PAVING THE PATHWAY FOR CLIMATE SMART AGRICULTURE AMONG SMALL SCALE FARMERS IN THE PHILIPPINES

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ABSTRACT

The climate variability and extreme events that the Philippines is currently experiencing should compel people to rethink our ways of doing. For the Philippine agriculture sector, one of the many ways to adapt to climate change and risks associated with it is to make science and technology work for Filipino farmers. This paper presents the endeavor to develop and deploy the technologies of the action-research program "Smarter Approaches to Reinvigorate Agriculture as an Industry in the Philippines (Project SARAI)." Project SARAI is anchored on harnessing a proactive monitoring and forecasting system with the ultimate goal of providing farmers with site-specific and near real-time crop advisories. The monitoring and forecasting system uses Geographic Information System (GIS), remote sensing, crop modeling, and field validation activities. This system is able to develop and provide recommendations on daily farm issues such as pests and diseases, crop-water stress, crop-weather recommendations, and nutrient and soil dynamics. Project SARAI is currently being mainstreamed in and adopted by the Department of Agriculture (DA) Central Operations, Region 3, and Region MIMAROPA.

Keywords: Monitoring and forecasting, GIS, crop advisories, farm recommendations, project SARAI

Profile of Filipino farmers

Globally, the intensification of disasters and climate hazards has been elevating. Climate change has already manifested its harmful effects on the environment. The Philippines is among the countries highly exposed and vulnerable to climate change. The vulnerability varies across regions, sectors, communities and at individual level. At the national level, the services sector had the highest number of workers followed by agriculture then the industry. In 1995, there were more agricultural workers than the services sector; however, the severe El Niño during the period of 1995-1996 have dropped the number of agriculture workers since then. The decline in the employment in agriculture was associated with the increase in the number of employments in services and industry. Moreover, the daily basic pay in agriculture was the lowest among the sectors.

Based on the report of Philippine Statistics Authority (2018), there were 11.3 million agricultural workers in 2015 where 74.25% were male and 25.75% were female. Majority (61.5%) of the agriculture workers belong to the prime working age bracket. Among the three sectors, agriculture had the highest number of older and elderly workers. Most of the young workers were in industry while the prime working age were in services. In terms of educational attainment, most of the least educated sector were in agriculture where 28% have only obtained tertiary undergraduate and graduate as compared to industry and services at 60% and 74%, respectively. The report also revealed that majority (62.4%) of the poor employed workers were in the agriculture sector.

At the regional level, most of the agriculture workers were concentrated in Western Visayas (10.37%), Central Visayas (7.95%), and ARMM (7.74%). It is interesting to note that the real wage rate of these regions was below the middle and below the nominal wage rate despite the high number of employed farmers. This may be associated with the incomplete schooling up to secondary education at 73%, 81%, and 78%, respectively.

Contribution of agriculture in the national economy

Stressing the importance of enhancing climate resilience, agriculture is continuously growing in size of its contribution to the national economy. For the first quarter of 2018, the agriculture sector accounted for around 10.1% of the national Gross Domestic Product (GDP) in current prices; where Php 252.2 billion pesos or around 57% is from the crop subsector. The subsector share has grown from the past first quarter numbers of the last 2 years being 48% and 52%. This is then related to the growth of the whole agriculture sector in general which has grown from the last 5 years by 30%. Different crops have been identified to contribute to this growth some of which are from priority crops included in project SARAI. Crops included in the program that have positively contributed to the increase in agriculture sector GDP for the first quarter of 2018 are banana and corn while those that decreased it are sugarcane and tomato. These effects on the national output are attributed to price changes but it is still largely acknowledged that causes of fluctuations in production volume are weather and climate related disturbances. The most common and destructive disturbance of which would be the presence of typhoons that decrease output at the quarter the event is recorded on and could increase eventual production. However, occurrence and increase in frequency of strong rainfall and typhoons also significantly affect production volume. A specific example is palay production in Central Luzon, Region IV-MIMAROPA, and SOCCSKSARGEN has increased in the same period, first quarter of 2018, and this was seen to have occurred because of favorable weather conditions as partnered with ideal seed varieties. In showing how production may increase after a period of unfavorable climate conditions, coconut production in the Davao Region has improved after experiencing dry episodes in 2016.

