Co-funded by the
Erasmus+ Programme
of the European Union

SUstainable developmeNT Smart Agriculture Capacity
« SUNSpace »

Smart Farm Vision in EU and Asia
Literature review

Project Reference No	**598748-EPP-1-2018-1-FR-EPPKA2-CBHE-JP**
Editor(s)	UWS & SUNSpACe Consortium
Document Description	D11 - Literature review on Smart Farm Vision in EU and Asia

Table of contents

1 Introduction

Farm productivity across the globe has been significantly increased since the last decade ("Global Smart Farming Market- Analysis and Forecast (2018-2022)," 2018). However, there has been a rise in global demand for food brought about by the exponential growth of world population and shrinking the agricultural lands. The rapid escalation of food demand due to the growing population worldwide is boosting the demand for precise and resource-efficient farming practices at one level with ensuring food security. ***Such an approach of using advanced technologies into existing farming techniques to increase the quantity and quality of agricultural products is termed as "Smart Farming".*** Ecologically and economically meaningful measures are applied in Smart Farming to improve productivity and food security. This change in the way of farming provides the foundation for the development of new forms of interaction and value creation, and delivers a baseline for business model innovations.

Deliverable D1.1 of WP focuses on compiling a comprehensive literature review on Smart Farming and its adoption within some countries of Europe and Asia. This output aims to explore the national and international policies and frameworks and observe how they facilitate the adoption of modern technologies in Smart Farming to facilitate the implementation of Industry 4.0 approaches. It covers the approach practised by SUNSpACe partner countries towards the realisation of the Smart Farming vision, and presents overlapping and complementary features of the approach. This output serves as a guideline for transferring and integrating the Smart Farming techniques in the European region with the farming practices in Asian countries.

2 Smart Farming

Smart Farming is an innovative concept that uses modern technology to increase the quantity and quality of agricultural products. Farmers in the 21st century have access to Global Position System (GPS), soil scanning, data management, and the Internet-of-Things (IoT) technologies. By precisely measuring variations within a field and adapting the strategy accordingly, farmers can significantly increase the effectiveness of pesticides and fertilizers and use them more selectively. Similarly, using Smart Farming techniques, farmers can better monitor the needs of individual animals and adjust their nutrition correspondingly, thereby preventing disease and enhancing herd health (Schuttelaar & partners, 2017). It involves the incorporation of information and communication technologies into machinery, equipment, and sensors for use in agricultural production systems.

The Alliance for Internet-of-Things Innovation (AIOTI) defines the concept of Smart Farming as a set of automatic data management processes; including data gathering, data processing and data analysis tasks; in agricultural production systems. Its main goal is to improve the productivity and sustainability of the farm regarding the overall value chain by using advanced information and communication technologies mainly Internet-of-Things technologies. Smart Farming should facilitate the production, sharing and reuse of meta-data about animals, plants and soil. This will improve food security, which refers to the awareness and prevention of foodborne illnesses from food production to consumption, and optimize the value chain regarding time and quality of products (Aioti, 2015).

The main Smart Farming advances have occurred in automatic data collection, which has increased the volume of data available for analysis, but the collection of information for farmers is secondary compared to field operations (Pivoto et al., 2018). New technology will requires modification of existing tools with sensors and adaptations increasing the costs and changing the way farms are organized. Big data demands higher processing (Philip Chen & Zhang, 2014) and higher costs, which may discourage farmers from adopting these technologies (Busse et al., 2013). Nevertheless, with the aid of researchers and agricultural experts, analysis models and instructions can be incorporated in the Smart Farming system and policy reforms made in governance to encourage the farmers.

The technologies related to Smart Farming are still in early development, but the possibilities are numerous. Smart farming is a compelling area for research whose basic requirements for rapid development are knowledge base and capital (Schuttelaar & partners, 2017). Initially, domestication of livestock and crops then, mechanization and chemistry brought profound structural changes to the agriculture sector that influenced the entire economy (Pivoto et al., 2018). Now, with the IoT, smart environments and cloud computing could be the techno-social changes that could revolutionize the agricultural sector. This context is a reflection of Industry 4.0 and these technological practices contribute in terms of planning, monitoring, control, optimisation, and documentation can bring forth significant improvements.

In the following, we present the general understanding of Smart Farming from framers, researchers & engineers, and consumers point of view, who are using, inventing and benefiting from the technologies underpinning Smart Farming.

2.1 Smart Farming: From the perspective of Farmers, Researchers, Engineers and Consumers

Smart Farming (SF) involves the incorporation of Information and Communication Technologies (ICT) into machinery equipment, and sensors for use in agricultural production systems. New technologies such as the Internet-of-Things and cloud computing are expected to advance this development, introducing more robots and Artificial Intelligence (AI) into farming (Pivoto et al., 2018). Researchers and Engineers are working for the advancement of such technologies and make it farmer friendly. The acceptance of modern technology depends on the resistance that farmers have towards such innovations. Farmers will quickly accept the innovations if it fits more into the existing system of beliefs and practices.

Farmers in developing countries are mostly undereducated and unskilled in modern technologies. Nepal, having ¾th of the population engaged in agriculture, only 1/4th of gross domestic product is occupied by agricultural products. Such a country needs technology, in fact, a smart technology which to increase agricultural products. Farmers desire a cost and user-friendly, simple and accessible technology, which can help them in plant disease identification, soil-plant requirement identification and weather warning features. Poor market reach is also one of their primary concern.

There has been the influence of numerous intermediaries from farm to market that decreased their profit and were very demotivating to them. Thus, they also desire that the market reach their farm using smart technology eliminating the intermediaries such that they can receive the price they deserve for their products.

Farmers' point of View

Mr. Mongkol Buksuntear, a farmer at Esan (Thailand) and the president of Nong Hoi Chiang Song Rice Growing Community Enterprise, states that Smart Farming is a type of agriculture that is self-sufficient. Mr. Somkid Peng-lee, Chairman of the Organic Farming Community Group, Ban Kut Chiang Mi mentioned that Smart Farming is a new type of agriculture that requires technology to drive agriculture.

Next, Mr. Natawat Inthawong from Chiang Mai explains that Smart Farming is that agricultural activity which is based on modern technology. New technologies can meet the needs of farmers. Mr. Phaitnarin Petchasen says that agriculture relies on various information to help farmers make proper decisions allowing farmers to adjust their farming methods to suit their area. Pedsan and Lalida state that Smart Farming is a new model of farming business that farmers need to know how to use technology to produce agricultural products to meet the standards of the market complete knowledge of agricultural occupations and keep up with the situation and circumstances.

Ms. Buddha Laxmi Maharjan, farmer and owner of "Kriba Krishi Farm Tatha Pashu Palan" (Agricultural Farm and Animal Husbandry; Area: 1.5 hectares) from Chandragiri Municipality, Kathmandu has been involved in Galvanized Iron (GI) structure tunnel farming for vegetables like tomatoes, cauliflower, spinach, mustard green, cabbage, radish, cucumber, carrot, etc., and poultry and livestock farming like pigeon, hens, goats, cows, etc. She has been using chemical fertilizers and pesticides along with the organic compost derived from both plants and animals waste. Mrs. Maharjan has installed a greenhouse for preparing seeds and seedlings with the partial financial support from the government of Nepal but is hesitant to use it due to the higher operation cost. The market price of her produce is always fluctuating and in general, she is in loss. It is getting harder for her to get sustained in agriculture and pay the salaries of her employers. According to Mrs. Maharjan, the scarcity of seeds, chemical fertilizers in the market makes her job even harder. However, Mrs. Maharjan is using some modern technologies in her greenhouse and GI tunnels but has limited knowledge of smart farming. Mrs. Maharjan needs regular guidance and support from the government, experts and researchers to make her stick to Smart Farming.

Mr. Akhil BC, a part-time farmer rents 0.5 hectares of land in Chandragiri Municipality, Kathmandu for GI tunnel farming. He produces fruits like kiwi, Japanese persimmon and vegetables like tomatoes, cabbage, radish, cucumber, green leafy vegetables, cauliflower, etc., and sells in the local market. He does not use chemical fertilizers and insecticides, but uses organic composts and organic pesticides as alternatives. He follows mixed crop cultivation method as a way to protect the crops from certain insects and diseases. He is happy with his low scale farming because it helps him to sustain his family of four members. He earns NRs. 60,000 ($500 USD) per month from his small farm. Mr. BC also researches with new varieties of plants and seeds for better production. In addition to his small farm, Mr.

BC and his friends own a workshop (Hamro Yantrasala) for making agricultural tools like dryer, seed planter, equipments for green house, soil plougher, crop harvester, etc.

Farmers from "Khani Khola Tarkari Tatha Falful Samuha" (Khani Khola Vegetable and Fruits Community), Dhunebesi Municipality, Dhading, Nepal are working in a group in over 110 hectares of land cultivating vegetables and fruits both in open and in plastic tunnels. This Municipality is one of the main pocket areas for vegetables supply to Kathmandu Valley. Presently, farmers of this area are aware of the consequences of the excess use of chemical fertilizers and pesticides so use organic composts and certified organic pesticides only. This group of farmers lacks direct access to the consumers and is compelled to sell their produce in lower rates to the middlemen and other intermediaries. This makes them struggle for sustainability in agriculture.

The smart farmers' in the Industry 4.0 era must be integrated into networks or technology in order to reduce costs increase bargaining power from the purchase of production factors or selling products to middlemen trade. Asst. Prof. Panomkorn Kwakhong (Faculty of Engineering at Khon Kaen University, Thailand) said that Smart Farming is a technology-driven agriculture processing various databases available to use in agriculture and must be able to use the existing data to analyse the required task.

