APPLICATION OF COMMON INFORMATION PLATFORM AND AGRICULTURAL MANAGEMENT SYSTEMS “I PLANT” FOR CONSUMER FRIENDLY FOOD PRODUCTION IN TAIWAN

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ABSTRACT

The agro-product traceability system is considered an approach that may lead to create product differentiation in the market, elevate product competitiveness, and bring about better production and consumption environment for agro-products in Taiwan. Through the integration of self-monitoring by agro-product operators, verification of product sources by distributors, feedback from consumers and government oversight with regulation, the local agricultural sector is able to promote the effectiveness of Taiwan’s agro-product traceability system and help to differentiate these products in the market. “Smart Agriculture (SA)”, a 6-year program initiated by the Council of Agriculture in 2017 and based on sensor/sensing technology, intelligence robot, internet of things (IoTs) and big data analytics, is expected to build smart production, marketing and digital service systems to efficiently enhance the whole agricultural productivity and capacity. Furthermore, it is anticipated to build an active, all-purpose agricultural consumption/service platform to increase customer’s trust for food safety by completing the program. In SA program, a common information platform which uses the Open Application Programming Interface (Open API) to connect with a range of existing application databases has been established. According to the the food safety policy, all primary and secondary schools need to use traceable agricultural and aquaculture products tagged with the information of the “4 Labels and One QR Code (4L1Q)”. The Campus Food Ingredients Registration Platform of the Ministry of Education can get food safety information daily from the common information platform by Open API mechanism to ensure safety of campus lunch. The agriculture management system “i-PLANT”, using technology of geographic information system (GIS), IoS and aerial photography, as well as cumulative agricultural experience and the information recorded via the APP of crop production. That is, “i-PLANT” combines environmental layer nesting with data services for field production risk management and decision analysis. It promises a new type of “agriculture service industry”, which allows farmers to cultivate and record field data more easily and also enables consumers to eat with confidence for food safety. Moreover, the relationship between agricultural operations and food can be further strengthened by the system, connecting the upstream agricultural production and middle or lower reached logistics sales to smart agri-food supply chains.

Keywords: Smart agriculture, Common information platform, Big data, Agriculture management system, i-PLANT.
As a net food-importing country, the calorie-based food self-sufficiency rate is relatively low (ca. 32%) in Taiwan, and is therefore very sensitive to factors affecting food production and supply. Occasionally, food shortage due to extreme weather events caused by rapid climate change would lead to higher food prices. Like all developed countries worldwide, Taiwan faces the problems of aging population and a declining birth rate. There is also potential risk to food production. To improve such situations, modification of industry structure and innovation of technological development are necessary to increase agricultural productivity.

Because of shifts in consumption behavior and the newly evolved technologies, cross-industry alliances and innovative marketing models are needed to be established in conjunction with existing value chains for improving agricultural industry and its structure. When new products, advanced technologies and marketing patterns are developed, it will push forward current agricultural value chains to reach to a new realm. With that, small-scale farming economy may have a chance to transform into an internationally competitive agribusiness. It could also overcome the predicament of small farmers struggling singly and increase their efficiency and capability of farming activities.

To enhance farming management and efficiency, a 6-year Smart Agriculture (SA) program has been initiated by the Council of Agriculture (COA) of Taiwan since 2017 (Fig. 1). It incorporates sensor/sensing technology, intelligence robot, internet of things (IoTs) and big data analytics in order to build a smart production, marketing and digital service system to efficiently enhance the whole agricultural productivity and capacity. Acting as an active, all-purpose agricultural consumption/service platform, it may facilitate an intelligent and automated production of safe and quality products to increase customer’s trust on food safety. Moreover, through big data analyses on production, supply and demand, strategic marketing and business model may be pre-planned and the internationalization of the agricultural industry can be established. There are three strategies for the Smart Agriculture program as follows:

- Improving the ability to stably supply of produce by innovating the agricultural management model with smart agriculture alliance and developing intelligent production technologies and applications;
- Building ICTs-based application models integrating convenient and diversified agricultural digital services with value chains; and
- Creating new communication models between growers and consumers via friendly interactive technologies.

With these strategies, ten (10) targeted industries have been selected to be transformed into ‘smart’ production ways. The competitiveness of concern is anticipated to be strengthened. They are moth orchid, seedling, mushroom, rice, agricultural facility, aquaculture, water fowl, traceable agricultural products, dairy, and offshore fishery (Fig. 1). Abundant achievements have been done to date, however, only two cases of best practices of Smart Agriculture that benefit eco-friendly food production are described in sections 3 and 4 due to space limit.
The ‘Four Labels and One QR Code (4L1Q)’ in Taiwan

In order to fully achieve domestic food safety, COA has promoted the use of 'Four Labels and One QR Code (4L1Q)' labeling system, which includes Traceable Agricultural Products (TAPs), Organic Traceable Agricultural Products (OTAPs), those are produced in compliance with Certified Agriculture Standard (CAS), and Good Agricultural Practice (GAP) as well as agricultural products with traceability QR code.