Another purpose of giving importance to the sector's resilience is the large portion of the nation's population employed in it despite the sector having the smallest share in the national output and also being the most vulnerable. The vulnerability varies across regions, sectors, communities and at the individual level. At the national level, services sector had the highest number of workers followed by agriculture then the industry. In 1995, there were more agricultural workers than the services sector; however, the severe El Niño during the period of 1995-1996 have dropped the number of agriculture workers since then. The decline in the employment in agriculture was associated with the increase in the number of employments in services and industry. Moreover, the daily basic pay in agriculture was the lowest among the sectors.

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Paving pathways for Climate-Smart Agriculture (CSA): The case of smarter approaches to reinvigorate agriculture as an industry in the Philippines (Project SARAI)

Climate-Smart Agriculture (CSA) is a defined as approach to develop the enabling mechanisms in terms of technical, policy, and investment conditions to achieve sustainable agriculture development in the context of food security in a changing climate (Food and Agriculture Organization, 2013). As a sustainable mechanism to agriculture development, CSA is anchored on three pillars: increase productivity, enhance resilience and adaptive capacities of livelihoods and ecosystems, and reduce greenhouse gas emissions (FAO, 2013). In 2013, an action-research program dubbed as Smarter Approaches to Reinvigorate Agriculture as an Industry in the Philippines (Project SARAI) was funded by the Department of Science and Technology – Philippine Council for Agriculture and Aquatic Resources Research and Development (DOST-PCAARRD), and was led by the University of the Philippines Los Baños (UPLB). Project SARAI aims to establish a real-time crop monitoring and forecasting system for rice, corn, banana, coconut, coffee, and cacao. The system uses crop models, ensemble of weather and climate data, real-time weather data, remote sensing, geographic information system (GIS), and field monitoring reports to come up with near real-time crop monitoring information, and seasonal crop forecast. Examples of real-time crop monitoring information include site-specific crop growth stage, crop health, weather and crop relationships, and possible pest and disease infestations.

In 2018, Project SARAI was granted a Phase 2 to continue its research work, and strengthen its capacity building and extension efforts. The phase 2 of the program covered new crops to be included in the system – sugarcane, tomato, and soybean. Project SARAI also included in its framework other DOST-PCAARRD funded research Drought and Crop Assessment and Forecasting (DCAF). With DCAF on board, Project SARAI can now establish crop and drought indices, and provide near real-time crop-drought forecasts to local government units (LGUs), state universities and colleges

(SUCs), and farmers. Currently, the program is working closely with 11 co-implementing SUCs and four partner national agencies to establish SARAI community hubs.

Contributing to the national CSA initiatives

The country already has several CSA initiatives such as Philippine Rice Information System (PRISM), Strengthening Implementation of Adaptation and Mitigation Initiative in Agriculture (AMIA), among many others. These initiatives focus on developing CSA technologies for rice, corn, and starting works on high value crops. Project SARAI contributes to the national efforts in terms of prioritizing the country's emerging industry for perennial crops.

On another level, Project SARAI contributes to the national CSA movement by providing a complementary proactive monitoring and forecasting system. The country's current agricultural monitoring protocol and operations are handled by the Philippine Statistics Authority (PSA). PSA is the mandated central agency for the primary statistical data collection, including that of agricultural data and processes. On June 5, 2017, PSA has released an updated conduct of four surveys on agricultural crops, namely:

1) 2017 Palay and Corn Production Survey (PCPS);
2) 2017 Palay and Corn Stocks Survey (PCSS);
3) 2017Monthly Palay and Corn Situation Reporting Problem (MPCSRS); and
4) 2017 Crop Production Survey (CrPS) (PSA, 2017).