From the farmers' point of view, Smart Farming should provide the farmer with benefit in the form of better decision-making or more efficient exploitation operations and management. It should provide the increased productivity to farmers that are strongly related to cultivation and livestock farm in both large and small-scale farmers having new and more precise tools to produce more product and provide the benefits in terms of environmental issues. Therefore, Smart Farming is based on the optimized management of inputs in a field according to actual crop needs that compose of data-based technologies, including remote sensing, internet, and satellite-positioning systems like GPS, to manage crops and reduce the use of water, fertilizers, and pesticides. In this sense, Smart Farming is strongly related, to three interconnected technology fields ("What is Smart Farming? - Smart-AKIS," n.d.):

- Management Information Systems: it refers to systems for collecting, processing, storing, and disseminating data in the form needed to carry out a farm's operations and functions.
- Precision Agriculture: management of spatial and temporal variability to improve economic returns following the use of inputs and reduce environmental impact. It includes Decision Support Systems (DSS) for complete farm management.
- Agricultural Automation and Robotics: it refers to the process of applying robotics, automatic control and artificial intelligence techniques at all levels of agricultural production, including farmbots and farmdrones.

Experts', Researchers' & Engineer's point of view

Smart Farming should provide added value regarding the environmental issues and the productivity that is strongly related to cultivation and livestock farm in both large and small scale.

Mr. Prem Lama, Chairman of Ashapuri Organic Pvt Ltd (http://ashapuriorganic.com), Ashapuri, Sanga, Kabrepalanchowk is also an expert in organic farming in Nepal. Mr. Lama carries organic farming of higher valued organic crops including herbs and spices like mint, basil leaf, lemongrass, rosemary, sativa, oregano; mushrooms like Shiitake; green tea; fruits like kiwi, papaya, etc.; and vegetables like cauliflower, tomato, cabbage, green leafy vegetables, potato, radish, etc. He owns or rents land in different locations of Nepal in partnerships with the locals to grow same produce in different seasons at different locations. He also adapts mixed crop farming method to avoid the use of pesticides. Mr. Lama sells his produce in organic markets of Nepal and abroad with higher price. His produce is organic certified by different agencies of Japan, Switzerland and USA. He follows climate-based agriculture and grows produce favored by the environment of the region. Mr. Lama has become a pioneer in organic farming in Nepal and works with different national and international agencies for the better future of organic farming in Nepal.

Mr. Prabin Pramod Khatiwada, Technical Director of Arava Nepal Modern Agriculture Company Limited and an Israel return has been working with a group of 111 other Israel returned Nepalese with focuses in integrated farming at Sundar Bazaar, Lamjung, Nepal in an area of 14 hectares of land. The company farms vegetables, fruits, livestock, poultry and fish. Chemical fertilizers and pesticides are used in optimum amount. Composts are used as supplements. This group of young farmers is familiar with the use of technology in farm from their training or education in Israel. Presently, this group faces problem of direct reach to the consumers and are compelled to sell their produce to the middlemen at lower price. These farmers are in a need of automation technology in drip system, temperature control, humidity control, and soil pH measurement.

Mr. Santosh Khadka, Junior Technical Assistant (JTA) of Dhunebasi Municipality, Dhading is working with the farmers of the region and helping them understand the need of Smart Farming in Nepal. Through different projects of the municipality, Mr. Khadka trains the local farmers about the crops and technology suitable for the area. According to Mr. Khadka, the lack of knowledge regarding market demand, farmers end up producing crops, which is surplus in the market resulting in huge loss. The scarcity of manpower in agriculture due to the youths migrating abroad for better jobs and life has resulted in the increase in barren land and dependency of agriculture goods imports from India.

Mr. Arun Kafle, Senior Horticulture Development Officer (Farm Chief), Vegetable Crops Development Center, Khumaltar, Lalitpur, Nepal (www.vcdc.gov.np) is working with more than 10,000 vegetable farmers in Nepal following both traditional and modern smart technologies in their farm. According to Mr. Kafle, the use of modern technology in agriculture in Nepal is very expensive because each and every components used in smart farming (like plastics, GI pipes, sensors, computers, agricultural tools, etc.) has to be imported from European countries or India. The operating cost of smart farming is very high with respect to the return from their produce. However, the government has several programmes like Prime Minister Agriculture Modernization projects for buying agricultural tools. In addition, the government has directed all the commercial banks to issue loans to the farmers in highly subsidized rates.

According to Professor Panya Lao-anantana at Department of Electrical Engineering of Kasetsart University, Smart Farming is a modern agriculture by using technology or robots that have high precision to help in the work. By focusing on the environment, consumer safety and using the most cost-effective resources are key factors to increase production efficiency. However, the farmers in this area does not use much technology to do a farm because they are not following the technology and having much debt. Also, there is not enough investment to choose the right technology.

A researcher like C. Visalapoone give comments about Smart Farming as a farming that focus on the efficiency of cultivation from seed selection to the planting process that brings technology to help measure soil conditions, moisture and minerals. Natural light conditions including the various pests. Also, there are programmers in private companies that have commented on Smart Farming as applying modern technology. S. Saeloe explains that Smart Farming is the farm which relies on Big Data for decision making, ranging from cost calculation to the marketing of products. This technology is introducing various innovative machinery technologies with high accuracy to use in work and safety for farmers, environment and consumers, to help increase productivity effectively.

Customers' Point of View

From the consumers' point of view, they are concerned about how, where and when they can obtain good quality products (ITU, 2015). Part of them is also interested in how their food is produced so that the consumer also performs buying with food traceability, quality and price (Mietzsch et al., 2011). The smart farm should provide good quality products to them. It would bring the consumers to benefit by delivering precise information concerning various products' food chain history.

Mr. Yogesh Mainali, a resident of Kathmandu, Nepal is a businessmen and buys his vegetables and fruits from Kalimati Vegetables and Fruits wholesale Market, Kalimati, Kathmandu, Nepal. According to Mr. Mainali, the lack of proper monitoring by the government authority, he is not sure whether the vegetables, fruits and meat he buys in the market has minimum international standards. He is worried about the quantity of pesticides residues and hazardous chemicals that might be present in the fruits, vegetables and meat he consumes. He is interested in buying organic produce but is not sure that the produce might even be organic.

S. Chanagied a bank staff who consumes organic products gave comments on making Smart Farming that it should involve with the supply chain, from cultivation, processing, marketing for food production. S. Siripak who is retired government official understanding that Smart Farming is a large amount of farming area that requires modern equipment to work in agricultural sector to deliver a product that can be negotiated at the market price. V. Jumaon who have travelled to work in agriculture in Israel has a view of understanding that Smart Farming is the use of modern technology to monitor production by themselves and may have to be knowledgeable and understanding of what is being done.

Based on the understanding of farmers, researchers and consumers, Smart Farming consider four fragments namely: 1) smart farm support system, 2) knowledge management, 3) lifecycle assessment, 4) and decision-making system as shown in Figure 1.

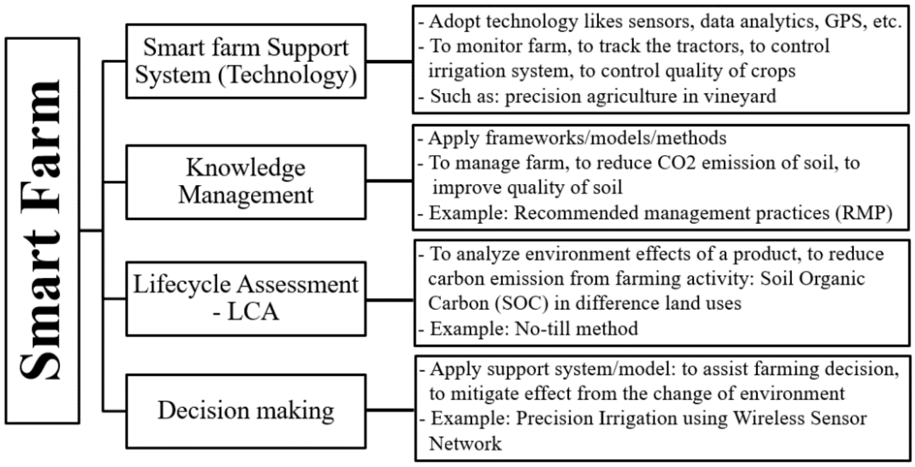


Figure 1: A Literature review on Smart Farming

3 Policy and Framework

Table 1: Some of Smart farming research grants provided by the Thai Government

Research Name	Research grant	Description	Output	Fund (Thai: Baht)
Development of IoT-Wetting Front Detector (IoT-WFD) sensor for irrigation management system	The Thailand Research Fund	This research aims to develop WFD sensor using IoT for detecting and collecting data of wetting front in the soil at one-meter depth on rice fields, corn fields, and longan orchards. The decision support system can decide for farm water management precisely based on data collected using IoT-WFD sensor.	A prototype of the smart IoT-WFD sensor and decision support system for farm water management	2.6 Million
MJU Smart farm	National budget, Engineering and Agro-Industry	The prototype of the MJU smart farm model has been developed using modern agriculture innovation (Electronic Agriculture; Agritonics), Agri-Big data, and smart cultivation system for enhancing an efficiency of production processes in the agricultural sector. Farmers can control the system via smartphone and Farm SCADA (Wall room system for monitoring and displaying the agricultural production factors of the system)	A prototype of a smart farm model	17 Million

Modular Farm	Research Gap Fund	Modular Farm is crop cultivation in closed areas likes container or greenhouse that the crops growth factors are controlled such as air temperature, air humidity, light intensity. The purpose of development Modular Farm is to enhance the crops cultivation in all areas, weather arid or cold areas. The Modular Farm system control the environment near comparable to the terrain suitable for cultivation so that crops can grow well.	Modular Farm system for controlling crops cultivation in container	1.7 Million
Farm Boxing	Council of University Presidents of Thailand	Farm Boxing has been developed for small closed areas cultivation to support crops cultivation in residence. Farm Boxing system can control, monitor, and see a report of crops' environment which are factors affecting to crops growth such as water temperature, light, humidity and light intensity, etc. by using IoT technology (Internet of Things), Mobile Application, MQTT protocol, Web Service, Web application and Cloud Computing. The users can control, track and retrieve such information through a web browser. Real-time is considered to use	Farm Boxing product/ System for increasing the cultivation area in the urban society which has limited space	730 Thousand

		agriculture in a new form that is a Smart Farm and is suitable for consumers in urban society.		
Smart Agriculture for the digital economy in Chiang Mai province	Thailand Digital Economy Promotion Agency (DEPA)	Smart Farm Operation Center and Smart Agriculture Service have been developed to support smart farming in a rice field. The smart sensors and sensing technology are set up into the field to collect data and farmers can monitor and control farm management via smartphone. Additional, consumers can traceability the information relevance agricultural products by scanning QR code to check quality and cultivation process of agricultural products.	Smart Farm Operation Center application to support cultivation and Smart Agriculture Service application for products traceability	9.7 Million

3.1 Policy and Framework in the EU

The EU currently supports the implementation and development of Smart Farming through a wide variety of policies.

