Precision Agriculture for Rice Production in the Philippines

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ABSTRACT

The Philippine population will increase to 128 million by 2030 and 142 million by 2040 based on medium assumptions using the year 2000 census. With the new rice tarrification bill and influx of cheaper imported rice, the concomitant reduction of domestic rice prices from USD 0.80 per kg to USD 0.70 will increase the annual per capita milled rice consumption from 110 kg to 114 kg, which can be translated to a national total demand increase from 13.91 million tons in 2019 to 15.88 million tons by 2030. This will put more pressure to increase rice production amidst the shrinking agricultural lands, ill effects of climate change and changing fossil fuel economics. Precision agriculture holds greater opportunities to boost local rice production especially with the use of information and communication technologies (ICT). The twin national programs of Philippine Rice Information System (PRISM) and Rice Crop Manager (RCM) had placed pivotal roles in monitoring rice production performance using satellite technology, and recommending precise nutrient management in specific farms. The Philippine Rice Research Institute (PhilRice) in its Strategic Plan for a “Rice secure Philippines” has a number of ICT initiatives: A rice information portal contains key executive information related to rice production; Android mobile applications were developed namely, AgriDoc for farm management, eDamuhan for weed identification and control employing artificial intelligence, Binhing Palay for varietal information and MOET App for fertilizer recommendation; drones or UAVs were shown effective for seeding, fertilizer application and chemical spraying; internet of things (IOT) installations as part of smart farming were used for irrigation control, and environmental monitoring in the field and seed warehouses. While technologies abound at different scales of effectiveness, working systems of components workable in specific locations are much desired especially at the farmer’s level where economic sense holds greater importance. The challenge to increase food production at competitive prices is still the main agenda for the realization of Philippine Agriculture 4.0.

Keywords: information and communication technology, smart farming, artificial intelligence

Introduction

The Philippines ranked eight in world rice production in 2013, but in terms of volume of importation, the country places second after Indonesia. Because rice is the staple food to most of the 100.98 million Filipinos (PSA, 2015), the average per capita consumption stands at 110 kg per year (PSA, 2018), and it has become a highly political crop as a barometer for food sufficiency for the country. The present population is projected to grow to 128 million by 2030 and 142 million by 2040 based on medium scale assumptions (PSA, 2015). In 2017 the domestic production output met 93% of the total domestic requirement. This had prompted the Philippine government to create programs to address the food gap and
address socio-political stability.

The overall vision and mission of the entire rice industry is anchored in the national goal of availability, affordability and accessibility of safe and nutritious rice as food for all Filipinos that defined the “Rice Secure Philippines” vision (Department of Agriculture, 2018). A roadmap was drawn to achieve a competitive, profitable, resilient and responsive rice industry in spite of the political and economic background pervading the country. Strategic interventions had been defined not only in the national level but also in the provincial level while accounting for the current state such as the productivity of the rice areas, prevailing costs of production, food demand of the population, and presence of trading ports and logistics infrastructure.

Rice is being produced in 4.8 million hectares with a total production volume in 2018 of 19 million tons. The provinces of Nueva Ecija in Central Luzon and Isabela in Cagayan Valley are the top producing provinces. The average yield is about 5.68 metric tons per hectare during the high production season (dry season) and about 3.84 metric tons per hectare in the low production season (wet season) (p. 91, Bordey et al., 2016). The most popular variety is NSIC Rc222 because it is high yielding reaching as much as 7 metric tons per hectare or more. The aromatic NSIC Rc160 and NSIC Rc216 is also popular mainly because of its good eating quality and can command higher prices.

The economics of fossil fuels affect not only the domestic retail prices of diesel (currently at $0.75-0.80 per liter) that is commonly used in most farm machinery operation, but also the costs of fertilizers and agro-chemicals. In turn, either the farmers decide to put lesser sacks of fertilizers into the field or bear the higher production costs, which they hopefully to recover from better selling prices at harvest time. Because of increasing population and demand for shelter, new residential areas are constantly being built in the productive irrigate rice lands despite the presence of national laws against re-classification of agriculture lands into residential, commercial or industrial zones. Furthermore, the widening of city or town limits also encroach into the productive lands that some people are heavily against for the construction of diversion or circumferential roads that cut across rice paddies that supposedly ease commuting traffic in the town centers. In turn, these good roads hasten the conversion of rice farms into commercial areas within shorter time frames.

