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SUstainabledevelopmeNT Smart Agriculture Capacity
« SUNSpace »

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Document Description	The purpose of this document is to develop the WP2/T2.3 "Guideline (meta-model) for Organic Pilots." This document summarizes the process of Smart Lab implementation and use in practical training. Since the first part of the training will be delivered on an online platform, it is needless to detail pilot description, but as the first section of this report, it can be included, and is enough to quote. Data collected through experiments training assignments will be used for other purposes (training, research). It is nice if there are available on local servers. Still, please refer to the future knowledge (excellence) center because connecting the local databases will significantly benefit the farmers' research in the region

	(outreach). Since this development is on the agenda of further action after the project lifetime, and there is no obligation to realize it, there is no obstacle to creating a nice fantasy (as part of the exploitation plan).

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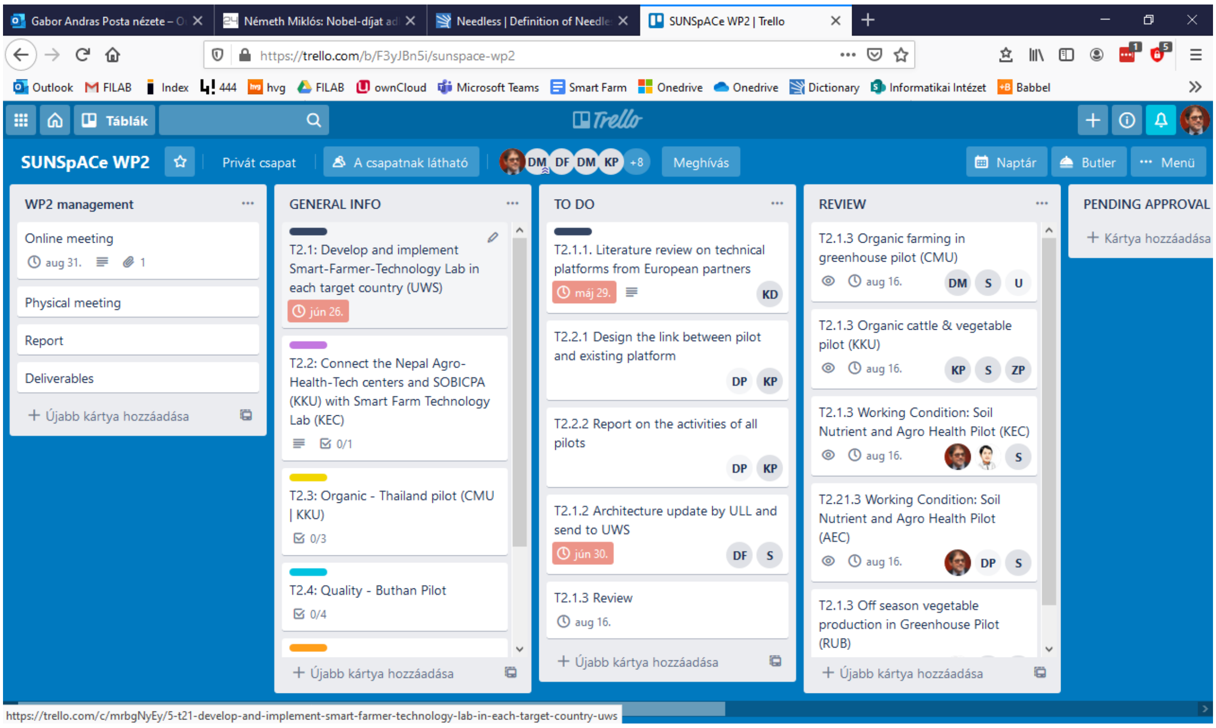
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GENERAL INFO
T2.1: Develop and implement Smart-Farmer-Technology Lab in each target country (UWS)
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T2.1.1. Literature review on technical platforms from European partners
T2.2.1 Design the link between pilot and existing platform
T2.2.2 Report on the activities of all pilots
T2.1.2 Architecture update by ULL and send to UWS
T2.1.3 Review
REVIEW
T2.1.3 Organic farming in greenhouse pilot (CMU)
T2.1.3 Organic cattle & vegetable pilot (KKU)
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T2.1.3 Working Condition: Soil Nutrient and Agro Health Pilot (KEC)
T2.1.3 Working Condition: Soil Nutrient and Agro Health Pilot (KEC)

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1 Situation Analysis: Organic agriculture in Thailand

Currently, the demand for organic products by consumers in Thailand is increasing. Additionally, the national development plan is also trying to promote organic agriculture products for sustainable agriculture and the health of producers and consumers. In Thailand, the Organic Agriculture Certification Thailand defines organic agriculture as a holistic production management system that promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account regional conditions that require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials to fulfil any specific function within the system. Organic farming is a complicated system that focuses on various things in the farm that helps imitate a natural ecosystem and is best suited to local consumption — building community bonds and a system free from market cost manipulation. Currently, there are three methods used to check whether a farm is organic comprising the third party (such as The National Bureau of Agriculture Commodity and Food Standards (ACFS) or Organic Thailand), the Participatory Guarantee System (consumers collaborate with producers and both work towards checking authenticity). Farmers set up their network and their standards.

Presently, researchers and private companies in Thailand also try to adopt smart farms and smart technology such as sensor technology, Internet of Things (IoT), GPS, machinery etc., helping in farming improve production and quality of productivity under unpredictable weather. Most research and projects on smart farms in Thailand relate to adopting and developing smart technology for farming such as smart irrigation systems, robots for farming, etc.

Organic livestock farming is an animal raising that complies with international organic farming principles with clear regulations to facilitate trade and build consumer confidence. Organic livestock farming is a production system that does not use synthetic chemicals mainly focuses on consumers' health and environmental ethics. Farmers must raise animals carefully to prevent disease on condition to animals healthy, reducing stress, not confining animals all the time, and releasing them according to each animal's natural behavior. The cattle housing has not been crowded, is well ventilated, does not use antibiotics, and does not use synthetic hormones, including not using growth accelerators. (Thai Organic Trade Association 2019)

Moreover, animal feed must be handled with special care using raw materials produced entirely organically. For example, the grass to feed animals must be organic grass that does not use chemicals to grow the grass, and even the grass fertilizers do not use chemical fertilizers. Manure is required, such as manure for planting organic grass. Even the use of pesticides and pesticides in the grass is prohibited. Free from using materials from the genetic editing process to be concern with the environment. It means that organic livestock farming requires more careful than normal livestock farming. (Chitov & Thararat, 2020)

Thailand has a fundamentally positive for organic livestock farming. Especially in the sales section, The market and consumer demand are huge. With the growings population, they have purchasing power. It is a positive factor for growing organic livestock farming in Thailand. At present, the Thai agricultural system is changing from chemical agriculture to organic agriculture. Due to the global environmental crisis, socio-economic factors such as degraded and polluted soil and water and climate change biodiversity affect the customer changing consumer tastes. Thai consumers are more concerned about their health. They buy beef by seeking the label of food safety standards and concerns about environmentally friendly production and animal welfare such as Thai GAP, GLOBAL GAP, GMP, HACCP, ISO 14001, ORGANIC FOOD etc. (Pattweekongka & Napompech & Wornchanok, 2019) So, the beef producers in Thailand have to adapt to the needs of consumers. Hnin Ei Win (2017)

Currently, Thailand has developed several quality beef cattle breeds. Suppose the Thai government focuses on supporting the production of organic cattle farming in Thailand. In that case, it will be able to replace imported quality organic beef from abroad and be exported to ASEAN countries. The principle of organic cattle production by Thai farmers starts with selecting breeds of cows that can live well in the country's environment. Because the principle of organic cattle farming prohibits using chemicals. When the cow was sick, the farmers did not inject antibiotics. Therefore, the farmers must find healthy cows that can survive in the environment's Thailand. It must be a well-adapted cow in hot and humid climates and uses bred cattle because Thailand is hot and rainy. They must be big cows and can live and adapt well to the environment's Thailand. Bopp & Judith (2020)

For breeding calf in organic beef production, artificial insemination is mainly used. Organic beef farming requires much space for the relaxing cow. For comfort and relaxation, it must have at least 12 square meters of space per cow. The food's cow must be organic food. Farmers must take care of all processes of organic cows' production. When the cow is about two years old, it can be in organic beef production by sending it to the slaughterhouse. Slaughtering a cow is like a normal cow but with a separate production system. For example, to slaughter organic cows today, the slaughterhouse has to clean everything and slaughter only organic cows on that day. Organic beef production has to start from the show until distribution, separate from normal beef production. The Thai government will support the organic beef producers by strengthening agricultural cooperative networks and looking for export opportunities. Because Thailand is already a professional in animal production, there is not too difficult to push farmers to produce organic beef. Panmethis & Islam (2016)

2 Organic Farming Pilot (CMU)

2.1. Organic Agriculture in Northern Thailand

The northern of Thailand is one of the main agricultural regions in Thailand. Over half the land is mountainous. Agricultural products in the region include rice, vegetables, fruits and livestock. Most farming in this region is in family framing that a farm is owned and operated by family members. Currently, traditional farming is a farming method of farmers in Northern Thailand using their experience for farming such irrigation, fertilizer, pesticides etc. Moreover, the forest is truncated in some areas, and farmland replaces the trees. Swidden agriculture of the hill tribes of Northern Thailand is one example that the hill tribes cut and burn the forest for growing upland rice or other crops for a year. Another example is farming of farmers in Ban Mae Kung and Ban Han Kaew villages which is located not far from the city of Chiang Mai province and is the lowland areas where fifty percent of households have their land, thirty percent rent land for farming, and the remainder both rent land and have their land for farming. Most farmers have practiced traditional farming without technology, planned for farming, and served by local irrigation. After harvest, the fields are burned for the next crop.

Farmers in Northern Thailand have problems wit consumers' increasing demand for organic foods h farming due to the global warming and climate change context resulting in the more diverse weather patterns, which impacts the production process, quality, and quantity of the agricultural sector in this region. Therefore, farmers in Northern Thailand need to revolve all domains of production that how to deal with the changing of unpredictable environments, especially water and weather, which are the major factor of farming for irrigation. The irrigation needs to provide enough water in the dry season to sustain a crop.

Due to the increasing demand for organic foods of consumers in Chiang Mai province, organic agriculture has also increased. There are 18 organic markets that are part of the Institute for Sustainable Agricultural Communities (ISAC), and a few more are independent. Organic farms also continue spread in Chiang Mai because consumers turn to consuming organic foods and environmentally friendly production due to natural fertilizers and pesticides. However, several factors impact the organic production in Northetn Thailand, such as weather, environment conditions like diseases and pests attack that affect the quality of products because farmers do not use the chemecal which quite hard to control these factors.

Therefore, using of multidisciplinary domain such an embedded system, wireless sensor network, and internet of things to support framing as we call a smart farming will lead the agriculture sector to dealing with the risk and changing of those conditions. In Chiang Mai province, some smallholder farmers who have knowledge and budget as well as private companies have started to adopt smart farm technology in their farm using smart technology to enhance farm production and to control the quality of products. For example, melon farm with soilless culture is the first greenhouse farm in Hang Dong district, Chiang Mai province that use smart farm technology to control irrigation system, quality of production and productivity that meets the needs of the market. Thai researchers develop High-Value Agricultural Product Cluster for Bresse Chicken farm in Northern Thailand which help smallholder farmers to increase their income by transferring information and knowledge of production to farmers.

Due to the communication infrastructure issue in Northern Thailand, the smart farm technology hard to apply efficiently because of unavailable or difficult to provide full services for example GPS and internet based facilities, especially in the rural areas. Additional, the high speed connection is requirement for processing the data accurately which the drawback here is that only some urban and rural areas are available to support. Apart from that, smart farm technology is an expensive technology that is creating a major limitation of applying smart farm technology in Northern Thailand that most of the farmer's lack of the financial support to sustain the ideas. Moreover, the knowledge of configuring the technology is also important for applying smart farm technology in Northern Thailand.

Consequently, the Thai's government tries to promote Smart Farm in Northern Thailand to farmers to manage their farm and control quality of productivity and to support smart farmers in Northern Thailand that they have several projects to promote and support farmers in Northern Thailand both knowledge and budget for smart farmers and young smart farmers.But, the major problem of farming is the lack of organic farm management knowledge and adoption of smart technology knowledge production of farmers in Northern Thailand.

2.2. The objectives of organic pilot consist of:

- Enhancement of farmers' skills relevant to crops cultivation based on organic standard
- Enhancement of farmers' skills relevant to smart farm technology and application

2.3. Expected impacts

The expected impacts of organic pilot consist of:

- **Improvement of the quality of produce:** the smart farming system/technology will help farmers for enhancement of the quality of produce.
- **Enhancement of the input use efficiency management:** the smart farming system/technology will help farmers to use less amount of inputs (water, fertilizer, chemical substances) to help reduce amount of water usage and the contamination by chemicals in agricultural products.