The EU Horizon 2020 project **Smart-AKIS** (AKIS, 2018) released Policy Recommendations for mainstreaming Smart Farming in Europe. Smart-AKIS is a Thematic Network whose overall objective is to close the research and innovation divide in the field of Smart Farming focusing on the dissemination of Smart Farming Technologies (SFT) in Europe, backed up by EIP-AGRI and funded by Horizon 2020 programme. Through its activities, the project gathered insights on the barriers and incentives for the adoption of SFT as well as on the needs from end-users and other stakeholders in the value chain, such as researchers, industry and advisors. These findings are now coherently presented in the Policy Recommendations. The Smart-AKIS Recommendations are developed in three domains:

- **Enhancing innovation-driven agricultural research within the EIP-AGRI ecosystem**: The Recommendations underline the need for increased participation by farmers to projects and demonstrations on the use of SFTs in the framework of Thematic Networks. This should include field visits, cross-visits, set-up of demo-farms, etc., thus mixing different types of approaches for engaging with them: online and digital tools, but also direct contacts and peer-to-peer demonstration activities.
- **Future research in Smart Farming**: The analysis performed by Smart-AKIS underlined several knowledge gaps in Smart Farming Research at the European level. Knowledge gaps were identified particularly between the measuring of the status of crop and soils on the one hand and using that information to make effective decisions in farming on the other hand. Measuring tools should also be tailored to different cropping systems. The Recommendations also highlight the need to support research on reactive technologies (variable rate fertilization, pesticide, seeding and tillage), as well as to develop robots for weeding, precision spraying and selective harvesting. An emphasis is put on the search of technical solutions to improve collaboration on data collection, standardization and management.
- Recommendations for mainstreaming Smart Farming, addressing potential solutions to overcome technical, economic and social barriers identified: The Policy Recommendations identify four main categories of “blocks” to Smart Farming adoption in Europe: 1) value for money, 2) the “3 Cs problem” (connectivity, complexity and compatibility), 3) agricultural data fuelling growth and 4) Smart Farming support strategies.

The fact that Smart Farming is a relatively new business sector means that a **structured business model** for the Smart Farming market is yet to be set up. Therefore, the high initial investment needed to set STFs up seems to be linked to uncertain value for financial returns. Farmers and advisors demand more empirical-based evidence of the economic benefits linked to the use of STFs in yield performance, and on more efficient use of inputs. For such evidence to be successful in engaging farmers, the community would welcome in-field evidence and demonstration of results coming from impartial and non-commercially biased actors.

Another policy is **Common Agricultural Policy (CAP),** which unify member states' agricultural policies around common goals. Today, with a budget of EUR 408 billion for 2014-2020, it represents 38% of the EU's total expenditure (Löprich, 2018). The policy has two main pillars:

- Pillar 1 includes required payments per hectare, an additional payment for young farmers, and income support in areas with natural constraints or in regions where specific types of farming that are of economic, social or environmental importance are facing difficulties. The EU sets the requirements for all pillar one funds, which are enforced across all member states.
- Pillar 2 allows national and sub-national governments to design rural development programmes that address regional challenges and needs. The Commission co-finances them after it has verified that the programmes comply with the EU's rural development rules and objectives.

Currently, the development of Smart Farming technologies in Europe is mainly financed through the Horizon 2020 research policy and the CAP's rural development policy (Schuttelaar & partners, 2017). The Horizon 2020 supports over 200 projects relevant to smart farming, most of them are related to applying IoT technologies in smallholders and large farms for gathering data from farm, analysing, and do farm management. The aims are to improve the capacity of food production and farming systems providing sufficient and healthy food while safeguarding natural resources.

The EU protects its farmers and growers (including UK) through its Common Agricultural Policy (CAP). European farmers receive CAP subsidies of around £40 billion each year. CAP has been introduced to protect EU farmers from a number of potential problems. Firstly, farm incomes have fallen because of increasing global food production, and higher yields following the application of new technology in the developing world, and new entrants into the market. Secondly, farm prices are extremely unstable, largely because of random supply shocks, such as poor weather and disease. Furthermore, farmers and growers have lost power to the large supermarket chains, which can exert their monopsony power in pushing farm prices down.

3.2 Policy and framework in France

In France, smart farming is developing at a rapid pace with more than 600.000 ha of winter wheat currently monitored via satellites (Farm Europe, 2017). France remains the most in favour of a secure CAP Pillar I. For applying CAP, the critical element, *the single farm payment (SFP)*, was set. SFP introduces a fixed aid per eligible hectare whatever the crop produced (except permanent crops, fruit, vegetables and potatoes). Producing is not mandatory as long as the farmer maintains his hectares into the right agricultural and environmental conditions (GAECs).

In order to define farmers' GAEC obligations, the French Ministry of Agriculture set up a working group (Table 4). Four issues related to GAECs include Soil Erosion, Soil Organic Matter, Soil Structure and Minimum Level of Maintenance.

Table 2:: GAEC farmers' obligations as enforced in France (Desjeux, Guyomard, & Latruffe, 2007)

EC Issues	Farmers' obligations	Control points	Comments
Soil Erosion	1. Implementation of minimum soil coverage (environmental surface) on set-aside, pasture and grassland at farm level. The area of this environmental coverage is set as being equal to 3% of the cereal, oilseed and protein area. Small producers are not obliged to follow these rules. 2. Prohibition of burning stubble and crop residues unless authorised.	1. Implementation of minimum environmental surface and location of grass strips as a priority along water courses. Presence of a cover during the compulsory periods and maintenance of the environmental covers. 2. Check for evidence of stubble burning or a derogation if relevant.	There has been research into the role of grass strips along rivers to limit the erosion of soil and pollution by fertilisers and pesticides. However, it is not thought this farmers' obligation will deal with all erosion problems particularly in areas with severe erosion problems.
Soil Organic Matter	1. Implementation of a minimum environmental surface at farm level is partially dedicated to this problem as well. The area of this environmental coverage is set as being equal to 3% of the cereal, oilseed and protein area. Small producers are not obliged to follow these rules. 2. Prohibition of burning stubble and crop residues. 3. Diversity of crop cultivations.	1. Check that rules for minimum environmental surface have been respected. 2. Check of the evidence of stubble burning or a derogation if relevant. 3. Check at least two crop families or three different crops grown on arable land.	The rules for minimum environmental surface distinguish between crop rotation and monocultures. These farmers' obligations are new in France at the national level.
Soil Structure	1. Rules relating to irrigated crops. Farmers must have a proof of authorisation to extract water for use on irrigated crops. All the farmers asking for "irrigated aids" are concerned by this GAEC.	1. Proof of authorization to extract water and presence of means allowing the quantity of water extracted to be measured.	The farmers' obligation was introduced with voluntary cross-compliance. Farmers' obligations on stubble burning and crop rotation are also considered relevant.
Minimum Levels of Maintenance	1. Rules for maintenance of land in production. 2. Rules for maintenance of pasture. Criteria defined at local level based on stocking density, or obligation for appropriate grazing or mowing regime. 3. Rules for maintenance of set-aside (compulsory or voluntary) 4. Diversity of crop cultivations.	1. Maintenance of cultivated land subject to single farm payment. 2. Check for maintenance of pasture. 3. Check for maintenance of set aside and land not in production. 4. Check at least two crop families or three different crops grown on arable land.	Some of these farmers' obligations are new in France and as such not based on a previous regulation. Aim of farmers' obligations is to avoid invasion of weeds, pets and shrubs. In relation with point 4, specialised systems or monocultures (i.e. when more than 95% of arable land is cultivated with one non-permanent crop) must have winter cover.

3.3 Policy and framework in UK

British farming sector is worth £109 billion and employing nearly 4 million people (NFU report, 2019).

The UK Government's 25 Year Environment Plan (January 2018) set out how a new environmental land management system based on providing public money for public goods (such as habitat enhancement) is proposed to replace current direct payments to farmers in England. Currently, CAP subsidies can make up anywhere from 50-80% of a UK farmer's income and their practices will be sensitive to fluctuations in support or a change of direction or priorities in this support. The key elements of the emerging new policy for England include:

- A five-year transition phase from farming subsidy to a system of public money for public goods over time whilst limiting some of the largest subsidy payments.
- No lower standards for animal welfare or environment in trade deals and a new approach to food labelling with a new "world leading" standard for food and farming quality.