The TAP provides certified products for consumers who need safe, sustainable and traceable agro-products in open information. The promotion of TAP system was carried out by formulating operation standards, such as the Taiwan Good Agricultural Practice (TGAP), and setting up a TAP information platform. Agricultural product operators are advised to adopt risk management measures and production methods that conform to the concept of sustainable agriculture to produce safe and traceable agro-products, which are then verified by international third-party accredited certification systems. Only those certified are entitled to use the TAP mark/logo and relevant labeling, allowing consumers to easily identify, purchase, and look over complete record of production.

According to the Agricultural Production and Certification Act, Organic Agricultural Product and Organic Agricultural Processed Product Certification Management Regulations, Imported Organic Agricultural Product and Organic Agricultural Processed Product Management Regulations and other relevant regulations, only those certified in compliance with organic standards stipulated by the central governing body can be sold under the name of “organic.” To establish the credibility for our national organic standards, a third-party certification system has been introduced. With this arrangement, certifiers should be accredited by COA authorized accreditation bodies before carrying out their certification works under the certification standards for organic agricultural products and organic agricultural processed products.
The logo of CAS represents the certification for Taiwan premium domestic agricultural produce and their processed products. As a matter of fact, CAS has progressively become the byword for the premium domestic agricultural products because of the strict standard. The main purpose for COA to promote CAS logo is to upgrade the quality and to add value to domestic agricultural, aquaculture, animal and forestry produce and their processed products. At present, there are a total of 15 major CAS certified categories, including meat, frozen foods, fruit and vegetable juice, quality rice, preserved fruits and vegetables, ready-to-serve meals, refrigerated foods, fresh edible mushrooms, fermented foods, snack foods, egg products, minimum processed fruits and vegetables, aquaculture, forestry products and fresh milk.

The GAP is Taiwan's earliest agricultural product certification. As a collection of principles taking economic, social and environmental sustainability into account, GAP is applied for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products. Furthermore, in order to strengthen the traceability, farmers are asked to apply for the traceability QR code of Taiwan's agricultural production. The two are used together and then upgraded to “GAP 2.0.”

Through the promotion of “Taiwan Agricultural Traceability,” consumers may gain timely access to all relevant details (producers' contact information, photos, as well as origins and overviews) of their products by scanning the QR codes along the way. By doing so, it also enhances consumer confidence. Distributors may also utilize it to confirm the origins of their purchases and locate the problem within the supply chain to reduce risks of food safety. The competent authority exercises within their power to audit the entire course by imposing mechanisms, such as on-site investigation, label verification, quality sampling and violation disciplining, to ensure the traceability is functioning properly, therefore deepening such practices in Taiwan agricultural industry.

The agro-product traceability system would create product differentiation in the market, elevate product competitiveness, and create better production and consumption environment for agro-products. Through the integration of self-monitoring by agro-product operators, verification of product sources by distributors, feedback from consumers and government oversight with regulation, the local agriculture sector is able to promote the effectiveness of Taiwan’s agro-product traceability system and help to differentiate these products in the market.

The common information platform in SA program

By deploying the next generation of agricultural production with supporting sales and tracking services, a common information platform (CIP) focused on comprehensive production, consumption and service is developed to raise the efficiency and predictability of agricultural production, as well as to enhance consumer confidence on the safety of agricultural products. Three main goals of the CIP are Sharing, Service, and Synergy (SSS):

- **Sharing**

  Standards and rules for data-sharing in different agri-areas will be established. The collected data will be provided for each other to create innovative, collaborative agri-service and solve complex agri-problems.

- **Service**

  Heterogeneous data (public data, such as agri-weather, market condition, pesticide, fertilizer and food safety, and private data, such as data from IOT sensors of the agribusiness companies) will be provided by a service under the clear announcement of the rights and obligations. It allows free access for academic research, but will be charged for a commercial use.
• Synergy

The combined power of agri-research institutes, government departments and agribusiness companies are to support agri-innovation. This platform will make it possible to collaborate and cooperate with various agri-experts, agri-ICTs, agri-machinery and sensors.

The structure of agriculture common information platform can be divided into 7 layers from data source to application (Fig. 2), including data source, collection, integration, storage, analysis, access interface and application layer. For data processing, there are 3 categories in terms of big data exchange, big data lake and big data analytics. Production or environmental sensor/sensing technology, IoTs, other big data collection and analysis, production of required materials or traceability data collection and analysis are encompassed for the development of smart agriculture to effectively improve agricultural productivity and efficiency.