Another main concern is the recently enacted law RA11203 or “An Act Liberalizing the Importation, Exportation and Trading of Rice, Lifting for the Purpose the Quantitative Import Restriction on Rice, and Other Purposes” Philippine Rice Tariffication Law (Philippine Congress, 2019) that removed the quantitative restrictions to imported rice and maintained a tariffication level of 35% for rice imported from ASEAN member countries. With the new rice tariffication bill and influx of cheaper imported rice, the concomitant reduction of domestic rice prices from USD 0.80 per kg to USD 0.70 will increase the annual per capita milled rice consumption from 110 kg to 114 kg, which can be translated to a national total demand increase from 13.91 million tons in 2019 to 15.88 million tons by 2030. Furthermore, with the implementation of the new bill, the local farmers were too concerned with the influx of cheaper rice from abroad, which is feared to might pull down the local farm gate prices of paddy. The farmers need to be more competitive by increasing their productivity of their farms and lowering the production costs so that they could compete well even if the buying prices will be reduced (Bordey et al., 2016).

The use of information and communication technologies (ICT) can greatly improve the production and economic efficiencies of the rice industry. This could range from improved decision making in seeds, fertilizer utilization, crop care, machinery operations, and getting better marketing arrangements. The old adage of precision agriculture that goes “right technology for the right location in the right time” is still
very relevant. There had been a number of precision agriculture technologies implemented in the country largely to assist farmers in decision making in their crop management or provide executive information to decision makers. While these technologies are ICT-based to enable rapid data acquisition, processing and formulation of insights and decision points, there is a great need to make these technologies work in the ground and to have a wider scope of utilization. Some of these technologies that are discussed in this paper are the following:

1. PRiSM - The Philippine Rice Information System
2. RCM - The Rice Crop Manager
3. Mobile applications
4. IOT - Internet of Things
5. Drone technology

**PRiSM**

The Philippine Rice Information System (PRiSM) is a collaborative project among the Department of Agriculture (DA)-Philippine Rice Research Institute, the International Rice Research Institute (IRRI), DA-Bureau of Plant Industry (BPI) and DA-Regional Field Offices (Fig. 1), which aims at developing a monitoring system in terms of scale and intensity of rice production in the whole Philippines in support of strategic decision making, resource allocation, and application of interventions. It also provides a rapid and systematic assessment of the impacts of significant events such as flooding caused by typhoons and drought brought by the El Niño. The system collects multi-temporal Synthetic Aperture Radar (SAR) images (about 641 to 918 images every semester) from Sentinel 1 and TerraSAR-X satellites (Fig. 2) to map out the rice growing areas (Figs. 3 and 4), which was effective even in extensive cloud cover. Additionally, the process-based crop model Oryza2000 was used to estimate actual yields. Ground calibrations had been made as to the presence of rice plantings and for grain yield assessment (Fig. 5).

![Figure 1. The operational framework of the PRiSM Project.](image-url)
Fig. 2. Satellite data are acquired from the Sentinel 1 and TerraSAR-X satellites consisting of about 641 to 918 images every semester.

Fig. 3. The 2018 first semester rice areas of the country.
Fig. 4. The 2018 first semester rice areas of Central Luzon (Region III), the highest producing area.

<table>
<thead>
<tr>
<th>Province</th>
<th>Rice area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aurora</td>
<td>8,480.00</td>
</tr>
<tr>
<td>Bataan</td>
<td>9,940.00</td>
</tr>
<tr>
<td>Bulacan</td>
<td>23,632.00</td>
</tr>
<tr>
<td>Nueva Ecija</td>
<td>171,772.00</td>
</tr>
<tr>
<td>Pampanga</td>
<td>65,679.00</td>
</tr>
<tr>
<td>Tarlac</td>
<td>63,722.00</td>
</tr>
<tr>
<td>Zambales</td>
<td>17,458.00</td>
</tr>
<tr>
<td>Total</td>
<td>396,885.00</td>
</tr>
</tbody>
</table>

Fig. 5. Ground truthing points collected in the entire Philippines.