- Building a new post-Brexit economic partnership with the EU that guarantees tariff-free access for agri-food goods between the UK and EU.
- Seeking a flexible migration policy overall and post-Brexit wants to ensure access to seasonal agricultural labour.

UK Strategy for Agricultural Technologies recognises that the infrastructure to support industry in applying science and technology to help modern farming and food production has declined over the past 30 years. UK agriculture's productivity growth has declined relative to its major competitors. There is huge potential to attract more global investment into the UK and open up new global markets for UK leadership in agri-tech innovation as the UK has strengths to support the growth of the sector due to:

- Institutes and university departments at the forefront of areas of research vital to agriculture and related technologies.
- Innovative and dynamic farmers, food manufacturers and retailers.
- Well positioned to make an impact on global markets through exports of products, science and farming practices.

The UK strategy for Agricultural Technologies[1] sets out a range of actions to deliver its vision for the agri-tech sector. The actions include:

- Improve the translation of research into practice through Government investment in an Agri-Tech Catalyst which will provide funding for projects, all the way from the laboratory to market. This will include funding to deliver international development objectives
- increase support to develop, adopt and exploit new technologies and processes through Government funding for Centres for Agricultural Innovation help the UK exploit the potential of big data and informatics and become a global centre of excellence by establishing a Centre for Agricultural Informatics and Metrics of Sustainability
- build a stronger skills base through industry-led actions to attract and retain a workforce who are expert in developing and applying technologies from the laboratory to the farm
- increase alignment of industry research funding with public sector spend by increasing understanding of what is being spent and where
- increase UK export and inward investment performance through targeted sector support

As a part of the UK Government funding, Innovate UK is supporting four Centres for agricultural Innovation to help to tackle problems that no one area of the agri-food sector can tackle on its own[2]. They exist to deliver applied solutions to solve real world problems. The four Centres are:

Agrimetrics[3] – the leading AI big data Centre focusing on agri-tech/food: Agrimetrics has pioneered the use of new web technologies specifically for the agrifood sector –

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/227259/9643-BIS-UK_Agri_Tech_Strategy_Accessible.pdf,
[2] https://innovateuk.blog.gov.uk/2018/02/15/smart-farm-a-new-approach-to-farming/

[3] https://agrimetrics.co.uk/

enabling its 'data platform' to connect disparate data and convert it into valuable insights. It provides the whole agrifood industry with a unique opportunity to analyse, compare and combine data – and the UK with an opportunity to lead the development of global food solutions. Its ambition is to provide the most comprehensive data resource needed to address the challenges of the food and farming sector.

Agri-EPI[4] - engineering precision innovation Centre: The Agricultural Engineering Precision Innovation Centre (Agri-EPI Centre) is one of four Agri-Tech centres established by the UK government. Agri-EPI Centre focuses on the delivery of research, development, demonstration and training on precision agriculture and engineering for the livestock, arable, horticulture and aquaculture sectors. The Centre has three main objectives:

- To operate a wide range of industry-led activities in applied research and development, demonstration, training and education.
- Be a key player in ensuring that the UK grows its status as a world leader in precision agriculture and engineering.
- Ensure that the knowledge generated is translated and transferred to relevant audiences.

CHAP[5], the crop health and protection Centre: CHAP is designed to make sure that the knowledge and insight from the UK's science base is translated into benefits for farmers, growers and the food industry both at home and internationally. The government and industry believe that wider adoption of science and technological innovation is the key to unlocking the potential of farming by improving productivity and tackling problems such as soil erosion, adapting to climate change, managing the impact of pests and diseases, depleting natural resources, and providing environmentally friendly solutions.

CIEL[6], the Centre for innovation excellence in livestock, it is also the largest applied animal research group in Europe. CIEL works to identify key challenges to the UK's farmed animal industries and provide world-leading, applied solutions through a research base of 12 leading UK academic institutions. It has helped to co-fund the development of new research facilities which are designed to bridge the gap between basic academic research and commercial products, utilising a range of projects, from small, pilot-scale experiments through to commercial-scale trials.

Although only been in existence for two years the Centres through their partner organisations are making great strides in joining up a complicated research landscape for industry and are starting to deliver on industrial projects. These facilities are open access - anybody can use them with some fees.

[4] https://www.agri-epicentre.com/

[5] https://chap-solutions.co.uk/

[6] https://www.cielivestock.co.uk/

UK Government Department for International Development (DFID) has published a conceptual framework[7] to guide DFID's future approach to agriculture and the agri-food sector. Promoting agricultural transformation will require a specific focus on market and value chain development that will help smallholder farmers to become sustainably profitable and respond effectively to market demand. Technology and innovation are equally important not least as a key driver of productivity growth and value addition. The availability of relevant technology requires global, regional and national research and development that responds to the priority needs of farmers and the agrifood sector, recognising the different needs of different levels of farms, geographical zones and value chains.

3.4 Policy and framework in Hungary

The ICT Association of Hungary prepared the digital strategy for agricultural sector in 2016. In the following paragraphs, strategic guidelines are summarized.

The economic benefits deriving from the IT development of the Hungarian agricultural sector are currently untapped. Existing enhancements are island solutions, linked by people, causing significant loss of data and data quality. Intelligent tools are included as standard in the technology purchased with support, but they only provide real economic benefits with proper integration.

EU analyzes of the cost-cutting effects of precision agriculture show well that, with smart machines, traceability, and automization approx. 2 EUR/ha can be saved. If the exact amount of seed, fertilizer, pesticide applied in the plot, and the also the harvest data is collected in database the savings can reach 40-50 EUR/ha from the third year. If the data is collected at plant level and the weather, plant protection data also added, the savings can reach 80 EUR/ha.

In addition to cost reductions, market data, information and income growth are also important. Consumers with their expectations and decisions, determine the total income available on product lines. IT can connect consumers with producers through databases and analyses on the longest product lines. Hungarian IT companies have the necessary solutions. Research and development activities in the field of agricultural informatics are also strong. However, in the industry, the use of information technology focuses on production, with many island solutions that only result in minimal cost reductions, but do not contribute to the efficiency of the industry.

The main obstacle to the spread of IT solutions in Hungarian agriculture is the unpreparedness, low skills and attitude of the human resources. Taking into account the number of farms, there are 3,000 IT and agricultural professionals who are familiar with the design, operation, user training and advisory services of the industry today, are missing. An additional barrier is the aid policy, which does not consider agri-IT innovation, the dissemination of existing products and the necessary training and counseling as a priority. The regulatory environment is not optimal, does not take into account the emergence of new technologies and their economic

[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/472999/Conceptual-Framework-Agriculture2.pdf

impact, making it difficult, for example, to access national data assets for business purposes and to use drones for production purposes.

IT applications supporting agricultural production in Hungary can be divided into five major groups:

1. Applications supporting production processes that directly support certain agricultural production activities through automatic or semi-automatic interventions;
2. Production control systems that provide information on farm management, decision support, and process integration at producer level;
3. Product-line integration support systems that support the integration process, both from the view of producers and the integrators, and are linked to producer-level systems as needed;
4. Professional background systems that provide background data for systems operated by producers and integrators, and collect and analyze data at producer level;
5. Administrative background systems that support administrative processes between public administrations and producers (eg product chain audits).

In order to increase efficiency at sector level, it is important that the service applications are able to communicate with each other automatically, and to cooperate minimizing human intervention.

The introduction of applications at sector level is expected to result in a significant increase in income of up to 10% as the quality and quantity of the products increases, the resources spent, costs reduced, and the use of environmental resources is more efficient. Developments also provide a significant market opportunity for domestic IT companies, both in the user and the innovation market.

Most of the application site currently does not have the skills and abilities to apply IT systems at the user level. There is only a small need for new systems to be used. Advisory networks are also characterized by the lack of knowledge and skills, so the innovation product line does not reach the producer level.

The regulation does not take into account the development of technology, its application possibilities and their competitive advantage. Online administration, electronic identification, multiple requests for data, lack of data sharing, limiting drone usage are all areas that take resources away from the producer level or limit potential benefits.

In the area of regulation, the restriction of access to national data assets should be resolved, with adequate entitlement management and adequate public funding of the producing professional organizations. Access to priority data for producers (weather, plant protection, cartography, market, support, etc.) serves to improve the quality of producer decision-making

In order to resolve the inhibiting factors mentioned above, six development programs have been formulated:

1. The knowledge and awareness development program provides basic knowledge and awareness raising thinking necessary for the use of digital devices and applications;

2. Education development program provides an opportunity for already aware users to get to know the possibilities at user level, to identify their own development directions and to communicate with agro informatics;
3. Consulting development program provides answers to the questions of producers and other agrobusiness players in the framework of individual, tailored advice;
4. The regulatory development program contains a modification of the regulatory environment needed to increase the efficiency of the digital agricultural economy;
5. Professional service systems development program ensures the development of public digital services (eg weather forecast) and access to public data from both the it and financial side;
6. The purpose of the e-administration development program is to minimize the resources of administrators and administrators to spend on their administration.

Though in a different level, Smart Farming has been mainstreamed into core government policy and planning frameworks. Smart farming policies must contribute to broader economic growth, poverty reduction and sustainable development goals. Coordination and integration between various sectors dealing with climate change, agricultural development and food security at the national, regional and local level is a crucial requirement for creating an enabling policy environment. Governments need to build a framework and make policies such as incentives for adopting Smart Farming to encourage farmers and to overcome initial investment barriers.

Food and Agriculture Organization, FAO, of the United Nations has identified two areas of intervention related to policies and planning for the adoption of climate-smart agriculture: Support to countries to ensure that agriculture and CSA are included in mid to long-term development planning processes and investment decisions and support to countries in creating the required policy, financial and enabling environment.

