. M-services can help expand your networks and facilitate contacts.

To negotiate better deals, farmers too frequently have no information about current prices on the markets. The dissemination of price information through mobile telephones is viewed to reduce asymmetries in information and increase farmers' negotiating power. Market participation may also be restricted because larger buyers tend to favor and do not pay for transaction costs associated with the procurement of many small, scattered farms (Pingali et al., 2005). The trust between buyers and sellers also plays an important role in business transactions. In addition, sales savings would enable farmers to better manage seasonal farm income and make better choices as to when and where to buy input rather than limited to when income is available or to get input from the creditor. Banking facilities may assist farmers to manage these savings and earn interest. However, like lending and insurance, smallholder banking costs result from small deposits, population dispersion, and poor facilities.

IV. BARRIERS IN ADAPTATION OF SMART FARMING TECHNOLOGIES

Despite the advancement being encountered and experienced in the agricultural sector in the Philippines, it cannot be denied that hindrances come to play. Here are the different barriers to the adaptation of smart farming technologies.

Lack of IT infrastructure and networks in rural areas.
One challenge is that network coverage is still limited in rural areas. Although 4G become the most common mobile network worldwide and 90% of the network is accessed through a 3G or higher quality network, 3G networks only cover roughly one-third of rural populations in the least developed countries (GSMA, 2019). For consumers, smartphones have become a major way of accessing the Internet. Falling prices and innovations, such as pay–as–you–go plans make it easier and more affordable for mobile devices and rural communities too (Hahn and Kibora, 2008).
The Philippines, an archipelago of over 7,000 islands with a mountain topography, can be a challenge for network operators who seek to expand into their rural areas. Aside from the development of infrastructure, it is hard for a reliable network to be maintained even in certain rural areas. For example, the internet has been inaccessible for a year and a half, after typhoon Ferdie reached the northernmost islands of Batanes.

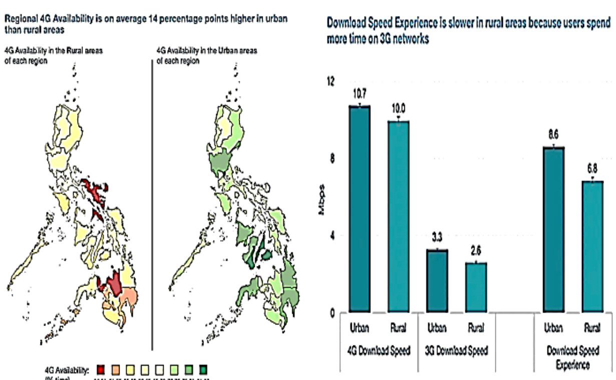

Fig.1. A comparison on the status of network coverage between the rural and urban areas in the Philippines.

As shown in Figure, 4G download speed is expected to be much quicker in urban areas because mobile operators usually focus their investments on networks being deployed and upgraded in densely populated areas. This was however not the case for the Philippines as 4G download speeds of 10.7 Mbps and 10 Mbps were similar on average in urban and rural users. Although the speeds of 3G downloads were, on average, about three times lighter than 4G network measures, the absolute difference between the 3G download speed experienced by both city and rural users was just 0.7 Mbps. However, in some regions, farmers in the rural Philippines spend up to 50% of the time with 3G's. This meant that 3G's or 3G speeds have had a major impact on their overall download experience, making 3G much more important for rural users rather than for urban users, who spend more time on 4G.
In some countries, such as the Philippines, where 53% of their population, over 108 million, is living in rural areas, where the topography can also make the deployment of mobile networks more difficult. Wireless connectivity is their only way to access the Internet for many of these 57 million rural residents who have no fixed broadband, which makes closing the urban-rural divide essential. Although rural users average download speed of 6.8 Mbps, they spent up to half their time on 3G networking, with an average speed of 2.6 Mbps (Salac, R.A. and Kim, Y.S., 2016).

Digital literacy in rural areas.
The utilization of digital technologies calls for basic literacy and computer science, as well as special technical skills. In societies with a growing number, people without such skills could end up marginalizing themselves. Digitalizing the industry will change the nature of jobs and demand for labor and skills considerably. Digital literacy will increasingly be necessary for the creation of agri-food jobs and appropriate education and training. According to the data from the UNESCO Institute for Statistics (2018), rates of educational attainment in the Philippines are frequently lower in rural areas than in urban areas. The inability to use digital technologies is hampered by a lack of basic literacy and numeracy.

Political interference.
The government has made funds available for rural development, including smart farming technologies. However, some politicians use these projects for their interests, particularly in areas where agricultural development is not a top priority for the local government. They only use digitization projects to raise funds, but the actual implementation is not always realized. Even if the project is implemented, political leaders without technical backgrounds might decide on purchasing machines or other technologies, resulting in technology mismatches.

