APPLICATION OF ICT TOOLS IN IMPROVING PHILIPPINE AGRICULTURE

Renelle Comia-Yebron
Science Research Specialist, Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development, Department of Science and Technology (DOST-PCAARRD)
e-mail: yell2005@gmail.com

ABSTRACT

Agriculture is an important sector in the Philippine economy. It employs a third of the labor force in the country and covers vast rich prime agricultural lands situated in rural areas. Although this sector plays a vital role in society, it only contributes 20% of the gross domestic product (GDP) to the Philippine economy—relatively lower than the manufacturing, trade, and other services sectors which served as the main drivers of such growth during the first quarter of 2017 (psa.gov.ph). Farmers, who are the key players in the production of commodities, comprise the majority of the labor force in agriculture. Most of the produce is focused on crops as food, both for local and foreign consumption. Common examples of these are mango, banana, and pineapple to name a few.

Despite the flourishing available resources in the country, there are inevitable issues that come in dealing with agriculture. Apart from the pressing concerns on securing food for the increasing population growth, other problems occur leading to low productivity and losses. Some of which are pests and disease incidence, climate change, lack of postharvest facilities, and insufficient knowledge on the application of proper cultural management practices.

The Philippine Council for Agriculture, Aquatic, Natural Resources Research and Development under the Department of Science and Technology (DOST-PCAARRD), in collaboration with other government institutions and the academe, takes immense efforts in addressing the concerns and issues on agriculture in the country. One of the initiatives done to improve productivity is on the application of information communication technology (ICT) tools in enhancing crop production through the so-called “smarter agriculture” or precision agriculture under the program “Smarter Approaches to Reinvigorate Agriculture as an Industry in the Philippines” or SARAI. The three-year program, which started in 2013, has five component projects which were implemented by the University of the Philippines Los Baños (UPLB) and funded by DOST-PCAARRD. SARAI is anchored on precision agriculture by optimizing the use in advances of technology such as crop and simulation modeling (CSM), remote sensing and geographic information systems (RS/GIS), and field sensors to develop decision support models for crop forecasting, crop advisories, and early warning systems (http://Corn-Toolkit/pdf).

Aside from addressing the effects of climate change, other initiatives cater to increasing/sustaining the genetic resources production and conservation; managing the occurrence of pests and diseases; and determining the appropriate areas for planting of various crops. Other ICT tools being used are breeding tools like bioinformatics, databases/computer-aided programs, and sensors and global positioning system (GPS).

Challenges experienced in the Philippines with the introduction of new technologies include adoption of and deployment to farmers, integration of technologies when applied in farmer’s field, accessibility of technologies to the end users or beneficiaries, and sustainability of ICT utilization.

For its part, DOST-PCAARRD aims for continuous implementation of projects on ICT in improving the agriculture sector. Only some of its initiatives in the pipeline include development of responsive ICT technologies, pilot testing and commercialization of products, capacity building for researchers, and upgrade of facilities.

Keywords: Smart agriculture, Precision agriculture, ICT, SARAI, DOST-PCAARRD
INTRODUCTION

Agriculture, being an important sector and key player in the Philippine economy contributes 9% or US $292.4 billion to the gross domestic product (GDP) of the country (PSA 2015). This is attributed mostly to the production of economically important crop commodities such as rice, corn, coconut, sugarcane, mango, banana, and pineapple.

Despite the availability of potential resources, various constraints still pose problems and challenges in the agriculture sector. Occurrence of emerging pests and diseases, inappropriate farming practices, and increasing postharvest losses, and climate change are some common issues confronting the local farmers and other stakeholders.

In response to these constraints, the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development, one of the sectoral councils under the Department of Science and Technology (DOST-PCAARRD), takes initiatives in developing technologies through the Information, Communication Technologies (ICT), which is a priority in the DOST R&D agenda. DOST through smarter agriculture aims to enhance farm productivity through technology, and reduce vulnerability of farmers to climate change.

ICT TOOLS

DOST-PCAARRD has provided support in promoting smarter agriculture or precision farming through the program “Smarter Approaches to Reinvigorate Agriculture as an Industry in the Philippines” or SARAI. The three-year program, which started in 2013, has five component projects which were implemented by the University of the Philippines Los Baños (UPLB). The program generally aimed to develop and implement science-based crops such as rice, corn, banana, coconut, coffee and cacao, and cropping system management technologies towards maximizing crop yield and minimizing adverse environmental and climate impacts (Espaldon et al., 2017).

Common ICT tools employed in generating desired technologies are geographic information system (GIS), remote sensing (RS), crop suitability maps, sensors, global positioning system (GPS), and computer-aided programs or databases. These tools basically cover the production and conservation of crops with respect to environmental factors such as climate and weather, and pests and diseases.

Sensors/Nanosensors

Moisture sensors (Figure 1) through the SARAI program, which are made of fabricated gypsum block, provide onsite and real-time information on soil moisture condition linked with an early warning system for monitoring water stresses. These can be easily fabricated using the locally available and affordable materials, providing easier access for farmers (Lansigan et al., 2017).