4 Local Innovations in Smart Farming

Smart Farming is a concept that originated with software engineering and computer science. In such an approach, computing elements are embedded in objects and communication technology are integrated with the traditional farming practices (Wolfert, Ge, Verdouw, & Bogaardt, 2017). Several such innovations are initiated locally in different countries. In this section, we will analyse the innovations developed locally to promote Smart Farming.

4.1 Bhutan

In Bhutan, the concept of Smart Farming has just emerged, and there are only a few instances of the use of smart technologies. Mountain Hazelnuts, Bhutan's only 100% foreign-invested company, financed partly by the World Bank Group's International Finance Cooperation and the Asian Development Bank is the first to make use of smart technologies and sensors in its operation and communication with the contracting farmers. It uses a central database overlaid on OpenStreetMap geo-reference the data and allows for planning in logistics operations, reduces transportation delays and costs. Furthermore, all over the country, electric fencing has replaced physical guarding of the field and scarecrows to ward off wild animals and reduce damage to their crops. Automatic irrigation with a sensor has been tried on a trial basis but is yet to find consistent and widespread use.

Agriculture Research and Development Centre (ARDC), a Research centre under the Ministry of Agriculture and Forest has recently introduced use of sensors for irrigation in the centre primarily aimed at managing their research plots as well as for demonstration. Temperature and irrigation sensors have been recently introduced in the Chimipang Project, located in Lobesa, Punakha Bhutan. This project aims at training and demonstration of improved farming practices.

4.2 Nepal

The approach towards Smart Farming in Nepal is also in an early stage. An example of the attempts made by the private sector in Nepal for the development of Smart Farming is the Smart Krishi App (http://smartkrishi.org/), developed by Smart Krishi Nepal with an objective to support the farmers. Figure 9 shows the user interface of the app.

Smart Krishi App is an application software developed in android platform. It connects various people associated with farming and help each other to communicate in need. It was initially designed with a motive of establishing constant communication with farmers so their queries and necessary information could be easily addressed. It encourages digital literacy and prompts farmer for communication through smart devices i.e. mobile and computers.

With recent advancement of world in terms of communication and devices that support them, field of agriculture cannot be isolated from the wave of IT. All the necessary information that a farmer needs to gather or transmit can be managed via web. Smart Krishi app incorporates this scenario as its core mechanism.

Currently, the app intends to provide following features:

- Access to all the information related to "High value", "Low volume" "category crops from Varieties, soil/ climate to harvesting and storage procedure.
- Daily Price Information Across cities of Nepal.
- Success/failure stories and News.

- Krishi Library: For exploration of large pool information related to agriculture related data, feedings for livestock, manure production, benefits of locally available herbs/fruits for particular disease and many more.
- Agricultural Documents, reports and e-books.
- Agricultural farm contact details with GPS tracking.
- Krishi Tips: Tips and tricks on daily life farming activities.
- Weather info: Live weather information of main places across countries from DHM/MFD.
- Queries to experts and scientists.

Figure 2: The user interface of Smart Krishi App

Moreover, these features are related to farming practices, which directly and indirectly helps farmers for cultivation and to understand their markets. Besides some have also been providing training and consultation services to farmers regarding agricultural equipment, veterinary services and skills development training.

Agricultural Engineering Division (Under NARC) has been actively involved in the research field covering the following areas:

- Introduction to mechanization in the field of agriculture, soil conservation and water management need
- post harvesting technology needs for high-value crops such as coffee, ginger, apple, millet crops.,
- Agriculture structures, energy in agriculture

Some of its achievements in the field of agriculture researches are:

- Reversible mould-board plough
- Zero/minimum tillage technology for wheat, rice and lentil
- Chinese reaper
- Rice weeder
- Pedal paddy thresher for wheat threshing
- Manual corn sheller

- Pedal corn sheller
- Water management technology for early rice, wheat and maize
- Improved rotary quern
- Low-cost solar dryer
- Improved cardamom dryer
- Rice seed dryer
- Plastic house for off-season vegetable cultivation
- Rice husk stove

Some of the Ongoing researches by AED

- Modification of agricultural implements and machinery like animal-drawn zero till seed drill, modular power tiller, jab seeder, millet pearler/thresher, modified seed drill and ridger
- Modification and testing of matching implements for 2-wheel tractors
- Study on irrigation water management in rice, wheat and potato
- Irrigation scheduling in a low-cost drip system for cauliflower
- Estimation of water requirement of rice and wheat based on 30-years data
- Improved multi-rack solar dryer
- Drying, storage and milling of rice and maize
- Study on pulping, drying and storage of coffee and Lapsi
- Action research and on-farm testing of the solar dryer for perishables
- Study on off-season vegetable cultivation in a semi-controlled environment
- Study on hailstone mitigation measures for small vegetable growing farmers
- Study on Finger Millet Pearler/Thresher
- Study on Coffee Pulper

4.3 Thailand

Agriculture plays an active role in the sustainable development. Thailand 4.0 focuses on the economy, driven by innovation and Value-Based Economy, by giving importance to innovations. Thailand has adapted Thailand 4.0, which focuses on the economy driven by innovation, especially in the food, agriculture and biotechnology sectors (Bureau of Academic Affairs, Secretariat of the House of Representatives (2016)). Thai farmers in the Thailand 4.0 era should become Smart Farmer by practicing nature-friendly farming using smart resources. Smart farmers need to understand the production process management and understand the use of technology (Sumit Hamprasit, 2016).

In Thailand, smaller farms still follow traditional practices of farming but the larger farms are leaning towards smart farming. The farmers of any small or large farm these days require instructions for device support, wireless network development (3G and 4G) and other assistance from the government, agricultural department or IT departments. Small Farming business is in a large number in the country. Smart Farming is a modern concept in farming, and the farmer does not yet understand the insight of data interpretation for productive farming. Farmers who own a large farm and require more labours to manage the farm are leaned towards Smart Farming. Even though the cost of the equipment is higher, it can reduce other associated costs in farming (Korn Kanyakonniam et al., 2012). In Smart Farming, communication, sensor and biotechnology systems are combined with agricultural works. This agricultural engineering development (Geoengineering) enables effective changes in farming practices with the integration of various advanced technologies (Chakkrit Manitwong, 2016) like computers, electronic devices, IT, communication, sensors, biotechnology including nanotechnology which will help to solve all problems related to farming and change farmland and ordinary farm into Smart Farm (Thirakiet Kerdcharoen, 2015). Some initiations in Thailand are discussed in the section below.

4.3.1 Developing Smart Farming from the private sector in crop cultivation

In Thailand, the majority of the population are working in an agricultural area. In addition, most of the agricultural products they produce have similar characteristics. The farmer who has uses machineries, information technology and innovation can be successful compared to another farmer who is farming traditionally. The use of information technology in agriculture enables controlled irrigation, monitor water and soil quality, control soil moisture, guides pests control and ensure proper use of fertilizers (Bradicich, 2015)

At present, the world is moving towards a Knowledge-Based, Digital Economy era, and the use of innovation like Unmanned Aerial Vehicles (UAVs) and drone is increasing. Even in farming to increase production efficiency, to reduce production costs and save time and labour. Drones are playing vital role to convert traditional farming to smart farming. From the article of the Kasikorn Research Centre, drone for agriculture is an interesting choice as a high precision agricultural tool, which is growing in the agricultural age 4.0 that focuses on technology and innovation. The Research Centre articulates that the use of agricultural technology such as drones enables farmers to reduce production costs by approximately 1,100 million Thai baht and expect to reduce production costs by approximately 6,000 million Thai baht in the next four years.

Foliar feeding of liquid fertilizer directly to the plants enables to absorb essential elements through the leaves. The absorption takes place through plant stomata and through their epidermis. It is best to use such fertilizers in the early morning so that, the leaves can absorb immediately without having to go through the roots. The use of drones saves time too. Besides, if the plants are not high, such as rice. It will be an advantage that bigger plants like rice will not be trampled and damaged. Image analysis/examination of plant diseases is allowing farmers to take care of plant diseases in a straightforward manner with the use of drones to remove water, fertilizer to spray in order to treat plant diseases accurately. One drone can spray 100-200 rai (one rai=0.16 hectares) lands per day where crops such as rice, cassava, and sugar cane are cultivated. One to two people can control the whole process.

In addition, the use of drones also helps to reduce the effect of chemicals due to direct exposure and inhalation while spraying. (Kasikorn Research Center, 2017) is an example of the private sector that has developed Smart Farming. Yamaha has collaborated with Kasetsart University to establish a cooperative project (MOU) to develop and research drones for farmers in Thailand. Yamaha RMAX project uses to sow and spray fertilizer to raise Thai agriculture (Bureau of Promotion and Training, KU, 2017).

Smart Farming or production can reduce costs in production processes, increase productivity and create standards for quality control by using machinery and technology. Khun Ob-Natthachai and Khun Art-Thirapat, Ung Sriwong farmers, are planting hops, one of the essential ingredients in making the first craft beer in Thailand at Pak Kret District, Nonthaburi Province. They learn to grow hops by themselves from the internet and they gathered useful knowledge of technology in cultivation. A central computer, operated from smartphones applications, controls overall process. They have used sensors to control temperature, irrigation and other environmental conditions. Every plant house has a fogger and a sensor to measure the temperature. When the temperature reaches to a set point, fog will be sprayed out to maintain the temperature and keep humidity. They grow crops from hydroponics culture, which is a method of growing crops without soil by using mineral nutrient solutions in a water solvent. In this method the use of fertilizers is through the water so there is no involvement of human (Creative Economy Agency (CEA), 2561).