2.4. Expected Outcome

The expected outcome of organic pilot consists of two main outcomes.

- Farmers can enhance 60% of their skills relevant to crops cultivation based on organic standard.
- Farmers can enhance 60% of their skills relevant to adoption smart farm technology and application for cultivation.

2.5. Description of CMU Smart Lab

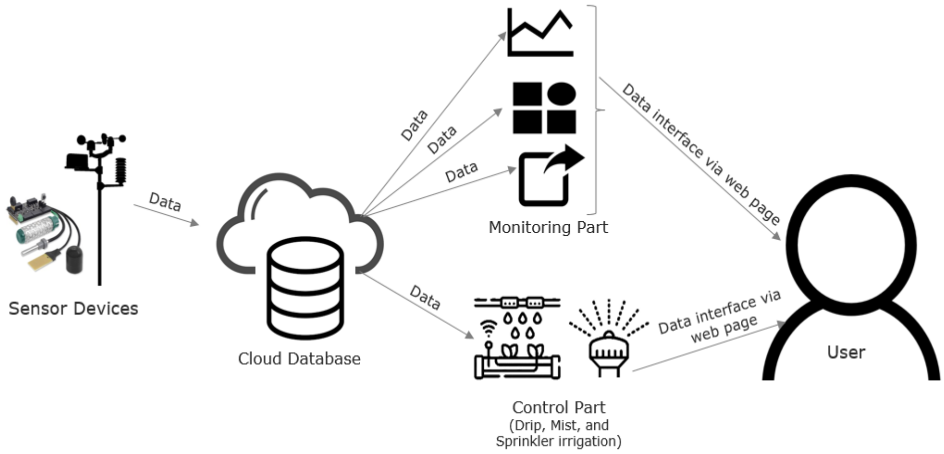
2.5.1. Process of setting up pilot/activities

The Smart Lab will be the portable greenhouse for organic farming production. The drip irrigation will be installed to give water to crops. The mist and sprinkler irrigation will be installed to control temperature and humidity inside the greenhouse. The sensors will be installed for monitoring and control system. The types of sensors are shown in Table 1.

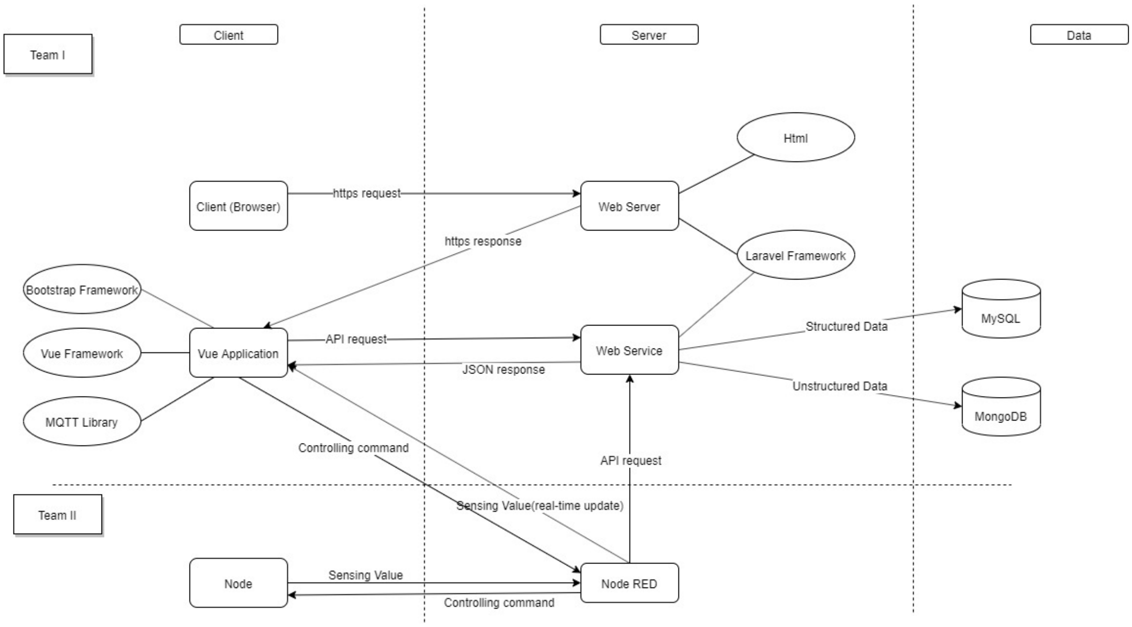
Table 1: Lists of Sensor Equipment

Equipment	Description
Outdoor weather station and sensors	To monitor - Air Temperature - Relative humidity - Rainfall - Wind speed and direction - UV radiation - Air pressure - CO2 sensor to monitor CO2 concentration in the air
Air indoor sensors	To monitor - Air Temperature - Relative Humidity - UV and Light Intensity - CO2 sensor to monitor CO2 concentration in the air
Soil sensors	To monitor - Soil Moisture - Soil Temperature - Soil electrical conductivity (EC) - Soil pH
Water sensors	To monitor - Water Temperature - Water Electrical Conductivity (EC) - Water pH

The data collected from installed sensors are stored into cloud database. The users can monitor the data via web page (platform). Meanwhile, the data will be analysed for control system consisting of drip, mist, and sprinkler irrigation to give the water to crops and control temperature and humidity inside the greenhouse. The system diagram is illustrated in Figure 1.



(a) System diagram



(b) System Architecture

Figure 1: System architecture diagram

Users can monitor data collected from sensors and the working status of sensors and controller via the platform (website) as illustrated in Figure 2 and Figure 3.

Figure 2: Main page of platform

Figure 2 shows the main page of the platform (modulars.io). This platform allows users to access and monitor their own farms. The system able to control irrigation of plants and temperature control in the greenhouse with the functions of the platform. The system consists as following

- Able to monitor data via graph.
- The platform can be monitored from many locations.
- Users can compare data from different sensors from the platform and share information of their farm to others.
- Users can control the systems through the platform.
- Users can monitor and operate status of the sensor.

Figure 3: Dashboard of platform

Figure 3 illustrates the dashboard of platform, where data collected by sensors will be stored into a cloud database. Data will be shown on the dashboard website in the form of table and graph. Users can monitor and download data from the website.

The main display page elements (Dashboard)

- Sites Bar is menu bar which collect all farm users' settings in the system
- Quick View is a menu box, showing values from devices installed through various forms of vapor.
- Quick Graph is a menu box, showing the graph period of time on that day.
- Equipment installed in farm is menu box, showing all equipment installed in the farms

2.5.2. Implementation of Smart Lab

Nowadays, there are lots of environmental factors that impact to cultivate organic vegetables such as unpredictable weather, chemical contamination, etc. The chemical substances could not eliminate immediately as the organic substances in terms of chemical contamination in the environment (like soil, water). In addition, the unpredictable weather is also being the big issue to farmers for cultivation. Moreover, most farmers lack technology in cultivation. Consequently, the cultivation in greenhouse is proposed for organic cultivation.

The proposed greenhouse is a moveable greenhouse that can be moved around for easy training. Also, the above cover is transpiration plastic to prevent rainwater. The bottom is a net of insect repellent. The advantage of the net is ventilation in the farm.

- **Dimension:** Moveable greenhouse dimension is 3 (height) x 6 (diameter) meters with aluminium material. The semi-circular dome shape has a radius of three meters and six meters in diameter.
- **Size of greenhouse:** total area inside 52.50 m^2
- **Greenhouse Equipment:**
    - *6 pieces of 5-way hubs and 20 pieces of 6-way hubs:* the ball connectors are connected to your sticks simply. You have to plug them into the hubs for greenhouse building.
    - *Ball connectors (150 pieces):* Screws onto the ends of your sticks.
    - *Screw (150 pieces):* Attaches the ball connectors to the sticks.
    - *Locking plate (26 pieces):* Clamps the ball connectors in place once the dome is in its final position.
    - *Hub screw (26 pieces):* Goes through the center of the hub for clamping.
    - *Wing nut (25 pieces):* Screws onto the end of the hub screw to clamp the locking plate in place.
    - *Hanging eyelet (1 piece):* Use this to hang something nice from the center of your dome.
- **How to set up?**
    - Prepare the aluminium stick: 30 pieces of shorts (1552 mm) aluminium sticks and 35 pieces of longs (1766 mm) aluminium stick, and the width of the aluminium sticks is 32 mm as shown in Figure 4

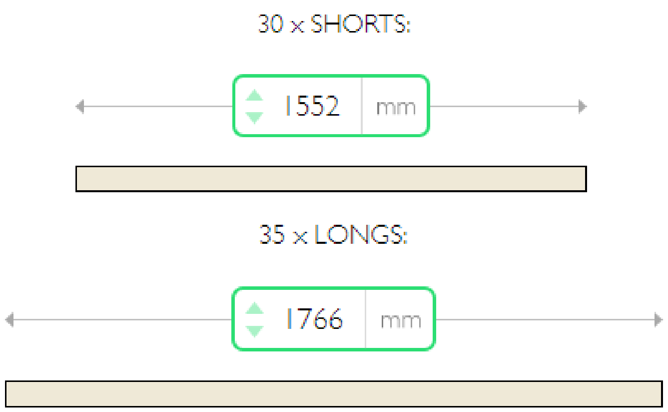


Figure 4: Required length of the aluminium sticks for greenhouse

- Put the screw to the end of the aluminium sticks

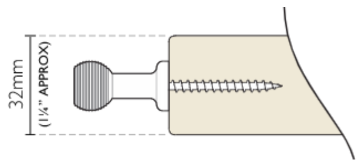


Figure 5: Put the screw

- Connecting all the sticks to hub connector: the ball connector with the aluminium socket are connected to the 5-way and 6-way hubs as shown in Figure 6. Then, we will get the greenhouse constructed as shown in Figure 7.

Figure 6: Connecting ball connector with the hub

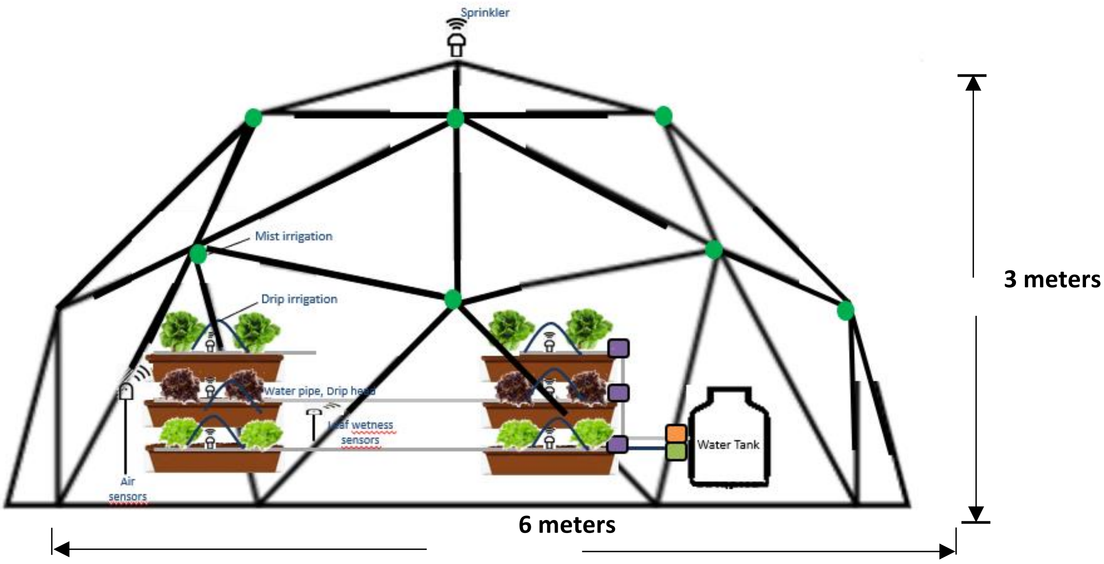


Figure 7: Complete construction of moveable Greenhouse

- **Irrigation System**
  This irrigation system will go with the moveable greenhouse dome. There are three irrigation system to be installed for the greenhouse consisting of drip, mist, and sprinkler irrigation as illustrated in Figure 4.
  - The drip irrigation is for giving an appropriate amount of water to crops via drip system.
  - The mist (green dot) and sprinkler irrigation are to control temperature and humidity inside the greenhouse.
  - The water pump is used for pump water to water tank and to pump water from the water tank to irrigate crops via drip irrigation system and sprinkler irrigation system
  - The mist water pump is used for pump water from water tank for mist irrigation system

2.5.3. The smart lab training materials

The Smart Lab will be built in the pilot site for training farmers. The list of equipment is shows in Table 2.