Lack of training of extension personnel.
The battleground of technology transfer is the extension. People involved in the extension must not only be technically up to date but also have good management and interpersonal skills. With so much on their shoulders, most of them may lack the ability to integrate smart farming technology into the overall farming system. Farmers were harmed as a result, because the courses omitted several details that could have been extremely beneficial to them.

V. POLICY RECOMMENDATIONS IN SMART FARMING

Agriculture is the most common occupation for members of agricultural households, whether as workers or business owners; services is the second most common occupation. According to Briones (2020), there is a split of employment sectors among employed people. The bulk of people are employed in agriculture is 58 percent. Meanwhile, the largest industry for entrepreneurs is services, which constitutes 77 percent. Males dominate agricultural employment; agricultural employees are on average older and have fewer years of schooling than the average worker.

Under 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 sectors. Last February 2020, TESDA offered a new training regulation related to smart farming technology that is Solar Powered Irrigation System (SPIS) Operation and Maintenance NCII (TESDA, 2020).

To uplift education towards smart farming in rural areas, TESDA (2020) cited that the government came up with the following programs and their corresponding objectives as shown in Table 1.

Table.1. Philippine government educational programs for smart farming.

Programs	Program Objectives
Enhanced Farmers Field School (EFFS)	To analyze agricultural production systems, identify problems, test possible solutions, and eventually adopt the practices and technologies most suitable to their farming system.
Agricultural Training Institute (ATI)	To encourage farmers to build up their knowledge, skills, and climate response by making observations and experimenting on the farm on various aspects of agriculture such as crop response to various types of nutrients and amounts of water, soil and water management, how to build organic matter in the soil, pest – predator relationship, and growth cycles for ecological pest control.
Digital Farmers Program (DFP)	To capacitate tech-savvy youths into helping small-scale Filipino farmers embrace the digital space. This initiative is a partnership with Smart Communications Inc. for capacity development and technology included 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 with the younger generation.

When it comes to increasing the country's agricultural productivity, vertical farming is a cost-effective, and sustainable solution in a controlled environment, that will help the Philippines overcome most of its major agricultural challenges while also helping to improve food safety and nutrition, especially this pandemic. Vertical Farming shall refer to the method of farming that is brought to the urban space by employing the concepts of indoor agriculture in skyscrapers and other modern buildings. Concerning engaging vertical or indoor farming, Senate Bill No. 2326 or also known as the "Integrated Urban Agriculture Act of 2014," where Department of Science and Technology (DOST) and Department of Agriculture (DA) are mandated to promote the use of integrated urban agriculture and vertically farming in the country's metropolitan areas as an instrument to address food security concerns and regenerate ecosystem function of the Philippines (Poe, G., 2014). Republic Act No. 11292 or also known as "The Seal of Good Local Governance Act of 2019", where Department of Interior and Local Government (DILG) will give incentives to local government units (LGUs) who are integrating urban agriculture in promoting livelihood and sustainability in their respective areas (Official Gazette, 2018). Table 2 shows a matrix between action items and their corresponding proposed policy actions to consider at the local government unit level while Table 3 describes some notable urban agriculture programs and projects by some local government units in the Philippines and how urban agriculture has been harnessed in response to COVID -19 pandemic.

Table.2. Policy recommendations to streamline urban agriculture in the LGU.

Action items	Proposed Policy Actions
Integrating urban agriculture into local	It's critical to pass legislation that institutionalizes, develops, and

development and policymaking	promotes urban agriculture, as well as mainstreaming it in the LCCAP and CLUP. This will ensure that the city/municipal council will provide funding and support.
The formation of a multi-sectoral team and the encouragement of champions of urban agriculture in the city, municipality, and barangays	Existing teams, such as the local development council (LDC) and the LCCAP team, maybe re-oriented, or an executive order may be issued to form a multi-sectoral team. The local government needs to have a policy that allows both agricultural and ornamental plants to be planted in open spaces and parks that are directly managed by the local government.
Barangay officials' urban agriculture capacity has been enhanced	The ability of barangay officials to implement urban agriculture plans and projects will be critical. The barangays are in the best position to identify and/or vet appropriate open spaces for urban agriculture, as well as potential funding sources to support urban agriculture, as they formulate their development plan.
Land use security and inventory of spaces suitable for urban agriculture	Identifying the types and areas of urban agriculture that are appropriate in the LGU context, as well as the location of suitable sites, especially during CLUP formation.
Building capacity and expanding the market regularly are essential.	Incorporation of urban agriculture PPAs into the Capacity Development Agenda, as well as network building and organizing farmers' associations, communities, and other stakeholders.
Funding and Financing for the Long-Term	To encourage LGU constituents to engage in urban agriculture, a tax reduction ordinance, lease agreements, and zoning mixed land use areas would provide a conducive environment. Idle land within the LGU's jurisdiction can be turned into productive farmland through urban agriculture.