The mobile network company like DTAC that has collaborated with Rak Ban Kerd and developed applications on mobile phones that are available to farmers. The Apps have functions called "Precision Farm" and weather forecast with the introduction of big data satellite technology. The farmers can plan farming and monitor plant health accurately. DTAC (Ruang Ded Kret Kaset, 2018) has contributed to the development of Intelligent agriculture. Now many companies have invented and developed technology for transforming Thai agriculture into Smart agriculture.

The agricultural structure in Thailand is going through a rapid change due to the systematic and efficient management of technology. Agriculture has been systematically managed in order to achieve production efficiency, planting area, development of new agricultural tootls and environmental conservation. Map server is used to store various data in the form of maps and various statistical information such as area, plant type, and fertilizer usage in each area. Field data collection toolset is a useful mobile app for field staffs to use in the field for collect data, such as taking a photograph, marking the location, placing images converting, or filling farmers' information. Planning tools analyse spatial data by linking the map data with other statistical data and provide a summary report for making further work plans (DTC Enterprise Co., Ltd., 2018). Smart Farm or Intelligent Agriculture is a new type of farming that can make farming immune to changing climate by bringing the information of the climate at the sub-area, i.e. microclimate farm level and macroclimate level so that the management for taking care of the planting area according to the weather conditions.

The Smart Farm system will integrate Microclimate and Mesoclimate data from the Wireless Sensor Networks installed at various points in the field (temperature data, moisture in the soil and in the air, light, wind, rain) and Macroclimate meteorological data (satellite data radar Weather models) available on the internet and presented to the farm owners of the site via the website. The data is collected and analysed to derive decisions and carry out several activities like cultivation planning, irrigation and fertilization. Information from the weather measurement station and soil measurement station from various points that are installed within the farm will be collected and transmitted wirelessly to the computer in the owner's house. This can track information in real time in multiple channels. Both from the display program on the central computer within the farm or viewing information on the internet via the website can be done and allowing the owner to take care and manage their farm at any time using a computer, tablet or smartphone. Currently, the smart farm system has been installed and used with the Gran-Monte vineyard at Khao Yai and the eggplant plantation of Chevy Chuan Foods Company Limited in Wiang Pa Pao District Chiang Rai province. Both companies have utilized the information obtained from the weather measurement stations and soil measuring stations in agricultural planning (Smart Farm Thailand, 2017)

4.3.2 Developing Smart Farming from the private sector in animal farming

SCB EIC states in a Smart Farming article that the future demand for food and agricultural products and meat per person will increase significantly due to the increase in the world population. United Nations Food and Agriculture Organization estimates that the world population will increase by 35% to 9.7 billion people in 2050.

The article presents research on the development of a smart chicken egg farm system to help farmers, especially independent farmers from both medium and small farms. These farmers have been experiencing the problem of loss caused by inadequate production because they cannot accurately control the environment within the farm according to good practices. Smart chicken egg farms operate by processing the input data collected from the built-in receptors in the farm, including temperature and humidity to create control signals such as farm temperature and humidity include exhaust fans, honeycomb panels, water heaters and water pumps installed in the poultry house. System testing performed on small real farms in real weather with heat and moisture from rain. The results showed that the system could control the temperature and humidity in the farm to be within the appropriate range automatically and accurately, consistent with changes in the external climate of the farm. Phitit Chitsaran and Faculty (2017) uses a computer (which has size as a credit card) with the Linux operating system (Linux) or Windows 10 (Windows 10). There is a hardware interface with the GPS pin (GPIO) with external devices and has a Bluetooth module for a communication network. Sandeep and Opal (2015), and (Jampour et al. 2011) presented feeding animal systems based on “Aquaponics” to grow crops in tandem with fish farming. Plants use the fish waste of water as nutrients. The wastewater is circulated through the filtered rocks down to the roots of plants, and the water will become clean as new water. The fish also take advantage of clean water. This system will make the water flow back. Some farmers in Thailand use this technique but still not widespread. Fish farming will determine the number of plants, such as 50-60 fish, need to feed 60-100 grams and suitable for plant areas of about 3-4 square meters.

4.3.3 Other innovations in Thailand

Some other local innovate projects are listed below:

i. Precision agriculture for the smart vineyard (GranMonte Smart Vineyard, 2010) is a research collaboration between the public-private (GranMonte farm, Nakhon Ratchasima province, Thailand) and academic sectors. Mahidol University and National Electronics and Computer Technology Centre (Nectec), Gran-Monte Vineyard have adopted technology known as "precision farming" at vineyard level. The system helps GranMonte to improve the yield and quality of crops. It wirelessly transmits temperature, humidity and wind data to the computer server in the office. GranMonte's website links to the satellite so that vintners they can see photos in real-time via satellite, and vintners can also link the network with the radar stations nationwide so that we can know the weather conditions. The drone-fly-out can monitor the fields; it could help farmers to give customized care to different sections of farmland. Ground robots can determine nutrients in the soil and weather forecast so that robots can help them to determine when they should spray insecticides on crops.

Figure 3: a. Ground robot (GranMonte Smart Vineyard, 2010), b. Weather station and c. Drone with camera

ii. IoT sensors for irrigation system was set up in vegetable farms in Chiang Mai province, Thailand. The sensors including air temperature, air humidity, solar intensity, and day length are set up into farm field for monitoring temperature, humidity, light intensity, and day length that help farmers to monitor, manage irrigation process automatically via website and application for improving quality of their productivity and reducing water consumption.

Figure 4: Setting up IoT sensors into the farm for irrigation, Chiang Mai, Thailand

iii. Digital Smart Farm Application was developed for demonstration and controlling factors, which affect to cultivation process and crops health of vegetable farms in Chiang Mai province, Thailand. The application receives data from IoT sensors, such as air temperature, humidity, water level and light intensity, for monitoring. Additional, farmers can control irrigation process via this application.

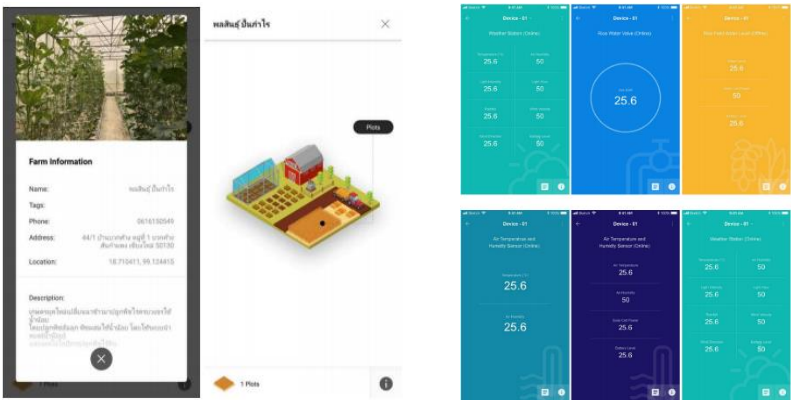
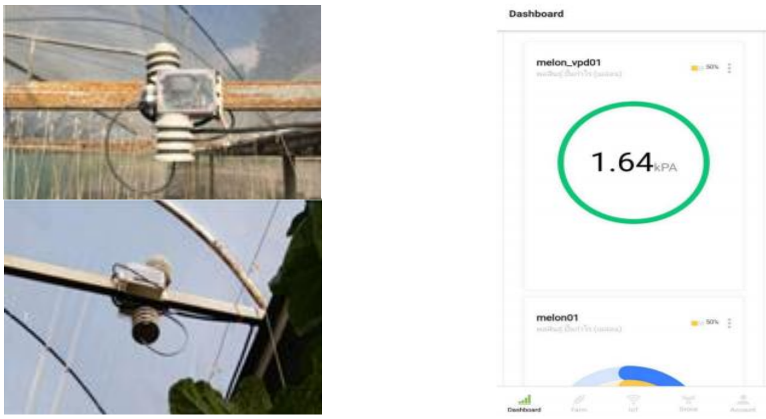


Figure 5: Farm information and Data capture from IoT sensors via application

iv. Vapor Pressure Deficit Application was implemented into melon farms in Chiang Mai province, Thailand. The IoT sensors for vapour pressure deficit was set up into melon farms for capturing data. The real-time data of VPD in the air was processed and calculated; then the system will decide for release steam mist to balance the VPD value into the normal range.



a. b.

Figure 6: a. IoT sensor for VPD monitoring, b. Example of VPD value via application

v. KM smart farmer website (http://km.smartfarmer.in.th/) is built for sharing cultivation knowledge among farmers. Thai farmers can learn how to cultivate crops from the website. Additional, farmers can share their knowledge into this website. This website includes knowledge relevance crop cultivation, fruit trees plantation, animal, and vegetables. It has video tutorials for understanding crop cultivation process.

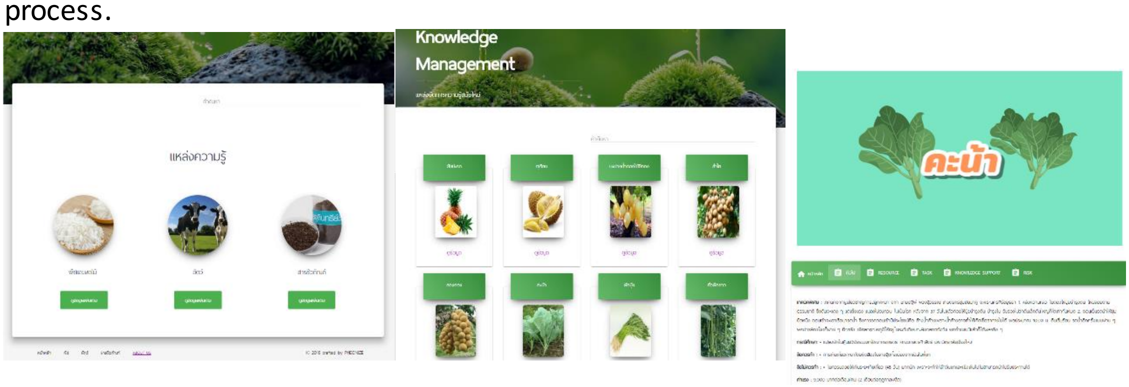


Figure 7: KM smart farmer website platform

Some private sectors have developed smart sensors and smart systems for smart farms. Some of the initiations are listed in the following section.