To create the convenient usage of agri-data and agri-digital service, the program integrated official data and open data such as weather, pesticide, fertilizer, food safety and market conditions is designed to share every stakeholder in agriculture sector by Open API mechanism (big data exchange). Each 3rd party vendors or research institutes can easily take advantage of the Open API to get agriculture data or digital service they need and develop innovative services to solve all kinds of farmers’ problems.

Besides providing agri-data, another assigned mission of the CIP is to provide agri-digital service, such as analysis of agricultural IoT data, big data analysis of heterogeneous agricultural data, etc. For example, the CIP helps the Ministry of Education to provide kinds of food safety certification data for Campus Food Ingredients Registration Platform.

In this case of big data exchange, the resources of 4LIQ data originally come from several different departments of COA. To provide the Campus Food Ingredients Registration Platform for national primary and secondary schools with useful data, the CIP integrated these heterogeneous data and solved the data asynchronous problem. Therefore, this kind of big data exchange application based on agri-data integration and sharing can help the government to strengthen consumers’ trust on food safety.

![Fig. 2. The structure of agriculture common information platform.](image)
Due to the complex sources of agricultural production and sales, the CIP must be designed to include structured data, semi-structured data and unstructured data to support the integration of heterogeneous agricultural data, big data analysis and different kinds of big data applications. In order to meet the needs of big data analytics, the CIP uses the Apache Hadoop framework to deal with heterogeneous data in agriculture and to implement reliable, scalable and decentralized computing.

At present, types of big data lake of the CIP are divided into four categories, including the food safety database of agricultural and fishery products, the meteorological database, the pesticide/fertilizer database, and the market condition database. The number of data collection is over 100 million records with 37 items. The meteorological data collection is the largest (about 40 million records), the traceability data follow (about 12 million records), and the market data is the third (about 10 million records). The method of big data exchange adopts the Open API mechanism.

To date, totally 56 Open APIs have been provided for 3rd parties or research institutes. The 3rd parties or research institutes registered for the CIP have exceeded 25 units, and the usage frequency of Open API reaches nearly 450,000 times. The highest usage frequency of Open API is for traceability data of agricultural and fishery products.

According to the policy of food safety, all primary and secondary schools (about 3,000) need to use traceable agriculture and aquaculture products tagged with the information of the "4 Labels and One QR Code (4L1Q). The Campus Food Ingredients Registration Platform of the Ministry of Education can get food safety information daily from the CIP by Open API mechanism to ensure safety of campus lunch (Fig. 3). This coordination of food safety information from platform to platform by Open API enable parents of the students to correctly and instantly understand what their children ate, and improve the convenience and benefit for 3rd parties in accessing food safety information.

Fig. 3. Big Data Exchange through Open API for food safety.
In addition to data sharing, the CIP also develops digital services such as the analysis for food safety. By integrating heterogeneous food safety data with the traceability data of agricultural and livestock products and the materials used by the Ministry of Education on campus, a Sankey diagram can be used as an analysis tool to establish a food safety traceability chain (Fig. 4). Through selecting several parameters such as what kinds of certification, date, production area, food company and school, the Sankey diagram can show very clearly that where and when the materials of campus lunch come from and which food companies cook. In other words, all traceable data can be displayed in a variety of ways by Sankey diagram to query different parameters needed. For example, if someone wants to know the traceability chain of the schools in Yilan County, Yizhen Group Food Center as shown providing most ingredients for Yilan’s schools need to be a targeted object for strengthening counseling and auditing. At the same time, the food suppliers and production areas are also included as counseling objects to reduce food safety scandals.

Fig. 4 also indicates how the Sankey diagram for heterogeneous food safety information works by selecting certification, location of agricultural products, food supply chain companies, and county which schools is located. First, choosing what kind of certification you want in the left. Second, you can choose where is the agricultural product with this certification (location of production) and which food company to deal with these products. Lastly, you can choose the County and know these agricultural products are bought by which schools in the very county you care.

![Sankey diagram of the food safety traceability chain for campus food.](image)

The alert function for pesticide residue monitoring is also a unique function. The results of pesticide residue testing for agricultural products are integrated in the CIP. If pesticide residue testing is unqualified, the CIP will show a red alert on the Sankey diagram and users can figure out what happen to this food safety chain. The information of this kind alert is about the details of unqualified agricultural products, which food company and school are effected (Fig. 5). This function will help government officials, teachers, and parents to understand quickly the situation of the food safety misconduct and avoid the society panic.
i-PLANT - agriculture management system

In Taiwan, lacking scientific data and difficulty in mastering production risks is one of the biggest problems encountered in agriculture industry from large-scale agricultural enterprises to individual farmers. For example, it is often based on the rule of thumb to determine when to seeding, where to plant, how to produce and benefit. Whereas, scientific data can provide actual insights with more considerable significance for agricultural farmers.