Table 2: Lists of Equipment

Equipment	Description
Greenhouse	
Outdoor Weather station and sensor	**1.To measure** - Air Temperature - Relative humidity - Rainfall - Wind speed and direction - UV radiation

Equipment	Description
	- Air pressure **2. CO2 sensor:** to measure CO2 concentration in the air
Air Indoor sensor	**1.Air Temperature and Relative Humidity sensor:** to measure temperature and humidity in the greenhouse **2. UV and Light Intensity sensor:** to measure the amount o **3. CO2 sensor:** to measure CO2 concentration in the air
Soil sensor	**1. Soil Moisture sensor:** to measure moisture, temperature, electrical conductivity (EC) of soil **2. Soil pH sensor:** to measure acidity and base of soil
Water sensor	**1. Water Temperature sensor:** to measure temperature of water **2.Water Electrical Conductivity (EC) sensor:** to measure the EC value of water **3. Water pH sensor:** to measure the acidity and base of water
Irrigation system	1.Drip irrigation system: to give water to crops **2. Mist irrigation system:** to give water to control temperature and humidity in greenhouse **3. Sprinkler irrigation:** to give water to control temperature and humidity in greenhouse
Water pump	**1.Water pump:** to pump water to water tank and from water tank for drip and sprinkler irrigation **2. Mist pump:** to pump water for mist irrigation
Controller	To control irrigation systems

2.5.4. Demonstration

The list of activities for training using Smart Lab validation:

- ***Pre-test:*** Farmers must do the pre-test to assess their knowledge before training.
- ***Greenhouse installation:*** demonstrate process to set up the moveable greenhouse
- ***Sensors installation:*** demonstrate the process to install sensors in farm, method to connect sensors to communication network, configuration sensor with the platform
- ***Irrigation system installation:*** demonstrate the process to install and set up drip, mist, and sprinkler irrigation system in greenhouse
- ***Data interpretation and control:*** demonstrate the method to interpret data from sensors and method to control in difference situations
- ***Post-test:*** after training, farmers must do the post-test to assess their understanding before doing real practice in their farm.

2.5.5. Implementation of use cases

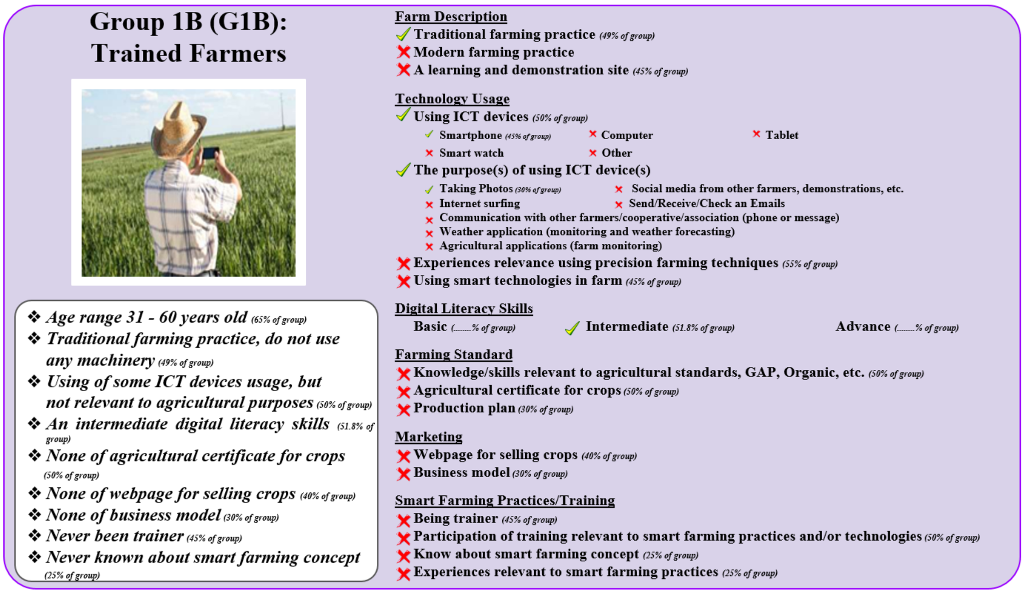
The Innovative village, Chang Khlan Sub-district, Chiang Mai province, Thailand is selected for the use case. This place is under the responsible of Chiang Mai University (CMU), Thailand.

2.6. Training process

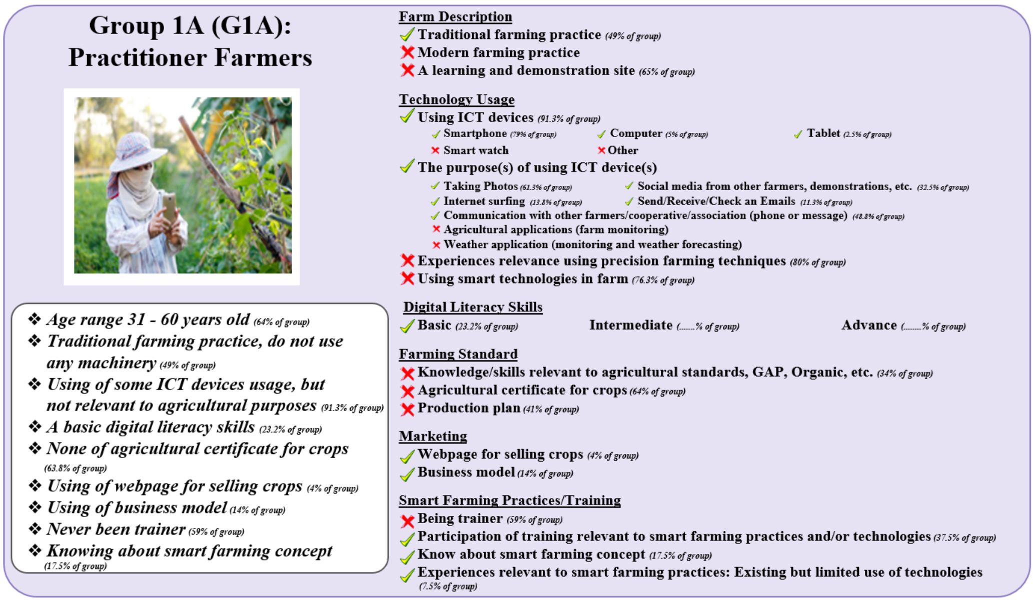
2.6.1. Smart Farmer Training

Thai entrepreneurs and farmers are already setting their sights on how farming should be done in the future. Here are some examples of 100 percent locally made innovations that will revolutionize the agriculture industry in Thailand. Recently, Researchers at Mahidol University and Granmonte Farm, a renowned vineyard in Nakhon Ratchasima Province, have created the Micro-Climate Monitoring System. A dedicated network of sensors detects key data, including temperature, humidity, light intensity, wind speed, and air pressure, among others. These data are then analysed by the intelligent system to increase the output yield and reduce the risk of failure. For an example, the irrigation system is automatically activated when the detected humidity is low. This feature, combined with the internet connectivity, not only increases productivity but also gives growers the freedom to manage their farms remotely.

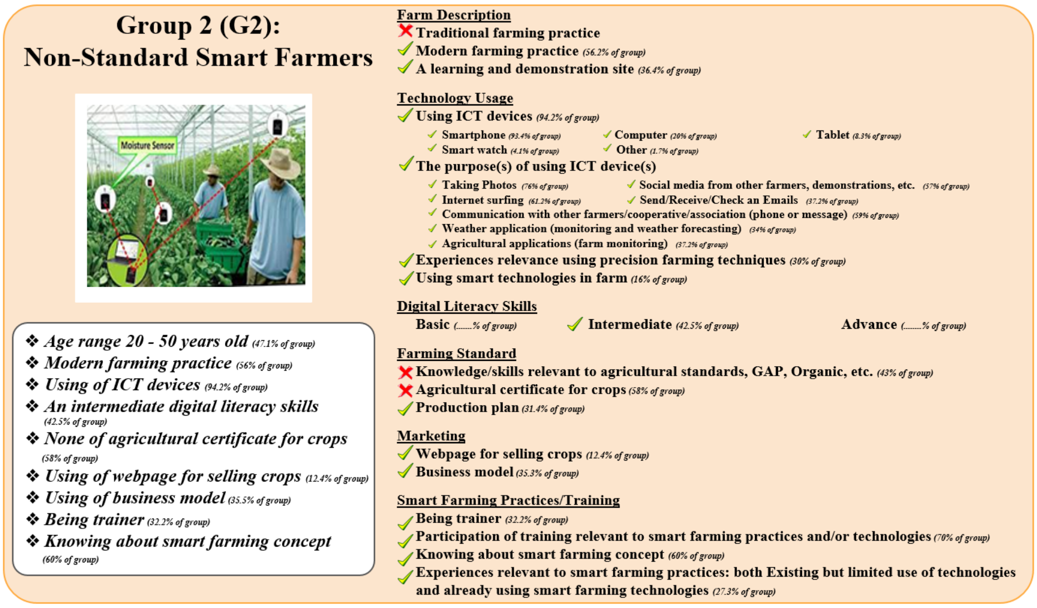
Thailand Professional Qualification Institute is the organization that responded for training the smart farmer in Thailand. The accreditation of personal competency is related to the occupational standards. These standards are consisted of competence of each occupation. TPQI is the organization that provide the certification bodies for both public and private organization. The certify processes are covered the requirement, method and conditions of certification letter to the certification body. Three levels of smart farmer characteristic (see Figure 8) have been identified and related to the occupational standards.



(a) Group 1B (Trained farmers) with the intermediate level in terms of digital literacy



(b) Group 1A (Practitioner farmers) with those who have some basic understanding



(c) Group 2 (Non-standard farmers) with those who do the modern farming practices

Figure 8: The three levels of smart farmer characteristic

2.6.2. Key Indicators

The expected indicators include 3 groups of trainers comprising ordinary farmer (50 persons), smart farmer (10 persons) and officer and researcher (6 persons) as shown in Figure 8.

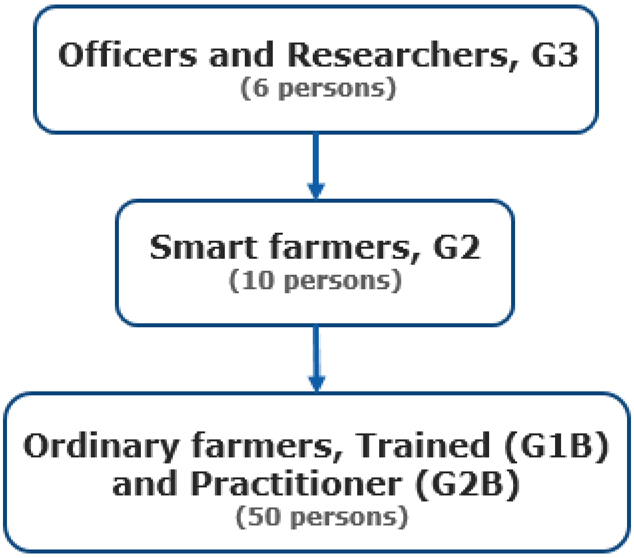


Figure 9: The expected participants by CMU

Figure 9 shows the expected groups and number of participants which is the indicator from CMU side. The groups of participants include three main groups comprising:

- Group 3 (G3): Officers and Researchers (6 persons) are government representatives, junior technical assistant, academic staff or administrative.
- Group 2 (G2): Smart farmers (10 persons) are non-standard farmers. Farmers do the modern farming practices. They are more advanced, may already have some technology. They also are entrepreneurs, which means that they are able to change their practices.
- Group 1 (G1A and G1B): Ordinary farmers (50 persons) are the less advanced farmers. They do not have Internet access in their farm, and sometimes also have difficulties to write and read. Farmers who are willing to learn can be included in this group (100 farmers). Due to the diversity of profiles, two subgroups are foreseen. Group 1B (Trained farmers) with the intermediate level in terms of digital literacy, Group 1A (Practitioner farmers) with those who have some basic understanding.