In cacao, a prototype sensor-based instrument was developed to determine the freshness and quality of freshly harvested and wet cacao beans. The features of the said device are as follows: 1) suitable for rapid assessment; 2) non-destructive sampling assessment; 3) portable (could be used easily in the field); and 4) user-friendly. Currently, the fabricated sensor is being calibrated for further testing (Gregorio, 2016).

Similarly, a nanosensor is being developed for early detection and rapid responses to manage fungal diseases commonly present in cacao such as vascular streak dieback (VSD) and black pod rot. With the nanosensors, the detection of the pathogens will be robust and economical for routine analysis, and with accuracy at par with that of DNA-based detection technique (Fernando et al. 2016).

Smarter Pest Identification (SPId)

This online and mobile application can be used for pest identification and management through digital processing or by using photos as shown in Figure 2. It also helps farmers and other users in identifying pests and its corresponding immediate management protocol (Lansigan, 2017).

Coconut Scale Insect Database (CocSID)

CocSID is a web application and decision-making tool for the formulation of management of practices about coconut scale insect (CSI) species (Figure 3). This also serves as source of reference information on CSI to form agricultural policies or develop protection measures for a proactive CSI management program (Yap et al., 2016).
Figure 1. A prototype of Arduino-based soil moisture meter which works with gypsum blocks.

Figure 2. The webpage of SPId technology.
Automatic Weather Station (AWS)

An instrument that is used in measuring and monitoring real-time local weather parameters such as rainfall, temperature, humidity, and wind velocity (Figure 4). The AWS is capable of weather forecasting and can also be used as an early warning system. Information obtained from AWS can help farmers in making informed decisions related to crop planting dates, crop varieties to be planted, and adjustments in farm operations (Salazar et al., 2017).

Unmanned Aerial Vehicle (UAV)

UAV or simply called drone, enhances risk and damage assessments, and creates a strategy to prepare for and respond to distress that affect the livelihood of vulnerable farming communities (Figure 5). This device is equipped with navigation and photogrammetric equipment that generates data-rich maps from aerial photographs, including Normalized Difference Vegetation Index (NDVI), a formula used for assessing vegetation and plant health (Salazar et al., 2017).

Water Support Balanced-Assisted System Irrigation (WAISS)

This is a spreadsheet-based water balance model that incorporates soil, crop, and irrigation data to estimate soil moisture deficit (mm) in the soil in tabular and graphical form (Figure 6). Other information provided includes total available water (mm) in the soil and days to irrigate (Lansigan et al., 2017).

SARAI Enhanced Agricultural Monitoring Systems (SEAMS)

SEAMS uses GIS, RS, and NDVI for monitoring crop growth, crop health and crop loss, and extent of crop damage due to typhoon and extreme weather conditions such as El Niño and La Niña. This system also provides near real-time and site-specific crop advisories (Salazar et al. 2017).

GPS, GIS, and RS

GIS and RS have been utilized in generating maps for crop suitability which serve as decision support tools. These maps are generated by overlaying six (6) different parameters: climate type; temperature; rainfall; soil; slope; and elevation. The resulting maps are evaluated using different crop-specific requirement and are then classified into different suitability levels. For instance, the Cavite State University (CvSU) has produced suitability maps (Figure 7).
for coffee varieties Arabica and Robusta to identify the appropriate sites in the Philippines for planting such varieties (Umali et al., 2017). Similarly, suitable areas for planting ‘Carabao’ mango have been identified through the collaborative effort of UPLB, Bureau of Plant Industry-National Mango Research and Development Center (BPI-NMRDC), Guimaras State College (GSC), and Central Philippine State University (CPSU) (Moscoso et al., 2014).

Aside from generating maps for cropping, these are also done in mapping disease distribution in plant diseases like in abaca (Lopez et al., 2017). The epidemics of abaca bunchy top virus is being recorded using GPS and inputted in a GIS to produce maps of disease intensity and spread. Moreover, the use of an abaca bunchy-top dynamic simulation model called bunchSIM can predict the development of bunchy top as affected by weather changes (Raymundo and Pangga 2011). Mapping disease distribution provides an opportunity to formulate management strategies designed to avoid epidemic infestation.

SARAI has also generated a risk map (Figure 8), which serves as an early warning for pest infestations along with its immediate management practices (Lansigan et al., 2017).

Figure 4. SARAI-installed automatic weather station or AWS in Bukidnon.
Figure 5. Unmanned aerial vehicle (UAV).

Figure 6. Water Support Balanced-Assisted System (WAISS).
Figure 7. Suitability map for *Coffea liberica*.

Figure 8. Risk map showing armyworm infestation in rice areas in Isabela.
**Computer Database**

Part of strengthening the germplasm conservation is through storing of data in a computer-aided database for future reference and inventory of plant genetic resources. UPLB, through DOST-PCAARRD support, is currently developing a database called PHLGRIS, which keeps records of descriptors of certain plant species (Figure 9). PHLGRIS contains all the basic information about a particular plant of interest, which includes common and scientific name, origin, growth habit, morphology, etc. (Huelgas et al., 2016).