All these monitoring protocols are done through farmer surveys on a quarterly basis. The survey method is not invalid; however, the survey methodology needs a complementary methodology to increase its accuracy and effectiveness (Cai *et al*., 2017). Project SARAI can provide a near real-time monitoring information using remote sensing and GIS. These pieces of information can be used to validate field monitoring data, and can also be used to compute for damage assessment after typhoons and other extreme weather conditions.

SARAI community-based CSA technologies and practices

At a community level, Project SARAI provides rich opportunities for communities to start adopting CSA frameworks, technologies, and practices. Project SARAI is currently establishing SARAI community hubs to be operated by SUCs, in partnership with LGUs. The community hubs are envisioned to serve as the go-to venue of farmers where they can report real-time farm problems such as pest occurrences, post questions on site-specific nutrient management, and discuss with other farmers about their experiences on adopting SARAI technologies.

Advancing the agriculture sector with technologies and innovations

1. Promoting a proactive agricultural sector through the SARAI-Enhanced Agricultural Monitoring System (SEAMS)

According to PAGASA, the Philippines is visited by an average of 20 typhoons annually because it is located in the Pacific Typhoon Belt. The Agriculture Sector suffers significant damage due to these extreme weather conditions. In 2018, NDRRMC reported crop losses of 8.96 billion pesos to rice and 4.49 billion pesos to corn due to Tyhoon Ompong (International name Mangkhut) alone. When it comes to these situations, Filipino farmers feel helpless when strong winds and intense rains cause severe damages to their crops. The Food and Agriculture Organization reported that agriculture monitoring and forecasting is a helpful tool in the context of food security by enabling the agriculture sector with crop-weather information making them climate resilient.

By utilizing information from advanced technologies from geographic information systems, remote sensing, and historical agrometeorological data, The SARAI-Enhanced Agricultural Monitoring System (SEAMS) is able to produce near real-time information on crop area, stage, and status throught the use of normalized difference vegetation index (NDVI). Monitoring of crop production areas is particularly useful in the national, regional, provincial, down to the farmer level. By providing crop-weather information and advisories to stakeholders on the occurrence of extreme weather conditions such as typhoons and droughts, the system can serve as an agricultural early warning system. Furthermore, SEAMS can also be used as a damage assessment tool for local government units enabling them to better allocate government resources in times of severe weather disturbances. Also, timely crop-weather advisories can help farmers adjust their daily farming activities to minimize the effects of climate change to their production by allowing farmers and other stakeholders to create better decisions in terms of daily farm activities. Farmers will be able to improve resource utilization, efficiency, and reduce crop losses therefore increasing their resilience to climate variability.

The system is currently being refined by improving its data gathering protocols through the involvement of farmers and farmer groups. This can be achieved through the encouragement of farmer field reporting. Agricultural information gathered from the ground is a significant input to the generation of crop advisories and forecasts.

2. Improving crop protection using the smarter pest identification technology (SPId Tech)

One of the primary concerns of Filipino farmers is the occurrence of pests and diseases which is a common problem when it comes to crop production. Pests and diseases infestation often result in significant crop losses. The typical response of farmers is the use of chemical pesticides which is generally not sustainable because pests and diseases develop resistance to these chemical compounds. Crops can be protected using other management practices, however, proper identification of pest and diseases is important for them to be effective. To address this, Project SARAI developed a pest and diseases identification by utilizing recent advances in image processing and machine learning technology. The Smarter Pest Identification Technology (SPId Tech) is a mobile and web-based application which allows users to quickly identify pest and diseases. The application also has the capability to recommend management protocols and remotely report agricultural pests and diseases.

Mobile pest and disease identification

The Insect Pests and Diseases Identification can recognize pests and diseases through the following:

- **Capturing live image using built-in phone camera**

This allows the user to remotely capture images of unfamiliar pest/disease that are present in their farms and indicated which crop is infested. The result will show the list of possible identified pest/disease with the indicated level of accuracy. The application will provide the basic information such as common name, Filipino name, scientific name, and description. Further, it also provides damage characteristics and management practices on how to control the pest.