2.6.3. Implementation of training process

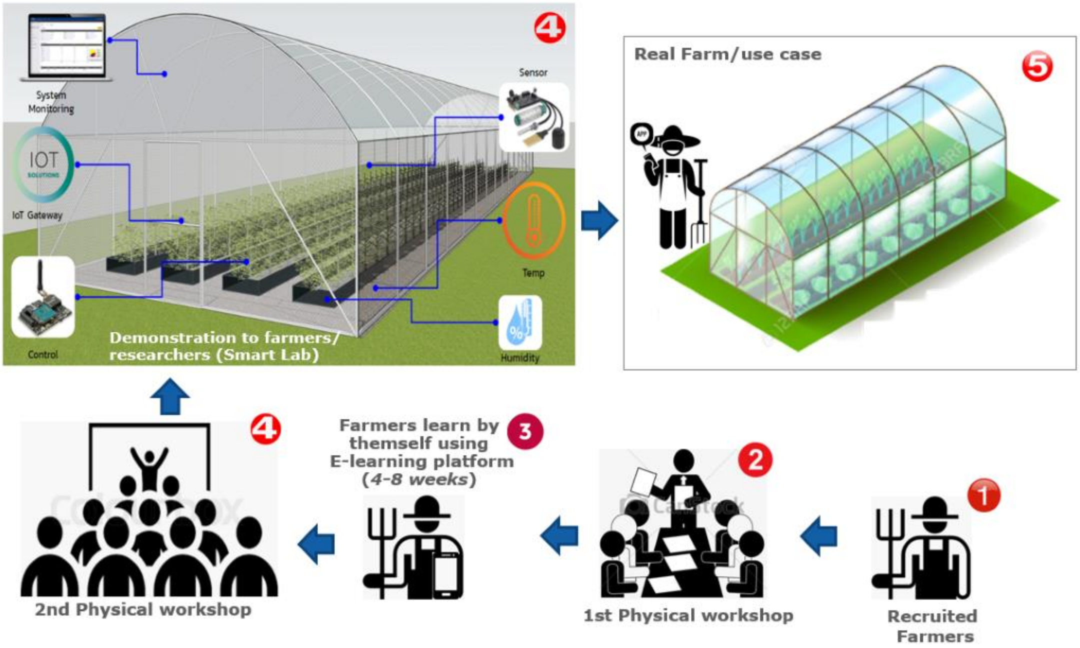
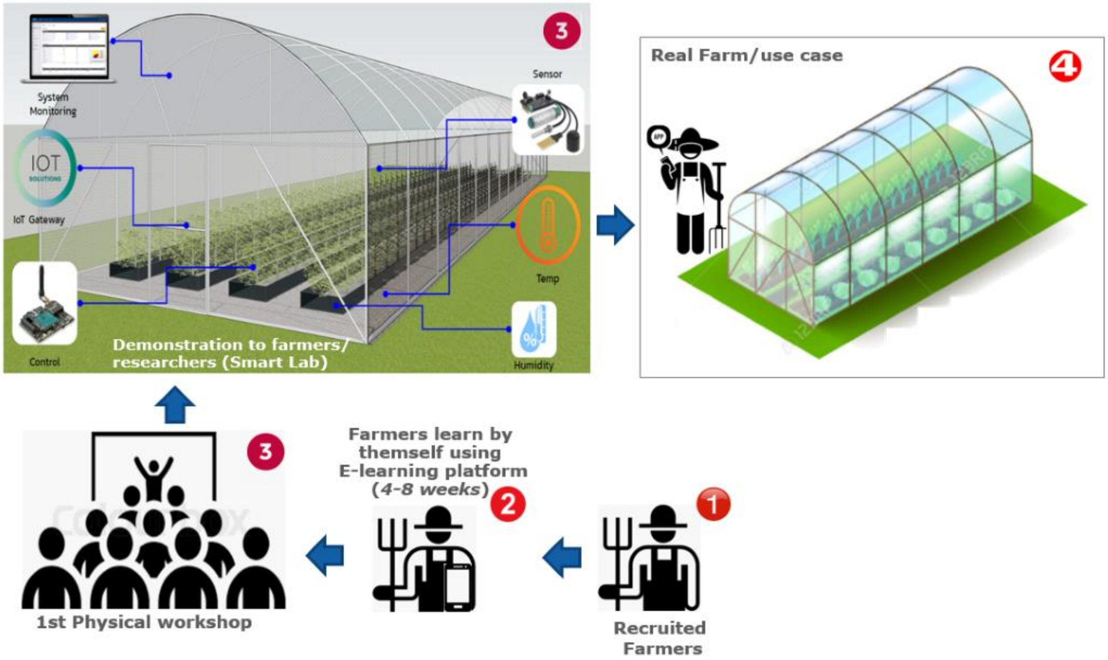


Figure 10: Process of training implementation

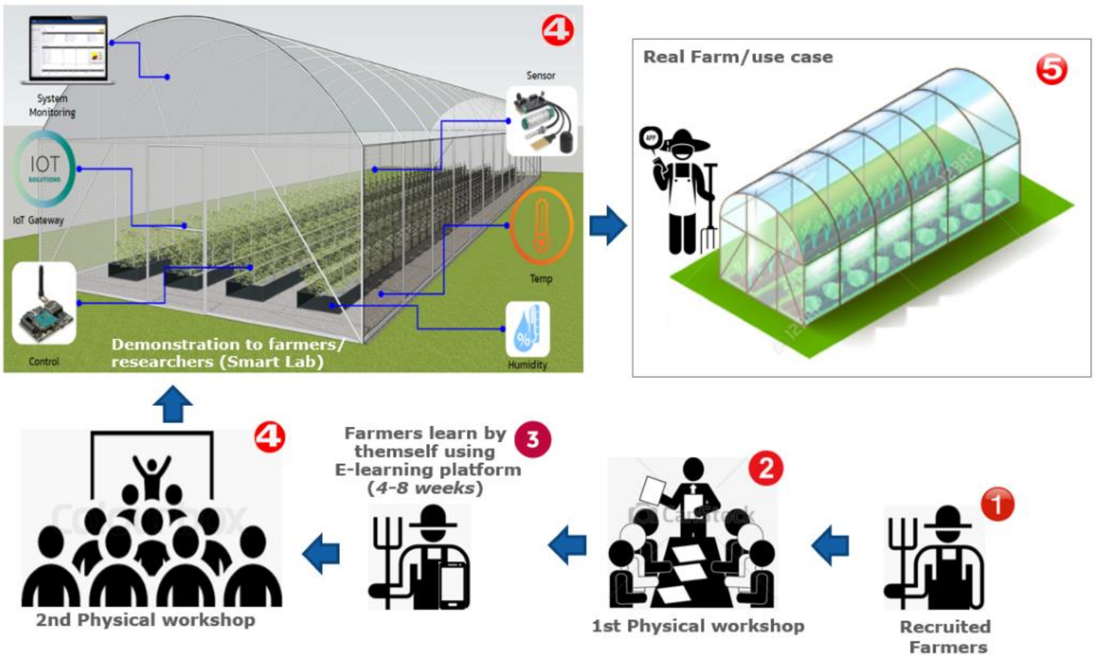
Figure 10 illustrates the process of training implementation comprising:

- ***Step 1:*** Recruit the farmers to participate our training course
- ***Step 2:*** Recruited farmers must participate in the first physical workshop to learn the introduction of smart farming concept and technology, introduction of SUNSpACe e-learning platform and how to use the platform.
- ***Step 3:*** Recruited farmers must learn themselves via learning platform. Farmers can interact with trainer when they have question or problem during learning. Trainer can monitor their trainees (farmers) via the platform. (within 4-8 weeks)
- ***Step 4:*** Recruited farmers must participate in the second physical workshop that will be held at the Smart Lab location to learn the introduction of smart farming concept and technology, how to install sensors and interpret data from sensors for controlling, and smart farm technology demonstration (Smart Lab demonstration). After that, farmers must do the assessment to test their understanding before doing the real practice in their own farms.
- ***Step 5:*** The examiners will go to recruited farmers' farm to discuss with farmers for getting feedback and doing an assessment after learning and practicing in real farm.

For CMU, the process of training and demonstration are different among different groups of farmers as illustrated in Figure 11.



(a) Group G3 and G2 (Researchers, Officers, and Smart farmers)



(b) Group G1A and G1B (Ordinary farmers)

Figure 11: Processes of training implementation

Figure 11 (a) illustrates the process of training implementation to group G3 and G2 which are researchers, officers, and smart farmers comprising:

- ***Step 1:*** Recruit farmers to participate in the training course
- ***Step 2:*** Recruited farmers must learn themselves via learning platform. Farmers can interact with trainer when they have question or problem during learning. Trainer can monitor their trainee (farmers) via the platform. (within 4-8 weeks)

- ***Step 3:*** Recruited farmers must participate in the first physical workshop to learn the introduction of smart farming concept and technology, and how to install sensors and interpret data from sensors for controlling. After that, farmers must do the assessment to test their understanding before doing the real practice in their own farms.
- ***Step 4:*** The examiners will go to recruited farmers' farm to discuss with farmers for getting feedback and doing an assessment after learning and practicing in real farm.

Figure 11 (b) illustrates the process of training implementation to ordinary farmers which are farmers in group G1A (trained farmers) and G1B (practitioner farmers) comprising:

- ***Step 1:*** Recruit farmers to participate in the training course
- ***Step 2:*** Recruited farmers must participate in the first physical workshop to learn the introduction of smart farming concept and technology, introduction of SUNSpACe e-learning platform and how to use the platform.
- ***Step 3:*** Recruited farmers must learn themselves via learning platform. Farmers can interact with trainer when they have question or problem during learning. Trainer can monitor their trainee (farmers) via the platform. (within 4-8 weeks)
- ***Step 4:*** Recruited farmers must participate in the second physical workshop that will be held at the Smart Lab location to learn the introduction of smart farming concept and technology, how to install sensors and interpret data from sensors for controlling, and smart farm technology demonstration (Smart farm Lab demonstration). After that, farmers must do the assessment to test their understanding before doing the real practice in their own farms.
- ***Step 5:*** The examiners will go to recruited farmers' farm to discuss with farmers for getting feedback and doing an assessment after learning and practicing in real farm.

The training plans mentions above are implemented before Covid-19 outbreak. Nowadays, physical training itself has the limitation due to the outbreak of Covid-19. Hence, we proposed 'Virtual/Hybrid training' as the diagram shown in Figure 12.

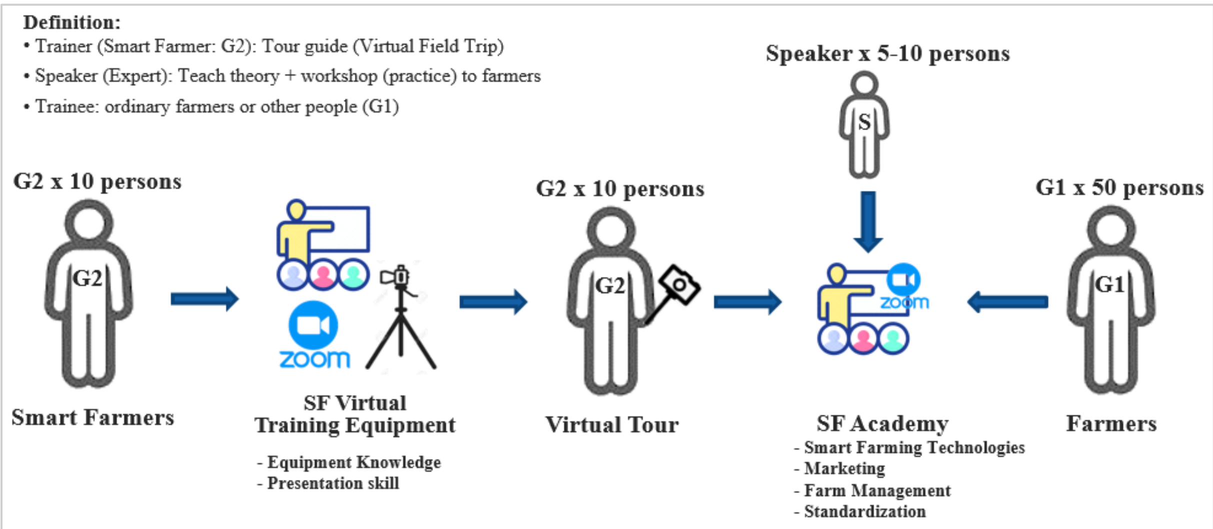


Figure 12: Proprosed new training plan

- **Training Modules**

CMU's Module	SUNSpACe's Module (E-learning platform)
Farm management	**Digital agriculture**
Smart farming (HW)	**Smart Farm**
Standard	**Standardization**
Marketing	**Agro-Business**

- **Train the trainers:** G2 (Smart farmers)
  - Training duration: 2 days
  - Offline Training: 1 days (workshop: presentation skill, equipment, installation, etc.)
  - Online Training: 1 day (Practice: live streaming from farm via zoom/etc.)