Similarly, CvSU has developed a database for coffee germplasm collected nationwide, called Coffee GRIDD (Genetic Information Documentation Database) (Figure 10). This likewise serves as guide for coffee farmers, researchers, students, breeders, and other stakeholders who are interested in coffee. People could easily get access to needed information on specific crops through these databases (Mojica et al., 2017).

Another database called Coconut Genome Database has also been developed by UPLB. It is a local genome database created to store the initially established coconut genome assembly with a fully functional bioinformatics tools such as BLAST, *In silico* PCR, and Jbrowse for maximum utility of the genome sequence database (Figure 11) (Galvez et al. 2016).

Bioinformatics as breeding tools have also been applied in molecular studies in other crops like abaca, rice, mango, and tomato.

**Knowledge Portal**

A web-based collaborative and innovative system which is designed to ensure that relevant, high-priority science and technology generation for climate-smart agriculture will be conducted and uptake of the technologies will be assured (Figure 12). It utilizes different media platforms such as short messaging service (SMS), web-based portal, broadcast radio, mobile applications, and television for information dissemination of Project SARAI. In addition, it aims to gain leverage in intelligent computing paradigms, broadband infrastructure, mobile technology and digital services in making the SARAI program accessible to Filipino people, especially the farmers, extension workers, agricultural scientists, and policy makers (Khan et al., 2017).

Figure 9. The home page of PHLGRIS.
Figure 10. The home page of coffee GRIDD.

Figure 11. The coconut genome database.
CHALLENGES IN ICT: THE DOST-PCAARRD EXPERIENCE

Over the years of implementing projects on ICT, DOST-PCAARRD has encountered several challenges after the technologies have been generated. The progress of generating said technologies is perceived as relatively fast and evident, but seeing them in the application and utilization level is quite vague. This can be illustrated by the common scenario in introducing modern farming technologies like ICT tools among local farmers.

The interplay of dynamic issues especially in mainstreaming these technologies employed a wide range of implications. These include major concern on technology deployment and adoption, integration of technologies in the farmer’s field, accessibility of technologies to end-users, and sustainability of ICT utilization. Numerous factors could influence these complex challenges such as the perception and appreciation of farmers on such technologies, cost in adopting and sustaining such technologies, and the manner by which the technologies have been diffused to the end-users.

In the Philippines, most of the farmers belong to the marginalized sector of economy. When being introduced to a new technology with a promise of improved productivity, it is only logical to expect farmers to adopt. However, the common profile and socioeconomic characteristics of Filipino farmers become a limiting factor to technology adoption. For instance, most Filipino farmers are tenants who do not own the land they are tending. Upon introduction of technology, their immediate concern would be on the cost or amount of money they would spend in adopting it. Hence, investing additional funds to take up modern farming practices become very challenging. Another consideration is the net gain—whether they would gain significant profit, just relatively the same, or breakeven. On the other end, others are just reluctant in adopting new technologies in general.

For some who wanted to adopt these technologies, the constraint would be on how to integrate them with the existing technologies or the traditional field practices. Such situations could lead to complication on the side of the farmers, resulting in eventually choosing the old practices over the new ones.

On the part of DOST-PCAARRD, as the funding agency, similar problem applies. DOST-PCAARRD should also look into closely the whole gamut of technology chain and readily available technologies before pushing forward the proposed initiatives. The kind of researches should also align with the different stages from production until postharvest. Complementation along with integration should co-exist.

Most areas devoted to agricultural activities are concentrated in rural areas which have limited access to market
roads. The farms are usually situated in provinces far from the center of commercialization where transportation is quite difficult. With this, technologies could not be fully disseminated or introduced into supposed beneficiaries. Hence, there is inability to deploy.

Adoption and utilization of technologies are not solely the indicators of a successful transfer of technology. The concern on sustainability closely follows. Experience and literature show that some technologies are only effective for a time, but eventually die out due to lack of funds and sustainability plan. This coincides with the lack of proper knowledge and training on such new technologies. As a more sustainable approach to stimulate technology adoption, policy recommendations must be in place. Since farmers are more receptive to technologies if they observed quantifiable results such as reduction on production cost, there should therefore be a greater emphasis on decreasing costs entailed by these technologies through government intervention. For the ICT tools to be truly effective and useful in smart and precision farming, the numerous drivers of technology adoption should be well taken into account.

CONCLUSION

The advances in ICT come with emerging issues on agriculture particularly on food security and global competitiveness. As part of its S&T agenda and program on smart and precision farming, DOST-PCARRD will continue to implement projects on ICT in improving the agriculture sector focusing on developing decision-support systems which would increase productivity efficiently and at low cost. Moreover, the technologies that would be generated should reduce/mitigate environmental impacts of intensive agriculture. Developing responsive ICT technologies, pilot testing and commercialization of products, building capacity of researchers, and upgrading of facilities are included in the future endeavors of DOST-PCARRD.

REFERENCES