- To improve corn crop yield, OMICA (Libelium Communication, 2015b) has established precision agriculture to identify the least productive areas and manage crop water and fertilizer requirements during the growing season.
- To protect vineyard, Dolphin Engineering Company (Libelium Communication, 2015a) developed PreDiVine. It monitors microclimate conditions to predict the spread of grapevine pests and diseases. It monitors air temperature, humidity, leaf wetness and rainfall.
- For empowering strawberry growth in greenhouses, Famosa Company developed esiFarm (Libelium Communication, 2016). The purpose of this project is to monitor air temperature and irrigation and to send notifications when necessary corrections are needed.

5 Global Case Studies

The following list is not exhaustive but describes the different relevant projects in the Smart Farming.

5.1 Cultivation technology

Application of IoT technology to control intelligent farms in fairy mushroom cultivation houses

This project designed the temperature and humidity control system for mushroom cultivation house with microcontroller. This work was focused on building a control unit and test the mushroom grown with in the controlled environment. Testing was done comparing the performance of 300 cubes Mushroom with controlled climate. The results of the operation control system test showed that the system was able to work according to the designed conditions, which yielded satisfactory results. In the test of the yield of the mushroom, it was found that the mushroom collected from the temperature and humidity controlled in building had the quantity more than the general building, and when weighing the mushroom, it was found that the mushroom obtained from the building with temperature and humidity control had an average weight of 1.506 Kilograms. This test confirms that the temperature and humidity have an effect on the growth of mushrooms, and the control system can be used in the building and can grow mushrooms as well.

5.2 Production technology

Development of a Brassica alboglabra Vegetable Seeder in Tray for Modern Agriculture

The Brassica alboglabra vegetable seeder (seeding tray) was fabricated in this research for the Brassica alboglabra planter. The machine aims to solve the problems of seed losing, long operating time, labours and the human fatigue of seeding. There were three units in this semi-automatic vegetable seeder. Firstly, the power transmission unit was designed to work with the ½ horsepower of electrical motor that assembled to the transmission gear and chain conveyor. Secondly, the soil packaging units designed for seeding tray type 105 holes (a CHIA TAI 105 I type) operate with the soil mixing and soil sweeping devices to contact the soil into the tray holes. Finally, the seeder unit was designed to control seed flow rate around 4 seeds per hole. The proper speed of the seeder unit (8 rpm) or seeding tray speed at 0.033 m/s was recognized. The performance could be obtained 138 seeding trays/hr or 14,490 holes/hr. The seed losing is around 12.48 %. The growth rate was obtained at 87.53%. On the other hand, the performance of labour seeding was obtained 16 seeding trays/hr or 1,680 holes/hr. The growth rate and seed losing were obtained 86.85 and 13.16% respectively.

5.3 Agricultural machinery technology

Small walking type rice transplanter with root-washed seedling for rained rice

This study aims at fabrication and testing a small rice transplanter with two rows for the root-washed seedling. The space between rice rows and hills are 30 and 25 cm, respectively. The experiment of the small rice transplanter process is performed as follows; preparing the rice field with 400 m2. Then preparing the seedling of rice-RD6 aged 25, 30, and 35 days. The speed of planting is 30, 45, and 60 rpm respectively. The planting experiment is recorded according to the depth, several seedlings in each hill, slipping, missing hills planting, working rate, field efficacy, and fuel consumption. The result has shown that the transplanting depth about 5 cm by planted three seedling/hill, slipping were 4.62-7.31%, missing hills planting was 4.40-5.23 %. The 30 day of seedling aged is suitable for the small rice transplanter. The 30 rpm of transplanting speed is the lowest rate in missing rice planting in each hill. The working rate is 2.34 Rai/day. The fuel consumption rates were 2.85-3.12 L/rai. To compare with the manual, the small rice transplanter can plant eight times faster than the human workforce. Also, the yield received has no difference, but the cost is less than the man labour performance, which the cost saving is about 954 Baht/rai.

5.4 Management technology

The study in (Changniam & Sintaweewarakul, 2018) aimed to improve layer hens farm management in order to relieve of layer hens farm data collection and develop control environment system in hens housing to be suitable for laying eggs. From the research objective, the working system could be divided into two sections. The first development sector was related to the application, which managed the farm according to eggs marketing. It recorded with QR code scanning the egg-laying frequency of hens and helped to remove hens that did not lay eggs according to the layer hens' standard. The system was used on each cage separately to keep high accuracy data record. It was more accurate than traditional farm systems, which record all data on paper. Farm owners could also record expenses during hens feeding in order to have information for farm's overall operations analysis and conclusion. The application was developed in Android smartphone with easy to use interface for farm owners. Moreover, the developed system could share operation data to host computer (server) in a research lab to analyse and compare with the previous farm operation.

The second development section was related to hardware that was used for controlling the hens housing environment. The fuzzy logic system was developed to control fan working, roof water spraying, and light in the hen housing. It fixed environment control accuracy. First, input pass fuzzy logic system was temperature, humidity, and light level sensors which installed in the front and back of the housing and out of the housing. The result of controlling hens housing environment with a fuzzy logic system improve the perfect environment inside hen housing. Also, the fuzzy logic system could connect with the application through Bluetooth or IoT to transfer housing environment data, report control instrument working status and set environment control through the application. The results show that the farmers could relieve about farm management and used the hen farm operation data. Although it was summer, eggs' quantity and quality still passed the standard criteria according to hens' species.

5.5 Other relevant projects

- The European Commission supports ENORASIS (ENORASIS project, 2014) under the 7th Framework Programme for Research in Environment. The main objective is to develop an integrated Decision Support System (DSS) for irrigation management based on advanced technologies and models.

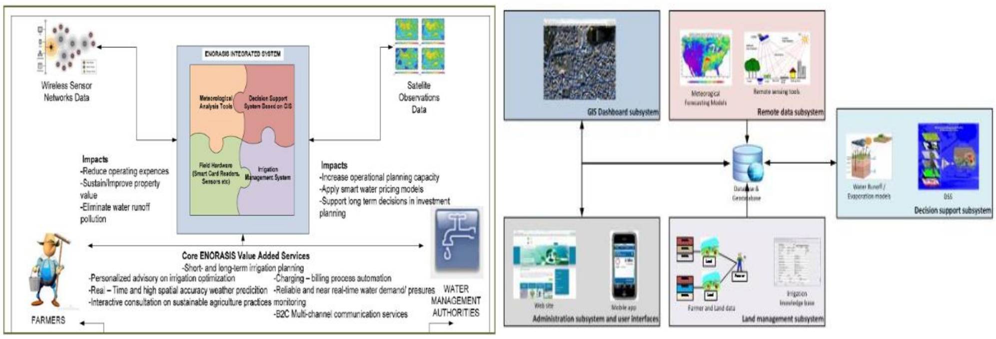


Figure 8: a. ENORASIS integrated system b. ENORASIS Service Platform

ENORASIS is a server-based system gathering data from satellite observations and remote sensing field equipment. It exploits meteorological forecasting models to provide high spatial accuracy estimations for irrigation water needed taking into the account information on specific crops and other factors affecting the irrigation process. These estimations are transformed in optimal irrigation rules using the FAO56 model. They are communicated to ENORASIS end users (farmers) via web or mobile.

For the farmer, ENORASIS aims to provide an optimal and personalized irrigation scheduling (when and how much), real-time and high spatial accuracy weather prediction and interactive consultation on sustainable agriculture practices. To increase operational planning capacity and support long-term decisions in investment planning, ENORASIS provides For Water Management Organizations, with information on actual and predicted water used for irrigation (**Erreur ! Source du renvoi introuvable.**).

ENORASIS pilots involve eight crop types (potato, maize, apple, sweet cherry, cotton, corn, grapefruit and raspberry) in four different climate regimes (North Central Europe- Poland, South Central Europe- Serbia, continental Mediterranean- Turkey and island Mediterranean- Cyprus) and three operational approaches (research farm, production farm, water management organization) in an attempt to cover an adequate spectrum of different real-life cases.

APOLLO (APOLLO project, 2017) is an EU-funded innovation project aiming to bring the benefits of precision agriculture to farmers through affordable information services, making extensive use of free and open Earth Observation data, such as those provided by the European Union's **Copernicus programme**.

These services will help farmers to make better decisions by monitoring the growth and health of crops, providing advice on when to irrigate and till their fields and estimating the size of their harvest. APOLLO services will be piloted during the project in three countries of continental Europe: Greece, Serbia and Spain. The pilots will be user-driven and implemented with the direct participation of two farmers' associations – the Agricultural Cooperative of Pella (ACP) in Greece and the Association of Farmers of the Municipality of Ruma (UPOR) in Serbia – and an SME providing farm management services (Agrisat in Spain).

- **Farm Oriented Open Data in Europe (FOODIE)** (Esbrí, 2014) is a co-funded research project within the Competitiveness and Innovation Framework Programme (CIP). FOODIE aims at enabling the (re)use of open data in the agricultural domain from different sources (Figure 16). FOODIE experimented within three pilots: Pilot 1: Precision Viticulture (Spain), Pilot 2: Open Data for Strategic and Tactical planning (Czech Republic), Pilot 3: Integration of logistics (Germany).