- **Train the farmers:** Group G1 be trained by smart farmers (G2)
  - Hybrid program: 10 days/round, total 4 rounds
    - 1 day = 3 hours;
    - 1hr => online seminar (theory),
    - 1hr => virtual field trip (practical),
    - 2hrs => workshop
    - 1hr => consult (Q&A)
  - 40 days of CMU's training = 20 daysof proposal
  - 10 days = 1 theme/program/Module
  - Training plan

Mon	Tue	Wed	Thu	Fri	
Seminar 1-1 + VFT	Workshop 1-1	Seminar 1-2 + VFT	Workshop 1-2	talking session....	Module 1 : Farm Management
Seminar 1-3 + VFT	Workshop 1-3	Seminar 1-4 + VFT	Workshop 1-4	talking session....	
one week to organize next training module					
Seminar 2-1 + VFT	Workshop 2-1	Seminar 2-2 + VFT	Workshop 2-2	talking session....	Module 2 : Smart Farm
Seminar 2-3 + VFT	Workshop 2-3	Seminar 2-4 + VFT	Workshop 2-4	talking session....	
one week to organize next training module					
Seminar 3-1 + VFT	Workshop 3-1	Seminar 3-2 + VFT	Workshop 3-2	talking session....	Module 3 : Digital Marketing
Seminar 3-3 + VFT	Workshop 3-3	Seminar 3-4 + VFT	Workshop 3-4	talking session....	
one week to organize next training module					
Seminar 4-1 + VFT	Workshop 4-1	Seminar 4-2 + VFT	Workshop 4-2	talking session....	Module 4 : Standard
Seminar 4-3 + VFT	Workshop 4-3	Seminar 4-4 + VFT	Workshop 4-4	talking session....	

Based on the ‘train the farmers’ plan above, each module includes four training topics with 10 days of each training module. Each topic set consists of seminar, virtual field trip (VFT), and workshop. Farmers must attend ‘Seminar and virtual field trip (VFT)’, otherwise they cannot join workshop session. On Friday, the government staff or start up relevant to agriculture field will be invite to be the speaker to talk or discuss about smart agriculture trend, technologies, or funding. In terms of certificate, we have three level of certificate as follow:

- *Topic Certificate:* Farmers who attend each training topic will receive this certificate. However, they have to join all sessions of the topic that they attend: seminar, virtual field trip, and workshop.
- *Module Certificate:* Farmers who attend all training topics in each module will receive this certificate. However, they have to join all topics and sessions of the topic that they attend: 4 topics with seminar, virtual field trip, and workshop.
- *Super/SUNSpACe Certificate:* Farmers who attend all training module will receive this certificate. However, they have to join 80% of the whole course.

3. Organic Pilot (KKU)

3.1. Situation analysis

Nowadays, agriculture in Thailand is one of the major sectors that drive the national economy since it makes a profit and many Thai populations are farmers. In the latest economic crisis, the agriculture sector suffered less damage than any other sector; however, the unequal earnings between agriculture and others still exist, causing resource deterioration. This situation is a requisite for the farmers for their self-improvement. Hence, the Ministry of Agriculture and Cooperatives has introduced a development plan to boost the agriculture sector as an agricultural development hub under a sufficiency economy philosophy. In addition, organic agriculture is a potential solution in sustainable agriculture development. It assures food security, causes healthy living, and meets organic agricultural product demand for national and international markets. This integration is achieved by cooperating between the government and private sectors (National Organic Agriculture Development Associate, 2017).

In Northeastern Thailand, most of the population are farmers and it is regarded as the poorest region in Thailand. However, in the last 20 years, there has been significant development in the agricultural sector in this region since large, medium, and small water resources have been developed in the northeast region to distribute water to the farmers for a better harvest and livestock development. In the past, only rice, cassava, jute and maize were grown in this region, but now the government policy has increased the productivity of crops and has motivated farmers to grow several vegetables, fruits, rubber plants, grapes, etc., in the region. To assure farmers of selling their product, i.e., support production and marketing, contract farming (Bank of Thailand, 2000) has been introduced.

Presently, the Department of Livestock of Thailand has encouraged livestock farming by developing some projects to catch farmers' attention towards livestock farming because beef cattle production in Thailand cannot meet consumer demand. The projects will encourage farmers to get more quantity and better beef quality to reach the demand domestically and internationally. There are importations of some beef products to feed the nation's demand, and most produced beef products are consumed. It is predicted that the demand for beef will increase depending on population growth. It is also predicted that milk production tends to increase from appropriate-age dairy cattle.

Moreover, dairy cattle farm management has improved than the previous years. Dairy cattle that produce less milk and old dairy cattle will not be selected and sent out of the farm. The government policy is focusing on milk quality development to reach the national quality standard.)Office of Agricultural Economics ,2020.

In Thailand, vegetable farming can produce vegetables all around the year, especially from December to February (cropping in winter). Vegetable products cannot meet the demand as the main problem in vegetable farming is flood which is responsible for huge loss to the farmers, and in many cases, they are not even able to secure their investment. Thai have been conscious of healthy eating habits so that the vegetable demand is always increasing. However, produced vegetable quantity per year is not enough for the market since farmers lack well breed seeds, knowledge of plant species, and technology. Having no link between producer and merchant, management, and environment (weather, season, etc.) have affected the quality and the quantity of vegetable production. Most of the chemical tests in the vegetables have found a significant level of pesticides residue in them. This might be due to the lack of knowledge and professional training about the use of chemicals. (Bureau of Agricultural Product Promotion and Management ,2012).

3.1.1. Outcomes

3.1.1.1. KKU Smart Organic Cattle Housing Pilot Site

The raising of cattle skills (nutrition and living conditions of cattle) and the adoption of smart farm technology and farmers' application will be improved up to 30-70%. To increase the exchange rate of meat and reduce cow stress with the following smart tools:

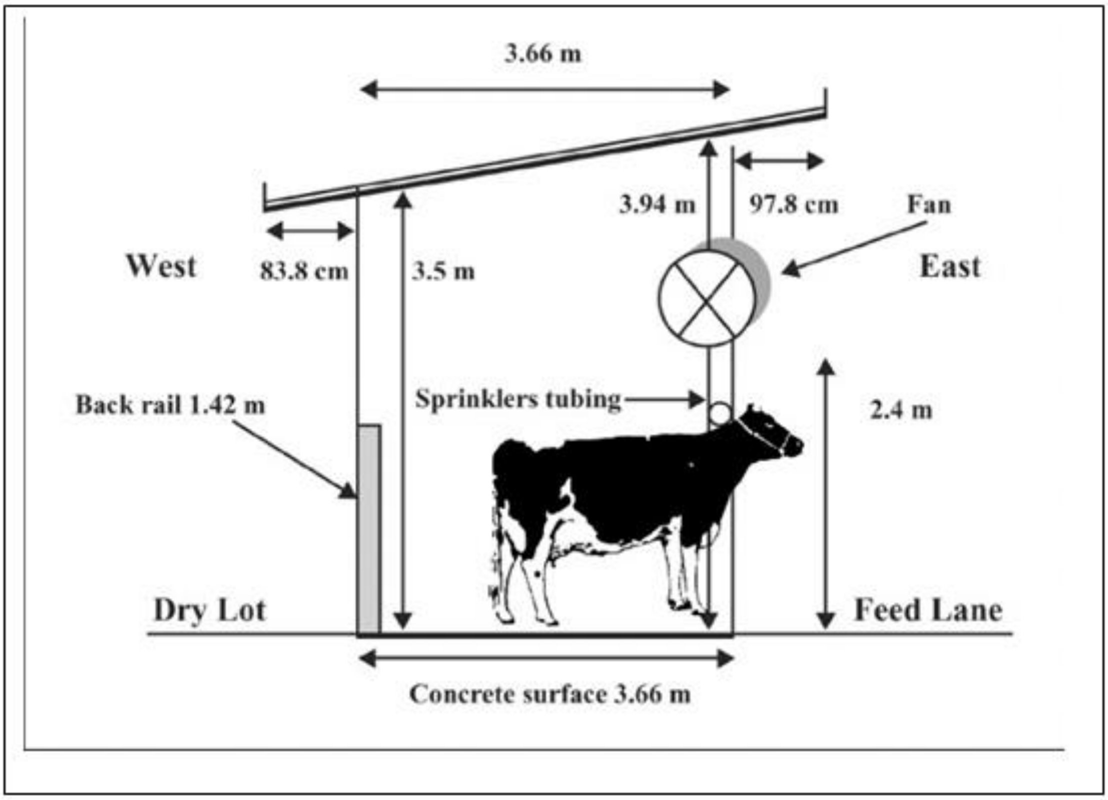
- The motion sensor system for monitors the cow's behavior.

- The cattle housing temperature control and detection system for keep cows cool.

- The data of cow growth rate will collect in the data collection system with an intelligent RFID system.

- All collected data will be stored on a cloud of the smart lab for further analysis.

Figure 12: Overall System in a Stable



3.1.1.2. KKU Smart Vegetable Organic Farm Pilot Site

The cultivating skill (such as reserving resources, fertilizers, and pesticides) and the adoption of smart farm technology and farmers' application will be improved up to 30-70%. To make vegetable cultivation more efficient and easier with these smart tools:

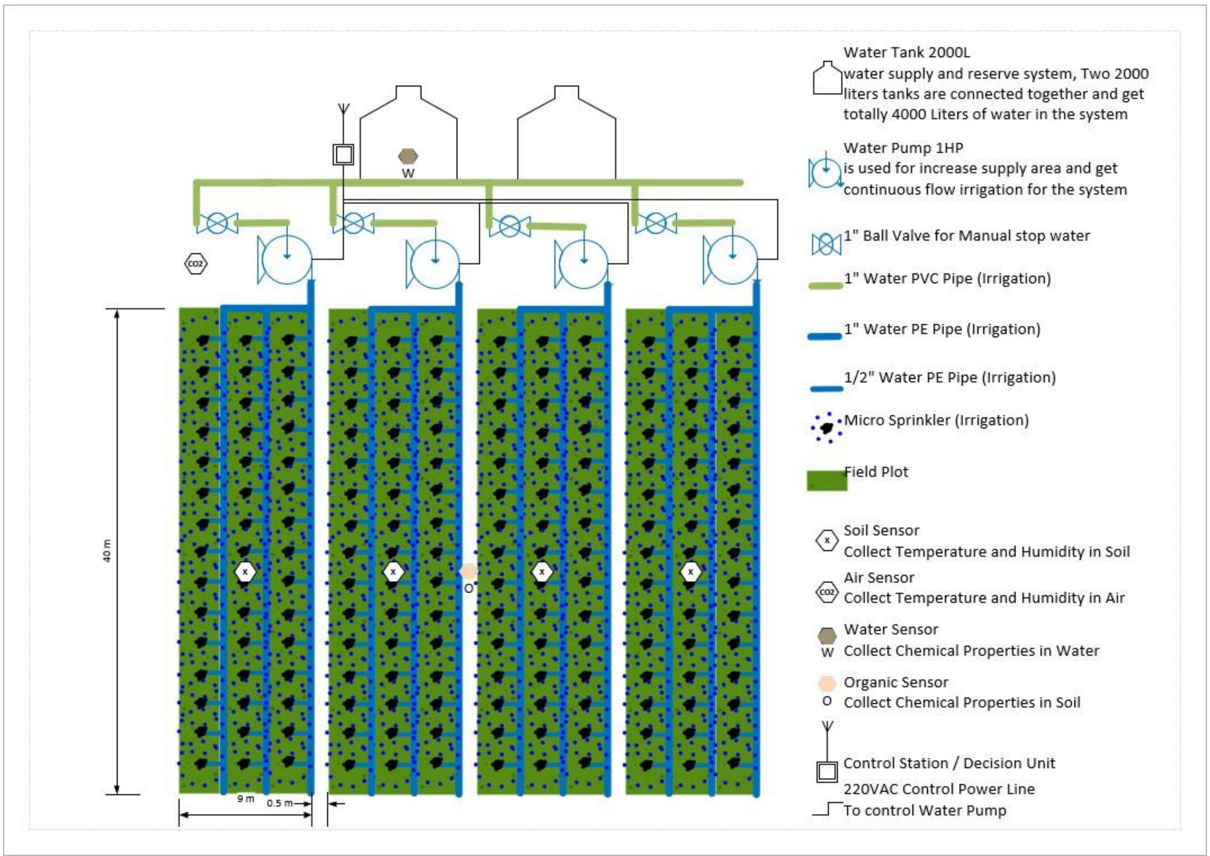
- The system for detecting toxins and contaminants in water.

- Water release control system via smartphone.

The smart sensor system measures soil moisture levels to efficiently provide adequate water to the plant's needs.

- The weather station for detecting climate for professional vegetable cultivation.