The Rice Crop Manager
The Rice Crop Manager (RCM) is a decision-making tool (Buresh, 2015) developed by the International Rice Research Institute and piloted in the Philippines that provides irrigated and rainfed lowland rice farmers with personalized crop management recommendation (Fig. 6). The application may be accessed through smartphones would require the farmer to answer a series of questions about his farm, then the data are sent to a central server. A set of crop management recommendations are then presented such as fertilizer, seeding rates, weed, crop health, and water management. RCM can increase realizable yields and may add further economic benefit especially when farm lots normally yield below 7 metric tons ha\(^{-1}\). The app is envisaged to be used by extension workers, crop advisors, and service providers, and is now also used in Bangladesh, India, Indonesia and Vietnam.

**Fig. 6.** The opening screen of the Rice Crop Manager application.

**Smartphone Apps for Rice Production**

PhilRice is constantly promoting the use of applications that took advantage of the capabilities of smartphones. AgRiDOC, eDamuhan, Binhing Palay and MOET-App are Android-based smart phone applications that were recently developed and released by PhilRice. The AGRiDOC application (Fig. 7) is a farm management app funded by the project titled “Improving Technology Promotion and Delivery through Capability Enhancement of Next-Gen Rice Extension Professionals and Other Intermediaries (IPaD)” that basically trained agricultural extension agents, and the FutureRice Program (PhilRice, 2015). It provides recording of farm activities, crop management recommendations based on the PalayCheck System that PhilRice is promoting, and geo-visualization of the farm extents.
Fig. 7. (a) AgriDoc provides (b) crop management recommendations, (c) farm visualization, and (d) recording of farm activities.

The eDamuhan (or eWeeds) app allows quick identification of weeds and their consequent management (Fig. 8). A photo of the weed is taken using the phone’s camera and sent to a central server that extract key image properties of the weeds. Using an artificial intelligence-based TensorFlow, the top matching weed species in the database are presented to the user which the user will select the closest. The app will then present more information of the weed species and its proper management. The Binhing Palay or Rice Seeds App contains the agronomic and grain quality characteristics of the different rice varieties in the Philippines such as information on grain yield in tons ha$^{-1}$, plant height in cm, no. of tillers, planting maturity in days, milling potential, grain size and shape and amylose contents as indicator of eating quality (Fig. 9).

Fig. 8. The eDamuhan is an artificial intelligence based application for weed identification and control management.
Fig. 9. The Binching Palay app provides agronomic and grain quality characteristics of different rice varieties in the Philippines.

Another app that PhilRice promotes is the mobile MOET-App (Fig. 10). It is based on the Minus-One Element Technique wherein about seven potted rice plants using the farm’s composite sampled soil receive nutrient sachets each of which is missing one key element. For example the -N (minus N) will provide all the needed nutrients except for nitrogen. The plant’s growth response can be easily seen after about 40 to 50 days so that farmers know which nutrient element should be added into his fertility management scheme. The MOET-App gets the biomass yield for each pot and correspondingly recommend the fertilization rates while removing the guess work the farmer has to make.

Fig. 10. The MOET-App or Minus-One Element Technique is an Android-based app that computes for fertilizer recommendations and yield estimates based on the pot-based fertilizer trial to identify significant nutrient elements lacking in the soil.

All of these applications are now available for download in Google Play Store and is being promoted in the social media. The effectiveness of these apps are yet to be gauged but this had already gained the enthusiasm of the younger generations of farmers who are keen on the use of smart phone technologies in their farming.