At the SA program’s early stage, an agriculture management system “i-PLANT” was developed, using technology of geographic information system (GIS), IoTs and aerial photography, as well as cumulative agriculture experience and the information recorded via the APP of crop production. i-PLANT combines environmental layer nesting with data services for field production risk management and decision analysis. Behind the i-PLANT, there is a high-precision agricultural database that provides differentiated environment and management information for each farmland in Taiwan to effectively assist farmers or agricultural enterprises in precise site selection, field operation decisions, and pest and disease risk management. It could not only create the highest production capacity per unit area but setup a demonstration zone for high-efficiency, energy-saving, and innovative agricultural transformation. The ultimate objective of i-PLANT is to provide the right suggestion at the best time and place for whole farm management to optimize returns on inputs while preserving resources.

i-PLANT accumulates the farmer's farming records through APP, and integrates them with the environmental database of each farm to grasp the suitable growth environment parameters of different crops accurately. Through big data analysis, all the gathered data are then further transformed into insights for various feedback service. Thus, i-PLANT provides the most accurate and immediate farming decision support, including weather information for risk warning to reduce damage, pest warning, yield estimation, precision fertilization and pesticide suggestions, harvesting advice, etc., for agricultural enterprises and contracting farmers. For large-scale agribusinesses, the introduction of i-PLANT can be particularly helpful in optimizing the farmer's farmland management. Recommendations and forecasts from this system can effectively avoid problems such as poor production, poor quality, over-production and slow sales.
Fig. 6. Service process and benefits of i-PLANT.

As a whole, i-PLANT includes the following services (Fig. 6). As individual farmers, they can easily record the field and crop status instantly through simple words or pictures via the APP of i-PLANT. As for the managers of individual farmers, records of crop growth or production nesting environment layer can be used to effectively support decision-making or management. At the beginning of system introduction, leading farmers or the leaders of production and marketing group take the lead. The other farmers are only required to take photos of their fields, record status of crops and then upload them to i-PLANT.

Currently, i-PLANT has more than 100 users in Taiwan, among them ten agricultural enterprises have a long-term partnership, and farming information of more than 3,000 farmlands has been established. Progress in analysis of crops and environment will be continuously made with more and more agricultural enterprises and farmland joining i-PLANT.
In recent years, agricultural policies are no longer focused on only the promotion of production, but also on the value of agriculture in response to the internationalization of trade and economics, the trend of liberalization, and environmental protection in the world. The detailed production process recorded by farmers via i-PLANT is also following the trends, enhancing the added value of agricultural products (Fig. 7). In addition, i-PLANT provides a consumer-friendly interactive module (Fig. 8). By scanning the QR-code on the agricultural product packaging, consumers can know exactly the product flow process with a beautiful, vivid and technology-friendly page, Agri-food Tracker.

Due to problems such as land pollution, pesticide residues, and unqualified inspection of farming products in Taiwan, consumers’ concern about food safety is quite common. As a result, COA has carried out quite a few policies on traceability of production, but the current agricultural product verification system still has difficulties in implementing universally because of high cost and complicated operation.

To narrow the knowledge gap between producers and consumers, i-PLANT encourages producers to record information and self-manage to establish mutual trust between consumers and producers. The Agri-food Tracker presents the painstaking results of producers to the consumers, including complete growth history, environmental information, photos of field operations, packaging process and inspection reports. Furthermore, it integrates food nutrition labeling, food mileage, food advice, business links, and so forth. The purpose of this friendly interactive communication model between growers and consumers is to help everyone eat healthy and contentedly.
CONCLUSION

The motivation of Smart Agriculture program is for innovation in agriculture by using science and technology such as sensor technologies, intelligent devices, IoTs and big data. Diversified models and concepts of smart agriculture are being developed to promote productivity and food safety. The CIP developed in SA program is applied to connect “Campus Food Ingredients Registration Platform (CFIRP)” effectively. By querying on line, it provides immediate, transparent school food information to the community, teachers, students, and parents. It also jointly supervises the quality of school food and beverage management by combining the campus food safety management system to increase the peace of mind and trust. The CIP provides unique entrance of food safety certifications information for the CFIRP, especially for food safety certifications information from different Agriculture agencies or departments.

Agriculture management system i-PLANT promises a new type of “agriculture service industry”, which allows farmers to cultivate and record field data more easily and conveniently. It also enables consumers to eat with confidence for food safety and lead to sustainable agriculture in the long run. Moreover, the relationship between agricultural operations and food can be further strengthened by the system, connecting the upstream agricultural production and middle or lower reached logistics sales to smart agri-food supply chains.
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