Figure 13: Overall System in Vegetable Pilot



3.2. Description of Smart Lab

3.2.1. Process of setting up pilot/activities

3.1.1.1. KKU Smart Organic Cattle Housing Pilot Site

Cattle barn is an open barn with shade, and the Smart Lab is set in the room next to the barn for collecting data. The sprinkler will spray from the cattle's shoulder to its body for reducing heat stress as it moves about to eat at a food trough. Electric fans will automatically run when the temperature and humidity rate exceed the setting rate. All monitor sensors will collect data of any situation and action; there are three sensor sections for the data, i.e., primary data, secondary data, primary data manual input as table 3.

Table 3: List of Primary Data from Sensors, Secondary Data from Sensors, Primary Data Manual Input in Cattle System

Primary Data from Sensors	1. Temperature 2. Humidity 3. Timestamp Cow Eating
Secondary Data from Sensors	1. Temperature Humidity Index 2. Cow Eating Times per day 3. Cow Eating Total minutes per day
Primary Data Manual Input	1. Weight 2. Height 3. Width 4. Body Temperatures 5. Breath Per Minutes 6. Cow Stain 7. Cow Birth Date (Age) 8. Cow Sex

3.2.1.1. KKU Smart Vegetable Organic Farm Pilot Sit

The Smart Vegetable Organic Farm Pilot Site is set as an open vegetable garden without a roof, and the Smart Lab is installed in a table near the pilot. When the humidity is lower than the set rate, sprinklers will automatically water vegetables; there are three sensor sections for the data, i.e., primary data, secondary data, and primary data manual input, as shown in Table 4.

Table 4: List of Primary Data from Sensors, Secondary Data from Sensors, Primary Data Manual Input in Vegetable System

Primary Data from Sensors	1. Air Temperature 2. Soil Temperature 3. Air Humidity 4. Soil Humidity 5. Air Pressure 6. Rain Fall (mm) 7. Wind Speed 8. Wind Direction 9. PM2.5 10. CO2 11. UV 12. Light Intensity 13. Timestamp Watering 14. PH
Secondary Data from Sensors	1. Temperature Humidity Index 2. Watering Times per day 3. Watering minute per day
Primary Data Manual Input	1. Weight 2. Height 3. Width

	4. Vegetable Types 5. Vegetable Name 6. Plating Date 7. Harvest Date

However, primary data and secondary data from the monitoring system will be simultaneously shown on the web page or application. Users can check the real-time data out. Primary data, secondary data, primary data manual input will be stored on a cloud system. Users can look at all the data or calculate for any result as the proposal.

Figure 14: System Architecture

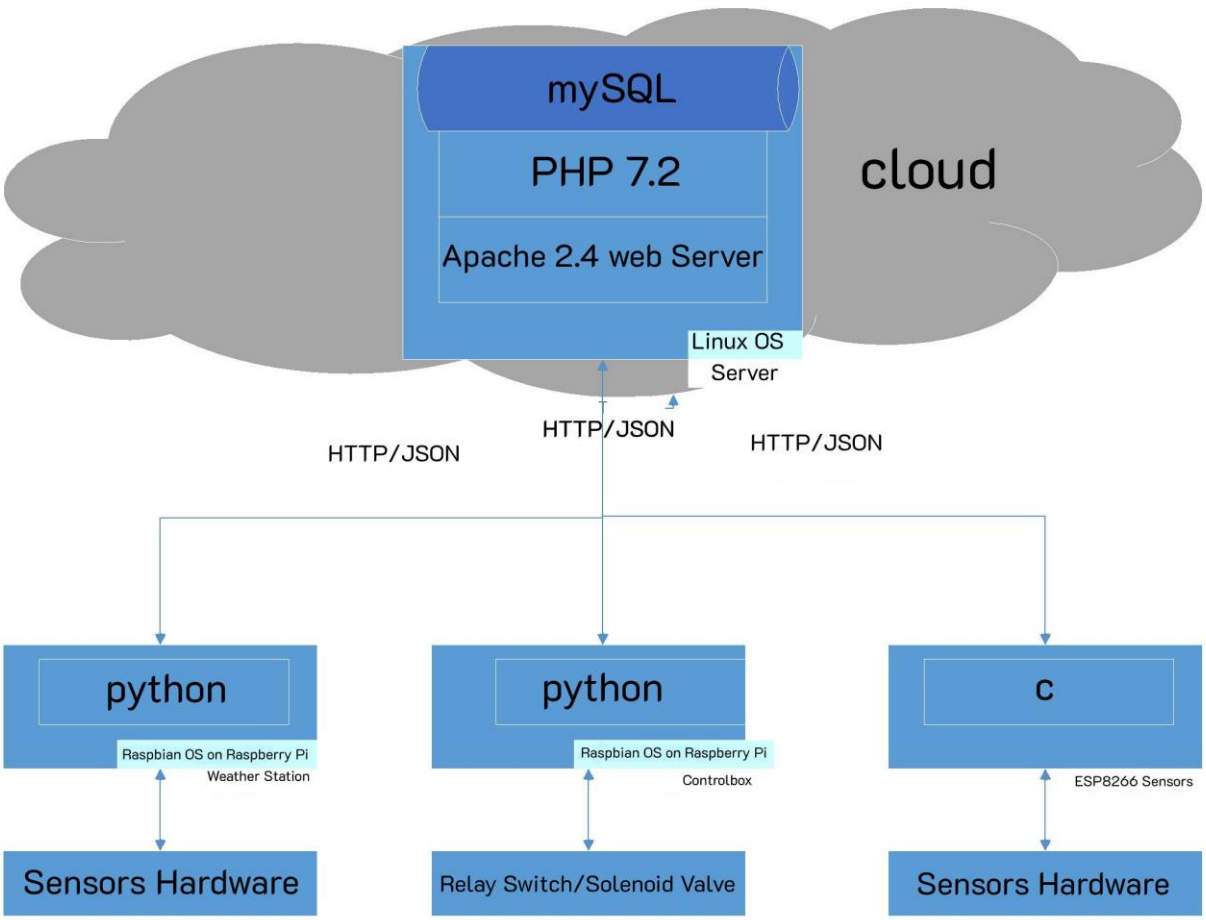


Figure 15: Diagram of the System

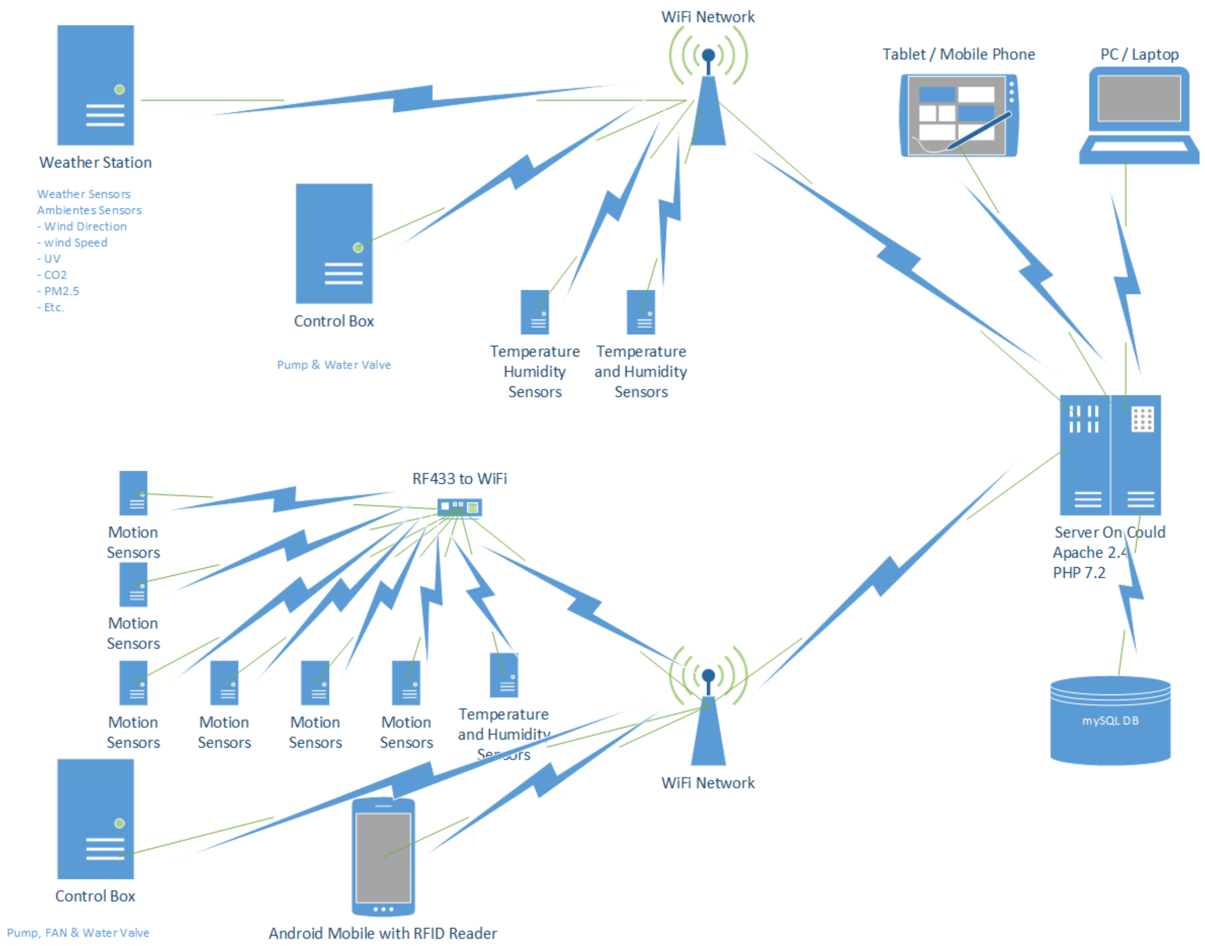


Figure 16:Main Page of Platform

3.3. Implementation of Smart Lab

There are two sections of the main page of the platform as follows.

1. Users will choose the the KKU Smart Organic Cattle Housing link or KKU Smart Vegetable Organic Farm link for operating from the right to figure 16.

2. The left one is the display of the weather station.

3.3.1. KKU Smart Vegetable Organic Farm System

Figure 17: KKU Smart Vegetable Organic Farm Pilot Site Home Page (Vegetable)

The left one is the control system on the Smart Organic Vegetable Farm Pilot Site, i.e., vegetable data, KKU Smart Organic Farm control system, and vegetable data addition (manual).

Figure 18: KKU Smart Organic Vegetable Farm Pilot Site Control System (Vegetable)

And all links at the right one are able to take users to collected data display, irrigation system control, and irrigation control and timer.

Figure 19: Data from Sensors Display (Vegetable)

Figure 20: Irrigation System Control (Vegetable)