- **Uploading image from the gallery or phone storage**

This works by selecting an existing photo stored in the phone gallery. Once uploaded, it will follow the same procedure as taking a live picture.

- **Taking a dichotomous key quiz**

A dichotomous key is a tool that allows the user to identify the identity of unknown pest/disease by answering a series of description choices which leads the user to the correct name of the pest/disease. However, this feature is still under development.

- **Pests and diseases library**

The Pests and Diseases Library is a compilation of the most common pests and diseases of SARAI priority crops. Users can manually search for pests and diseases depending on their crop grown. The application provides relevant information for each pest and disease including interventions on how to employ proper pest and diseases management. This feature is currently being updated to improve user experience.

SPId Tech aims to aid Filipino farmers to be more resilient to pest and diseases attacks especially now where erratic climate conditions lead to unpredictable occurrence of pests and diseases. The application provides the farmer the advantage of early detection and real-time help which helps them avoid further crop damage and losses.

3. Understanding coffee and cacao crop phenology for a better integrated management

The Food and Agriculture Organization reported in 2016 that the average yield of coffee and cacao in the Philippines is around 500 kg/ha. This yield figure is significantly lower than reported yields in other neighboring countries which is around 2.0-4.6 tons/ha. Although there are recent efforts by the Department of Agriculture and other organizations to revive the coffee and cacao industry in the Philippines, we are still challenged by low productivity due to pests and diseases infestation, declining soil fertility, unpredictable agrometeorological conditions among others. By understanding crop phenology for perennial crops like coffee and cacao, development of effective farm management practices that suit our climatic conditions is possible. The most feasible strategy is through Integrated Crop Management (ICM), which involves the incorporation of modern and enhanced technology to the traditional farming systems. ICM combines different crop production and management strategies in order to maximize yield while maintaining economic balance and environmental sustainability.

ICM practices on Coffee and Cacao

- **Rejuvenation**

This is done through the cutting of vertical stems of aging and unproductive trees. This is a widely accepted practice in reinvigorating coffee farms and is reported to a more viable strategy rather than replanting. The aim of Project SARAI is to convince coffee farmers that rejuvenation is a sustainable practice to significant increase productivity.

- **Fertilization**

Studying coffee and cacao phenology using the BBCH scale will identify the crucial stages in which fertilization is most required. The required nutrients can be supplied with urea (46-0-0), solophos (0-18-0), and muriate of potash, MP (0-0-60). Fertilizers are applied in a ring 50 cm from the base of the tree in 2-3 splits beginning at anthesis and every 2 months afterward.

- **Pruning**

Pruning is done to (a) control the tree geometry; b) to remove damaged and unproductive parts; c) to provide easier access to the plant for other management activities; d) to inhibit pest and disease occurence; and e) to promote the growth of productive branches. This is usually done between after harvest and before flowering.

- **Shade management**

Too much shade imposed by intercropped trees can encourage abnormal tree growth which affect tree geometry and make it more difficult to control plant growth and perform farm activities. Proper maintenance of shade trees should also be observed to monitor the light received by coffee and cacao trees.

- **Cover cropping**

The use of cover crops such as *Calopogonium sp*. and *Arachis pintoi* can prevent soil erosion because these plants develop a strong mat of rooted stolons thus, suitable for conservation of soil in steep slopes. Being leguminous plants, they help condition the soil by promoting the production of nitrogen and other soil nutrients.

- **Pest and diseases management**

The encouragement physical and biological pest and disease management such as traps and parasitoids can reduce the use of chemical pesticides which makes the system more environmentally sustainable.

- **Harvesting**

Harvesting is one of the most labor-intensive activities in coffee and cacao production. Using the appropriate harvesting method in coffee involves selective picking of ripe berries rather than strip harvesting. This method produces higher quality beans which also minimizes losses in the processing of green coffee beans.