Unmanned Aerial Vehicle

The Unmanned Aerial Vehicle or better known as the drone technology had been a potent approach for precision agriculture. Because of its agility and relative freedom from obstructions in the air space, it can quickly move between point with great ease. The fixed wing type has an advantage of longer fly times suited for reconnaissance operations such as field mapping of crop status and post-typhoon disaster assessment. The other type, multi-rotor drones can have high payload capacity that aside from moving
between points and focusing on areas of interest, it can do some farming operations, which is now PhilRice is exploring. With partnership with a private company, New Hope Corporation, demonstrations (Fig. 11) for rice seeding, chemical spraying, and fertilizer application had been successfully conducted in 2018 (Reyes, 2018). A rice direct seeding rate of less than 20 kg ha\(^{-1}\) had been achieved which was half of the recommended 40 kg ha\(^{-1}\) for inbred rice varieties. Seeding at this low rate was very difficult especially if done manually. Thus, drone application for hybrid rice would be a certainty because of the high cost of these seeds. The fertilizer application was also done using urea fertilizer but because of the hygroscopic characteristics of urea, significant corrosion occurred in the drone’s delivery system. The chemical spraying was the first feasible operation for drones. Another potential use of drones that was explored by PhilRice is aiding in the pollination of hybrid rice parentals during the F1 seed production. The shear wind from the rotors can easily detach and transport the pollens from the male parental to fertilize the female parental. Alternative to the usual shaking of the plants manually or using long stretches of rope, the drone can quickly do the operation in lesser time with the same level of effectiveness.

Fig. 11. The New Hope Corporation demonstrates their agricultural drone for farming operations.

But there are some issues confounding the use of drones in agriculture. Firstly, the Philippine laws require the operator to get a licensed as aviation pilot, thus the operator must undergo stringent training and achieve flight time requirements before applying with the Civil Aviation Authority of the Philippines. Secondly, there is a maximum flight height of 121 m (or 400 ft) thus limiting the sweep area per pass of the drone. Finally, flying the drone at night is also prohibited. There was an interest to do the chemical spraying at night because the insects normally come out after sunset. By limiting the drone only to daytime flights, service providers will not be able to take advantage of this nocturnal insect behavior wherein we could have more effective approach for insect control. Getting the drone services require payment of about $20 ha\(^{-1}\), which is already quite cost effective because of savings in material costs (seeds, fertilizer, chemicals), timeliness (compared if manually done) and reduced drudgery. Recently, a number of drone service providers had come out offering the same set of services.

**Internet of Things**

Real-time remote wireless acquisition of data is a solution desired by research and government agencies to address the timeliness of data delivery and insight generation, loss of data integrity and reduced overall-cost. This used to be confined among the people possessing electronics and programming skills particularly the electronics and communications engineers, who are more eager to work with consumer and industrial applications. Quite recently with the success of open source technology expounded by Arduino, internet of
things or IOT had become more visible and its applications to agriculture can transform the measurement and control landscape of food production. In PhilRice, demonstrations on the use of wireless sensor network was done in a demonstration Future Rice farm that records temperature and relative humidity, water quality EC and pH measurements and recently for irrigation control. Initially, Zigbee modules were used but later found to be limited because of short communication distance and expensive modules. The switch to Arduino based had enabled the use of interface modules or shields which were cost effective and plentiful. Recently, WiFi technology based on the WeMos platform made it more cost effective and easier as long as a sufficiently strong WiFi signal is available. This has been explored for monitoring seed warehouses micro-environment. The Philippine government had lately chosen a third telco player to enter the communications market, which would intensify competitions to deliver the next 5G technology. This would make IOT more pervasive not only for monitoring and control but also for robotics and the use of artificial intelligence driven applications.

**SUMMARY**

In summary, rice being the staple food for most Filipinos, is being affected by critical factors of climate change, rising fuel prices, and shrinking and degrading agricultural lands. The recent socio-political developments such as the lifting of quantitative restriction will put greater pressures to the rice farmers to become competitive by increasing his productivity and reduce the costs of production. There are many technologies to bring competitiveness in the countryside. This could range from better high yielding plant varieties and appropriate farm mechanization. Precision agriculture with the use of ICT in specific farm areas will bring about a new level of technology to reduce costs, improve efficiency and provide insights for improvement. While the extent of use is yet very limited, but this is churning interests especially for the young farmers and make them realize that rice agriculture is not just dirty work, but can be made smarter with the use of advance technology. This will lead to the realization of Rice Agriculture 4.0 for a better future Philippines.

**REFERENCES**


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