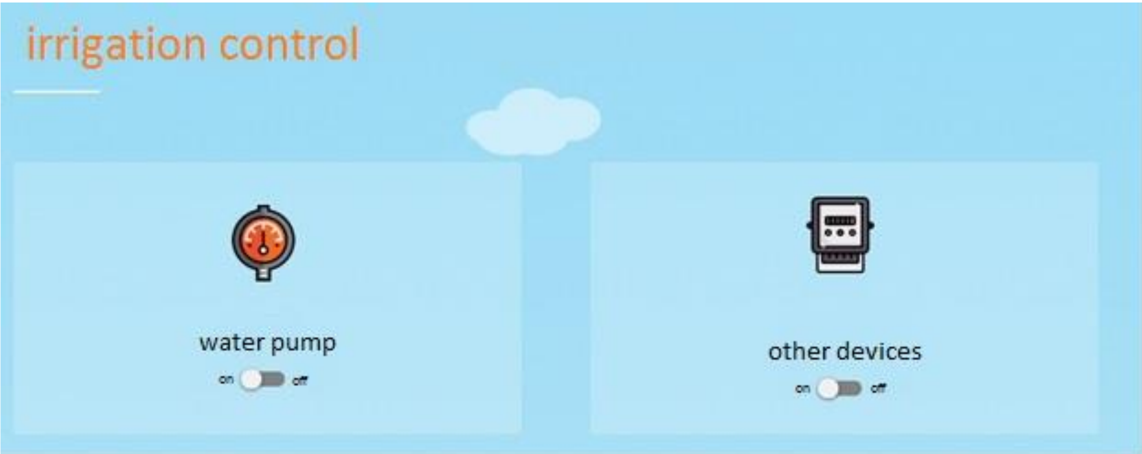
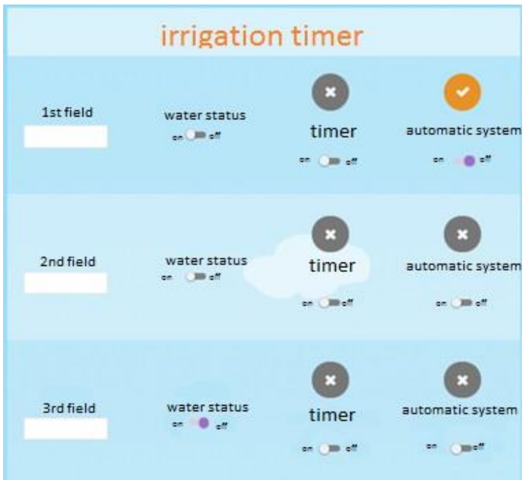
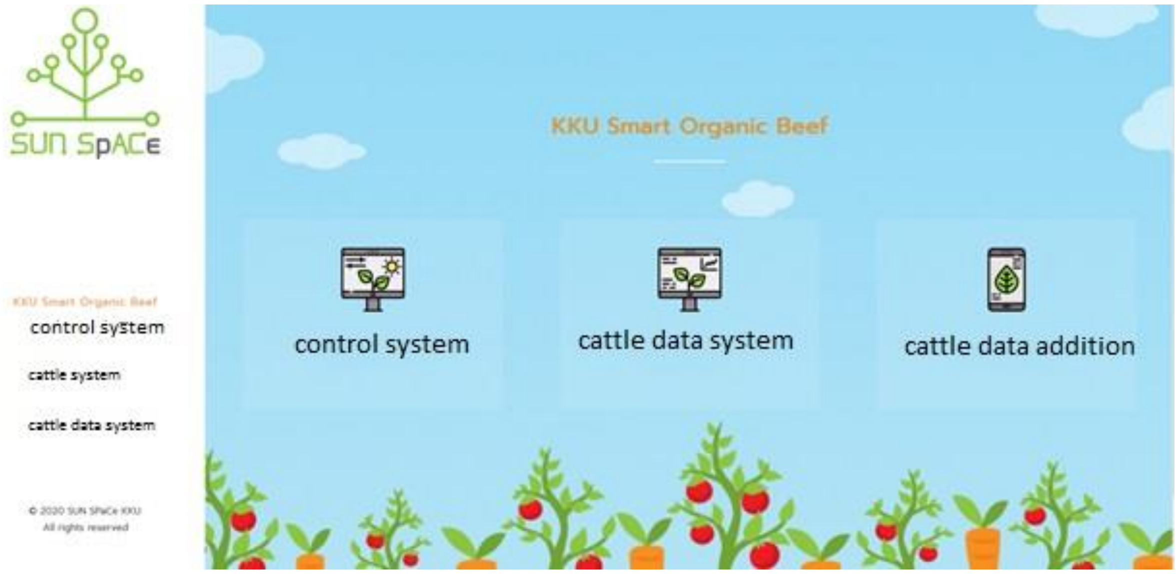


Figure 21: Irrigation Control and Timer (Vegetable)



3.3.2. KKU Smart Organic Cattle Housing System

Figure 22: KKU Smart Organic Cattle Housing Pilot Site Home Page (Cattle)



On the Smart Organic Cattle Housing Pilot Site, the left one is the control system i.e. Cattle data, KKU Smart Organic Beef control system, and cattle data addition (manual).

And all links at the right one are able to take users to collected data display, irrigation system control, irrigation control and timer

Figure 23: Humidity Sensor System of Barn (Cattle)

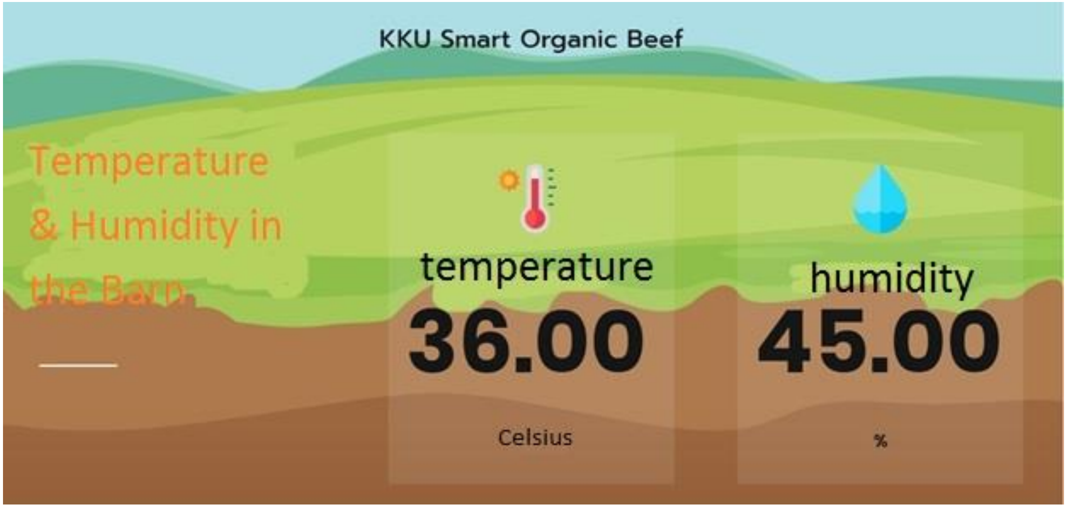


Figure 24: Irrigation and Electric Fans Control (Cattle)

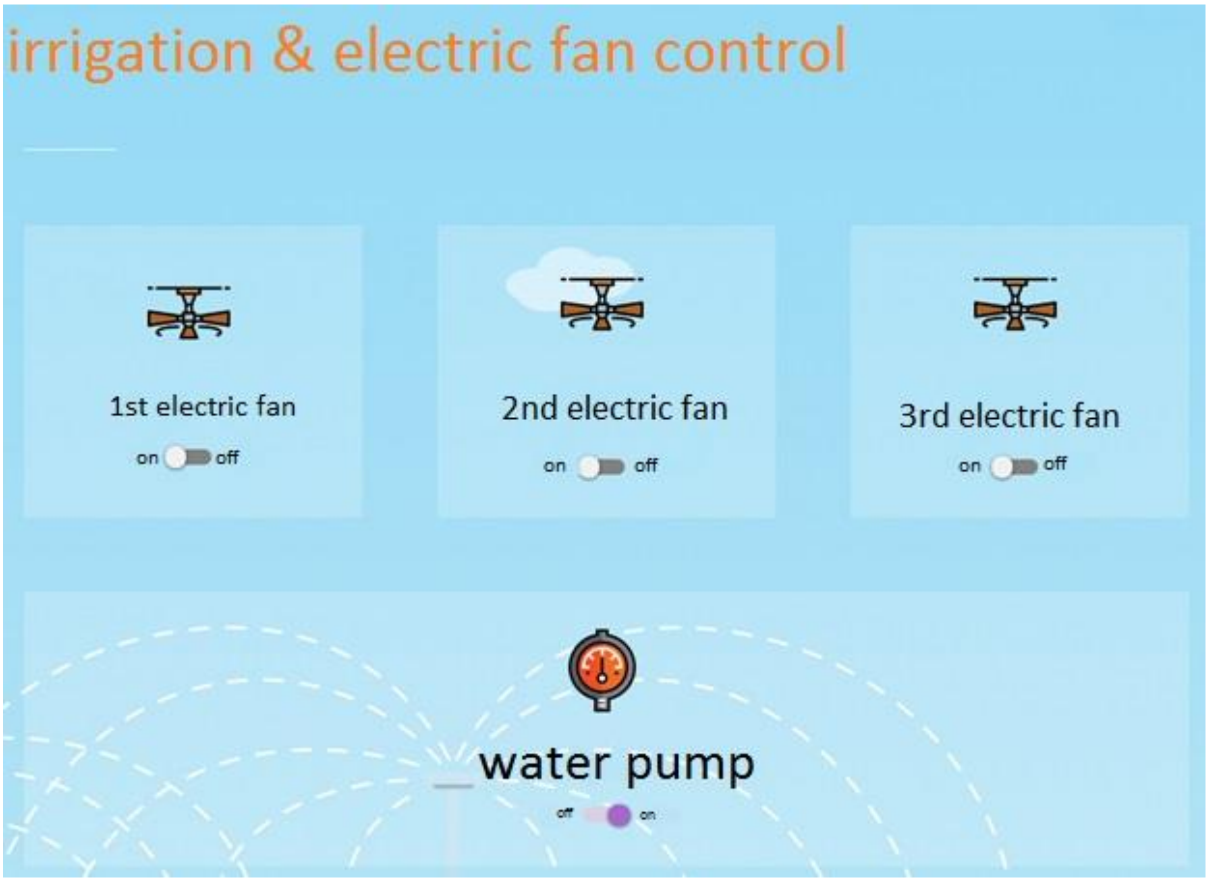
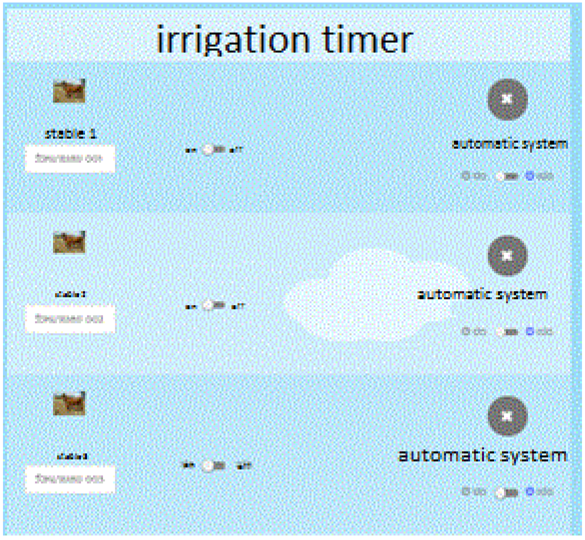


Figure 25: Irrigation Control and Timer (Cattle)

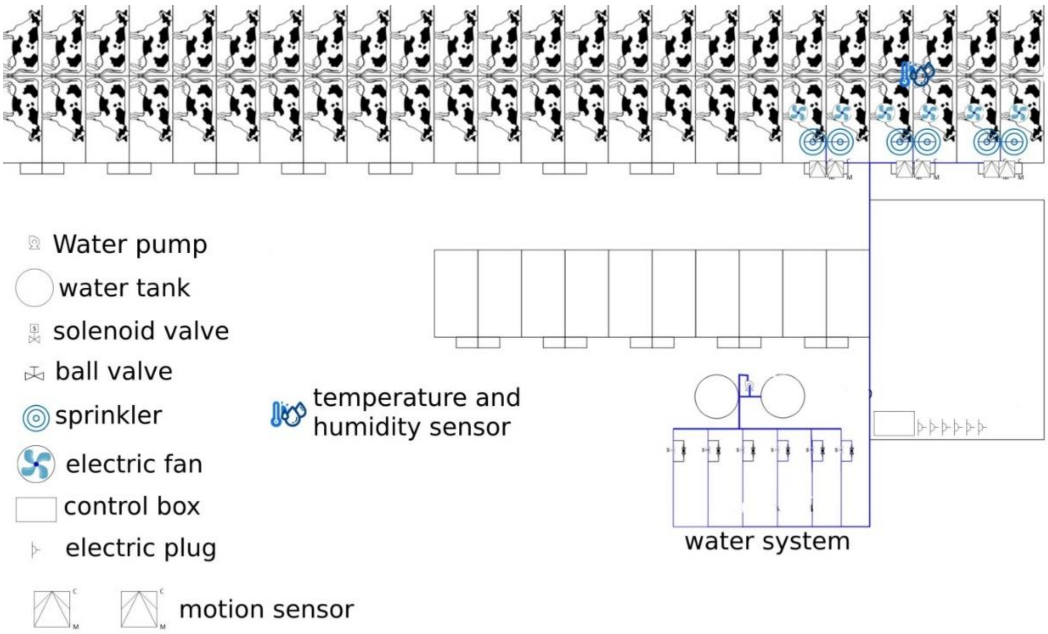


3.3.3. Operation of Smart Lab

3.3.3.1. Smart Organic Cattle Housing Case

1. When the cattle come for eating, they will pass the motion sensor. The sensor will send the signal to the control box to switch on the water pump then the solenoid valve will be releasing the water to sprinklers showering a cattle's body automatically.
2. The temperature sensor will report the real-time temperature. When the temperature in the cattle housing is higher than the setting rate, the censer will send the signal to the control box to turn on the electric fans. And the electric fans will turn-off automatically when the temperature in the cattle housing is stable.
3. Adhered ear Tag RFIDs show a cow's data such as age, sex, height, body's temperature, and breath rate (frequency per day), food taking (minutes/time and times/day) and weather data such as temperature and humidity (Humidity + + Temperature humidity index (THI) = can be calculated by Temp+Humid which is THI = ((1.8 x temperature o C)+32)-((0.55-(0.0055x%humidity))x((1.8xtemperatureo C +32)-58))); users can edit and set the ones above via the application and cloud.
4. All collected data will be stored on a cloud of the smart lab for further analysis.