Table.3. Some notable urban agriculture programs and projects by some local government units in the Philippines and how urban agriculture has been harnessed in response to COVID -19 pandemic (Ancog, et.al., 2020).

Santa Rosa City, Laguna	As part of its efforts to strengthen the city's climate change adaptation program while also ensuring the promotion of safe and fresh produce, the city government of Santa Rosa has implemented a pilot urban agriculture demonstration project. It is spearheaded by the City Environment and Natural Resources Office; the city government of Santa Rosa has jointly implemented the project with the school of Environmental Science and Management of the University of the Philippines Los Baños and with funding and technical support from the ICLEI – Local Government for Sustainability – Southeast Asia. In addition to the establishment of a demonstration farm that features a variety of containerized and modular set-ups, selected barangay representatives are given a series of urban farming training.
Science City of Muñoz, Nueva Ecija	Since early 2000, Nueva Ecija has been implementing urban agriculture concepts using recyclable containers and receptacles, thanks to the efforts of Central Luzon State University (CLSU) and the Science City of Muñoz, which has been disseminated and replicated in several barangays throughout the municipality. Several initiatives related to hydroponics and aquaponics have also flourished because of CLSU and its local partners' collaborative efforts, providing concrete urban agriculture modalities that potential farmers could allow and implement. Urban farming is critical to ensuring municipal, barangay, and household food security in the wake of the government lockdown.
Quezon City	In 2010, the Quezon City government launched the Joy of Urban Farming Program, an urban farming initiative. It has been instrumental in showcasing urban agriculture concepts and set-ups for interested individuals and organizations, having piloted three demonstration farms in Quezon Memorial Circle. The program has established community commercial gardens in collaboration with the Department of Agriculture's Agricultural Training Institute (ATI) and the Bureau of Plant Industry (BPI). In response to the outbreak, the government of Quezon City provided seeds, seedlings, and pots to residents, as well as technical assistance.

In place of the efforts by some institutions in the adoption of smart farming technologies in the country, the level of innovation-led development is not that well established since the major players in the national innovation are not united and there is a missing link or gap, that is the Science and Technology innovation ecosystem, which does not work at all or simply does not exist at all. To address this concern, a proposed paradigm called iSTART Framework as shown in Figure 2 was developed to ensure the success of the innovation ecosystem through its policy reforms, especially on smart farming.

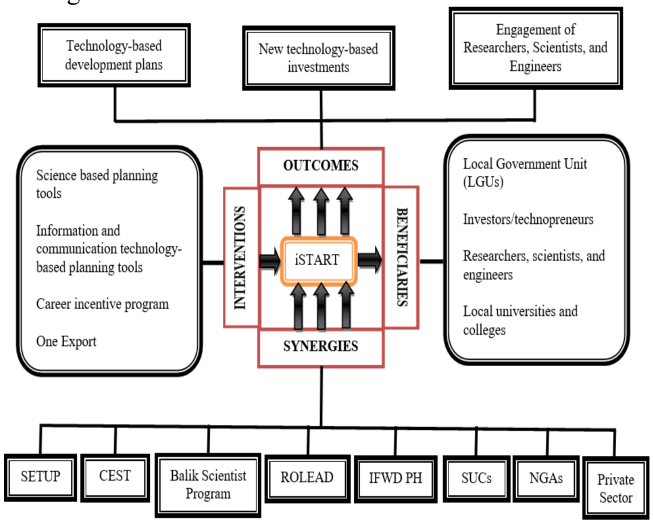

Fig.2. The proposed iSTART Framework for innovation ecosystem in the Philippines

VI. CONCLUSION

To wrap up, the role of smart farming technologies has been seen both in the global and local setting, and truly that these disruptive technologies have brought impacts in the economic aspect, industry/manufacturing including labor aspect, and social aspect. Despite the negative consequences made by the COVID – 19 pandemic, technological innovation keeps flourishing especially in agriculture. It gave opportunities to society all over the globe to be creative and innovative to adapt to the new normal, but there are facilitating factors to consider. On the other side of the picture, barriers are also present, which hinder the adoption of these smart farming technologies. To address these constraints and strengthen the program on precision agriculture here in the Philippines, policy recommendations have been made through human development or education, government laws or policy, and lastly in the field of research and development and innovation. It's high time also that Science and Technology innovation ecosystem in the Philippines is established in every region of the archipelago by implementing the iSTART framework, which will bring major players for innovation together.

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