- **Primary processing**

Following the most suitable method of processing can dictate the final quality and market price of the processed green coffee beans and cacao beans.

4. Good agricultural practices: Rehabilitation strategies for banana

Growth and development of banana heavily depends on weather and climatic condition in order to produce good yields. The presence of extreme weather conditions such as typhoons leaves banana plants very susceptible to crop damage. In 2012, the Department of Agriculture reported that typhoon "Pablo" (international name Bopha) caused about 7.4 billion pesos crop damage to banana alone in the Mindanao area. This is due very strong winds and flooding due to heavy rains. It is also important to note that the recovery process will be slow because banana takes a full 9 months from replanting to harvesting. This could greatly hamper the banana industry and could result into further revenue losses.

A banana rehabilitation program is being proposed by Project SARAI Banana Group to give support to the typhoon-struck banana production areas. The rehabilitation program utilizes good agricultural management practices (GAMP).

- **Fertilizer management**

Appropriate fertilizer management is crucial in the rehabilitation program. The result of the rehabilitation process heavily depends on the strict compliance of farmers in the schedule and rate of fertilizer application.

- **Water management**

Banana is known for its rapid growth and high water consumption. Carr (2009) noted that water is probably the most limiting non-biological factor affecting banana production. Banana has a average daily water requirement of 3.6 mm rainfall (Bassoi, *et al*. 2004). For areas with pronounced dry periods, efficient use of irrigation system is recommended.

- **Population management**

For newly established banana farms, pruning shall be done as soon as possible after third month from planting to select potential follower. Desuckering, thinning, or re-planting shall be done to control the plant population in the farm. In permanent plantations, the population shall be 1 mother plant and 1-2 sucker(s) ratio.

- **Crop protection**

Regular monitoring is done to check for any presence of pests and diseases and suggest implementation of intervention, treatment, and eradication of infected banana plants. Weed control can be done either manually (slashing bolos and sickle), mechanically (weed cutter), cultural practice (mulching) and chemical application (FPA-approved herbicide only). Stem and mat sanitation are done by removing dead leaves and sheaths to minimize the chance of insect infestation. Also, regular sanitation of tool and equipment used in farm operations shall be observed to prevent the spread of unwanted diseases.

Due to financial constraints, it is important for banana farmers to receive fertilizer support specially during the rehabilitation process given the significant contribution of banana to the Philippine economy and income of small farmers. The development of crop insurance for banana would allow risk management to enable banana farmers to immediately rehabilitate their crop after a devastating typhoon.

5. SARAI crop suitability maps

The crop suitability maps developed by Project SARAI aims to evaluate the agricultural lands in the Philippines according to the soil, rainfall, and temperature requirements of agricultural crop commodities such as rice, corn, coconut, banana, coffee, and cacao. The generated maps can be used by farmers, policy and decision makers, and entrepreneurs in planning and development of agricultural lands.

6. Maize nutrient expert

The Maize Nutrient Expert was developed with collaboration with the International Plant Nutrition Institute. Project SARAI enhanced the system by providing a digital platform for the technology. The system can provide the user with a comprehensive farm analysis including site-specific fertilizer rates and profit comparison between farmers' practice and recommended practice.

CONCLUSION

The challenges of climate change and food security is global in scale. It requires the agriculture sector to be adaptive and be able to mitigate the effects of changing climate to agricultural production. Climate-smart agriculture is aiming to (1) increase agricultural productivity and income through sustainable agriculture; (2) build an adaptive and resilient agriculture sector; and (3) explore ways to reduce greenhouse gas emissions (Willams, *et. al.,* 2015). The goal is to identify the most suitable combination of strategies in terms of local climate, physical characteristics, and socio-economic condition. However, large-scale implementation demands an immense amount of investment, and requires support from various stakeholders from the national down to the farmer level, and from various sectors, with emphasis on the necessary involvement and commitment of private sector.

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