Figure 26: Overview of Smart Organic Cattle Housing Pilot Site



3.3.3.2. Smart Organic Vegetable Farm Case

1. The system for detecting toxins and contaminants in water: in groundwater and surface water, trace contamination detection sensors detect the presence of harmful contaminants, thereby making the water better suited for vegetable

irrigation purposes. Sensors for trace contamination detection in wastewater detect the severity of contaminants.
2. Soil sensors have been installed in the vegetable plot for monitoring the moisture of the vegetable plot. When the soil is dry more than the set rate, the sensor will send a signal to the control box then the irrigation system will turn on automatically. And when the soil has moisture in the rate-setting, the sensor will send the signal to the control box to turn off the irrigation system.
3. Or user will control the irrigation system via the mobile phone. Users will check the data of all sensors at the vegetable plot in real-time at the website and can turn on or turn off the irrigation system manually by phone anytime and anywhere.
4. All collected data will be stored on a cloud of the smart lab for further analysis. The sensor readings from the interconnected stations help farmers to evaluate the maturity of their crop and choose the ideal time to proceed to harvest by a weather forecast. These data can be linked to decision support tools, allowing to follow the progress of the development cycle and anticipate the date of harvests such as humidity level and precipitation forecast, cumulated temperatures and growing degree days

3.4. Training materials

3.4.1. Training Materials

3.4.1.1. Cattle case

Motion Sensors: detect the motion and send the motion data to a cloud system

Sprinkler: spray to shower cattle

Control box: control electricity distribution to the water pump, solenoid valve, and electric distribution plug.

Temperature sensors and air humidity sensors: measure temperature and humidity

Water pump: control water pressure system

Solenoid valve: control the releasing of water supply to the water pipe

125 kHz Tag RFID

125 kHz Tag RFID Interpretation machine

3.4.1.2. Vegetable case

Sprinkler: water vegetable

Control box: control electricity distribution to the water pump, solenoid valve, and electric distribution plug.

Temperature sensors and air humidity sensors: measure temperature and humidity

Water pump: control water pressure water system.

Solenoid valve: control the releasing of water supply to the water pipe.

Weather Station: measure environment condition.

3.5. Conducting training/ demonstrations for different groups of farmers in the Smart Lab

3.5.1. Chosen Key Indicators for Pilot Success

There are three groups of KKU's key indicators, i.e., 50 traditional farmers for G1, ten modern Famers for G2, and six professionals/officers/researchers for G3.

- Group 1 (G1): traditional agriculture farmers, having the basic skill of using a smartphone, being less literate, and not having business model knowledge
- Group 2 (G2): modern farmers, having a skill of using ICT in their farm, and having advanced skill in using technology, having business model knowledge
- Group 3 (G3): being officers/professionals/researchers officially in an agricultural field.

3.6. Training process

KKU SUNSpACe training proposes an appropriate adaptive learning approach to develop the farmer's capacity to implement Smart Farms. The Training Program addresses both "train-the-trainer" and "train-the-farmer." For each pilot, we integrate smart farming techniques, group discussions, lab practice, project assignments, assessment, and teaching as well as real-world exercises to put learning into practice.

Figure 27: Processes of training implementation

The training is in hybrid training (online learnings via the online platform and onsite learning) Our training consists of 4 modules training program as follows:

3.6.1. Training Modules

KKU Train of Trainers organized and hosted in Thailand with the aim to build capacity of academicians, researchers and agriculture extension agents in implementation of smart technologies in Northeastern of Thailand. Training of trainers provide knowledge by researchers from the SUNSpACe project under the operation of Khon Kaen University consists of researchers from the Faculty of Business Administration and Accountancy, the Faculty of Pharmaceutical Sciences, the Faculty of Agriculture, the Faculty of Engineering and Phu Sing Agricultural Development Center due to the royal initiative. There are also researchers from member countries in the SUNSpACe project to provide knowledge for the training of trainers.

This training course is designed for 4 modules in smart farming practices on hybrid program training. Topics of training are the followings; Digital Agriculture, Livestock Farming or Cultivation Farming, Standardization and Argo-Business. The training modules included IoT in Agriculture, smart monitoring and smart controlling, data processing, business modeling, occupational health topics supplemented with field visits; demonstration of agro-meteorology, soil, pH and moisture sensors, automation of irrigation equipment installed at the smart lab, Integrated Organic farm, CNR. The participants discussed the smart farming technologies that could be adapted in Thailand. The training was formed both online and onsite mode. Some participants could not travel to class due to pandemics because they live in another province but they can participate in the training virtually via Zoom cloud meeting.

Developing an appropriate adaptive learning approach for smart farmers and designing the training program in 4 modules as follows.

Table 5: KKU Training Modules

KKU's Module	**SUNSpACe's Module (E-learning platform)**
Digital Agriculture	**Digital agriculture**
Livestock Farming and Cultivation Farming	**Smart Farm**
Standardization	**Standardization**
Agro-Business	**Agro-Business**

Figure 28: Training schedule

Mon	Tue	Wed	Thu	Fri
Day1: 05/07/2021	Day2: 06/07/2021	Day3: 07/07/2021	Day4: 08/07/2021	Day5: 09/07/2021
Digital Agriculture Lecture	Digital Agriculture Lecture	Livestock Farming Lecture	Cultivation Farming Lecture	Cultivation Farming Lecture
Digital Agriculture Group Discussion	Digital Agriculture Group Discussion	Livestock Farming Demonstrate	Cultivation Farming Demonstrate	Cultivation Farming Demonstrate
Day6: 19/07/2021	Day7: 20/07/2021	Day8: 21/07/2021	Day9: 22/07/2021	Day10: 23/07/2021
Digital Agriculture Lecture	Livestock Farming Lecture	Standardization Lecture/Demonstrate	Standardization Lecture/Demonstrate	Cultivation Farming Demonstrate
Digital Agriculture Group Discussion	Livestock Farming Demonstrate	Standardization Lecture/Demonstrate	Standardization Lecture/Demonstrate	Cultivation Farming Workshop
Day11: 2/08/2021	Day12: 3/08/2021	Day13: 4/08/2021	Day14: 5/08/2021	Day15: 6/08/2021

Digital Agriculture Lecture	Argo-Business Lecture	Argo-Business Lecture	Livestock Farming Lab Practice	Cultivation Farming Demonstrate
Digital Agriculture Workshop	Argo-Business Group Discussion	Argo-Business Workshop	Livestock Farming Demonstrate	Cultivation Farming Group Discussion
Day16: 16/08/2021	Day17: 17/8/2021	Day18: 18/8/2021	Day19: 19/8/2021	Day20: 20/8/2021
Standardization Group Discussion	Livestock Farming Group Discussion	Cultivation Farming Group Discussion	Livestock Farming Field trip	Cultivation Farming Field trip
Standardization Workshop	Livestock Farming Workshop	Cultivation Farming Workshop	Livestock Farming Field trip	Cultivation Farming Field trip

3.6.2. Implementation of Training

Ten Smart Farm trainers have been trained and assigned to train fifty local farmers (1 smart farmer per 5 local farmers). With this "cascade" approach, knowledge transfer will be fast and efficient, and the number of trained farmers will cross quickly. Academic staffs and government agencies are also part of the Training Program to promote the project, to better manage the project and its sustainability.

3.6.2.1 KKU Train of the Trainers

The training of the trainer process for groups G3 and G2, which include researchers, officers, and smart farmers, Group 1 (G1), Group 2 (G2), and Group 3 (G3) will be trained on cattle use case systems and vegetable use case systems in the same process. The difference among the groups is their knowledge and their skills, including the following these steps:

1. Select farmers who can participate in the training course and have the knowledge and qualification required for G1, G2, and G3.
2. Invite all selected farmers to participate in the workshop training that will take place in Smart Lab and pilot site as located in the university (The Faculty of Agriculture, KKU) to be trained about the system of both smart labs.
3. Ask for feedback from the participating farmers and let them assess after training and encourage them to practice on their real farm.

Khon Kaen University possesses all benefits. The operation results, such as the project itself, the research, the training, and the activities, must be in line with the agreement between the departments involved (Khon Kaen University and the Faculty of Agriculture) in the project.

Step 1: Find farmers who want to take part in the training course. Select farmers who can participate in the training course and have the knowledge and qualification required for G1, G2, and G3.

Step 2: Farmers who have been hired must use smart technology to educate themselves. During the learning process, farmers can communicate with trainers if they have any queries or concerns.

Step 3: Before the training course, all selected farmers will examine as a pre-test to let trainers assess their knowledge base.

Step 4: Farmers who have been recruited must attend all of the training programs to learn about smart farming principles and technologies, as well as how to install sensors and evaluate sensor data for control. Farmers must then assess their understanding before implementing the approach in their farms.

Step 5: All trainees will take a lecture class to learn the overall infrastructure of the pilot site, smart lab, system, etc.

Step 6: All trainees will learn installation processes (devices, equipment, etc.).

Step 7: Trainers will demonstrate device use (setting up, controlling, interpreting data, application and web page control, etc.).

Step 8: All trainees take an examination as a post-test to let trainers assess their new knowledge and understanding of the lessons.

Step 9: The examiners will visit the farms of the farmers who have been selected to talk with them, collect comments, and complete an evaluation after learning and practicing on a real farm.

Training Date: 1st Session 5th -9th July 2021
2nd Session 19th – 23rd July 2021
3rd Session 2nd - 6th August 2021
4th Session 16th - 20th August 2021

Program Training: Hybrid (online and onsite)

At the end of the project, the Faculty of Agriculture at Khon Kaen University will be the owner of all devices installed at the pilot site and smart lab to teach other interested parties.

Table 5: KKU Course Outline

Module	Trainers	No.of Days	Training Format
Module 1 Digital Agriculture	Dr. Watis Leelapatra (KKU) Assoc. Prof Dr. Keshav Dahal (UWS) Assoc. Prof Dr. Ravi Koirala (UWS) Assoc. Prof Dr. Dharmendra Mishra (AEC) Assoc. Professor Dr. András Gabor (CUB)	4 Days	Lecture 15 hrs. Group Discussion 9 hrs.
Module 2.1 Livestock Farming	Assoc. Prof. Dr. Kritapon Sommart (KKU)	5 Days	Lecture 6 hrs. Lab Practice 6 hrs. Demonstrate 9 hrs. Workshop 9 hrs.
Module 2.2 Cultivation Farming	Asst. Prof. Dr. Chanon Lapjit (KKU) Assoc. Prof Dr. Phub Dorji(RUB) Dr. Ugyen Yangchen (RUB) Asst. Prof. Dr. Pradorn Sureephong (CMU)	6 Days	Lecture 6 hrs. Lab Practice 3 hrs. Demonstrate 12 hrs. Workshop 9 hrs.
Module 3 Standardization	Assoc. Prof. Dr. Supatra Chadbunchachai (KKU) Assoc. Prof Dr. Rameshwar Rijal (KEC) Assoc. Prof Dr. Keshar Prasain (KEC)	3 Days	Lecture 15 hrs. Group Discussion 9 hrs.

Module 4 Argo-Business	Assoc. Prof Dr. Pensri Jaroenwanit (KKU) Dr. Pongsutti Phuensane (KKU) Assoc. Prof. Dr. Aicha Sekhari (ULL) Assoc. Prof. Dr. Claudine Gay (ULL)	2 Days	Lecture 6 hrs. Group Discussion 6 hrs.

3.6.2.2 KKU Train the local farmer (G1)

The process of training implementation to ordinary farmers which are farmers in group G1 (local farmers) comprising:

• Step 1: Recruit farmers to participate in the training course by smart farmers (G2) invitation and by a suggestion from relevant government agencies (Application period 1st - 12th February 2022)

• Step 2: Recruited farmers must participate in the training program comprising of 3 days of hybrid training and must have the qualification as follow:

1. The intention to apply new knowledge and skills
2. Opportunity to apply and train others
3. Farming experience
4. 100 % times contribution to the training

• Step 3: farmers must do the assessment to test their understanding before doing the real practice in their own farms.

• Step 4: The examiners will go to recruited farmers' farms to discuss with farmers for getting feedback and doing an assessment after learning and practicing on a real farm.

- Duration of the training: 3 days (Online:1 day/Onsite: 2 days)
  - Class Orientation: February, 15th 2022 (Online)
  - Online training: February, 18th – 19th 2022
  - Onsite training: February, 21st – 22nd 2022
- Number of participants: 50 participants
- Speakers: KKU team and smart farmer (G2)
- The expectation from this training
  - Knowledgeable in smart farming.
  - Apply smart technology on their farm.
  - Obtain information to make the right decisions.
  - Understand product management and marketing.
  - Aware of product quality and consumer safety issues.

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