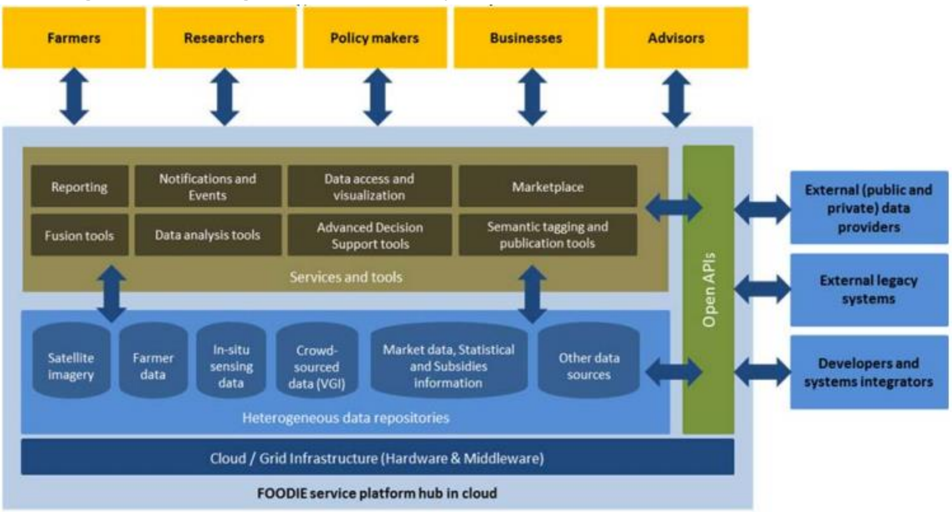


Figure 9: FOODIE service platform hub in the cloud (Esbrí, 2014)

- Flexible and Precise Irrigation Platform to Improve Farm Scale Water Productivity (FIGARO) is co-funded by the European Commission under the FP7 Programme for Research and Technological Development (Doron, 2016).

FIGARO (Figure 17) aims to increase water productivity in major water-demanding crops and develop a cost-effective precision irrigation platform through the development of cost-effective and precision irrigation management platform (**Erreur ! Source du renvoi introuvable.**). The project also contributes to the sustainable use of natural resources and adaptation of agriculture to climate change.

FIGARO platform was developed and tested in Europe field environment including Denmark, Italy, Spain, Portugal, Bulgaria, and Greece.

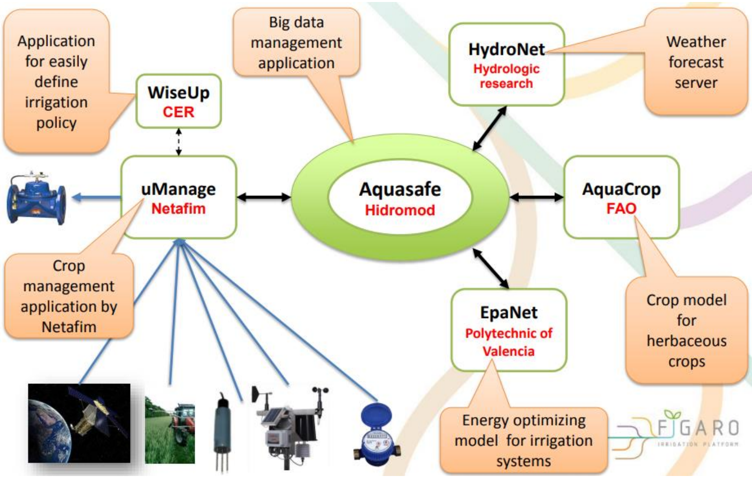


Figure 10: FIGARO system deployment (Doron, 2016)

- Agroforestry systems (Cardinael et al., 2015) refers to efficient practices to enhance soil organic Carbone (SOC) stocks in agricultural lands. It contributes to climate change mitigation, which the study site is in France. Agroforestry quantifies all organic inputs (leaf litter, fine roots, etc.) and spatializes SOC stocks plot to 2 m soil depth, and assessment effect of agroforestry on SOC fractions.

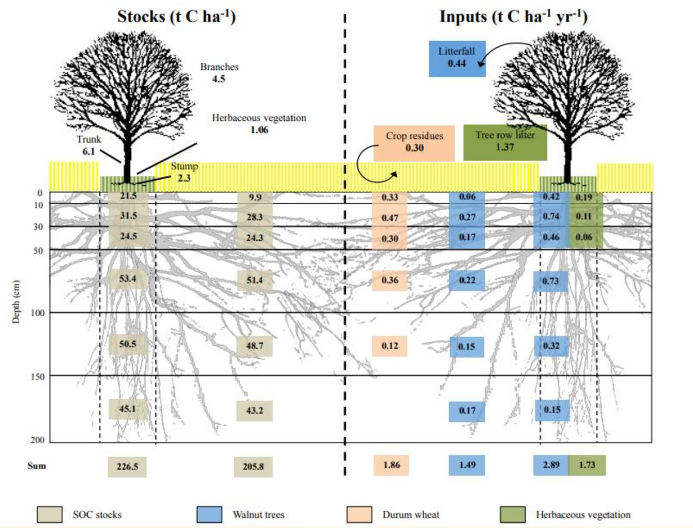


Figure 11: SOC stocks and organic carbon inputs in an agroforestry system (Cardinael et al., 2015)

In France, an extensive program of the experimental smart farm has been set up for five years.

- **DIGIFERMES®** consists of digital innovation accelerator in farms. In addition to its vocation to be demonstration platforms, DIGIFERMES® have the ambition to move from concepts to Prove of Concept (POC). Since 2016, a series of projects have been engaged in full-scale experimental tests (Digifermes, 2018).

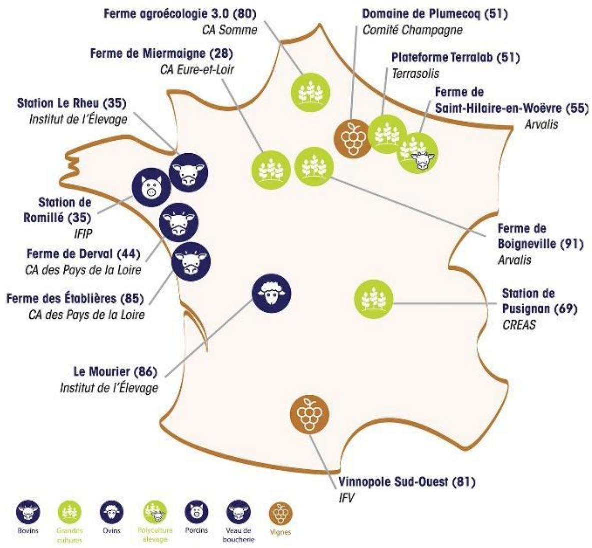


Figure 12: distribution of digiferms in France (Cardinael et al., 2015)

- **Sun'Agri (**Sun'Agri project, 2018) refers to an agrivoltaic project in wine growing that is born in the Pyrénées-Orientales (France). Sun'Agri produces clean, renewable and competitive electricity (as shown in Figure 20). The shade brought to the plants can be controlled in real time by the dynamic photovoltaic panels so that we can avoid plant's water and heat stress during excessive sunlight. Moreover, spring frosts are avoided if the panels are positioned horizontally (+ 1 to 3 ° C at night).

Figure 13: Field set up of Sun'Agri system (Sun'Agri project, 2018)

Figure 14: Field set up of Sun'Agri system (Sun'Agri project, 2018)

- **Smart Agriculture System** (SAS) project (Smart Agriculture System, 2016) aims to design an original system modelling, simulating and predict performance to support decision agricultural stakeholders (farmers, advisors, seed companies, processors). SAS combines real-time field data (biomass, soil, yield map) with a dynamic growth model while providing imaging guarantees for key stages regardless of the weather.

- A novel method for **Robotized Probing** (Alenyà Ribas, Dellen, Foix Salmerón, & Torras, 2012) is developed by the Institute of Robotica Information Industrial, Barcelona Spain. It detects plant leaves using Time-of-Flight (ToF) sensors. Plant images are segmented into surface patches by combining a segmentation of the infrared intensity image, provided by the ToF camera, with quadratic surface fitting using ToF depth data. Leaf models are fitted to the boundaries of the segments and used to determine probing points and to evaluate the suitability of leaves for being sampled. The robustness of the approach is evaluated by repeatedly placing an especially adapted, robot-mounted spad meter on the probing points, which are extracted automatically. They tested the robustness of the method by repeatedly probing a leaf. This was done for several plants. On average, probing succeeded in 82% of the cases.

- **TrimBot2020 (TrimBot2020, 2018)** is one of 'green' Horizon 2020 project aiming to investigate the underlying robotics and vision technologies and prototype the next generation of intelligent gardening consumer robots. The project is focused on the development of intelligent outdoor hedge, rose and bush trimming capabilities, allowing a robot to navigate over varying garden terrain, including typical garden obstacles, approaching hedges to restore them to their ideal tidy state, topiary-style bushes to restore them to their ideal shape, and rose bushes to cut their flowers. The project partners are the universities of Edinburgh (the UK, coordinator), Wageningen, Amsterdam and Groningen (from the Netherlands), Freiburg (Germany), Zurich (ETH, Switzerland), and a German company Bosch. In Wageningen gripper design, software development (ROS control) and system integration were taken up, and a test field was laid out. The project aims for a technology readiness level of 5-6 for the entire trimming robot concept. Bosch already markets the autonomous lawn mower that will be used for the vehicle base and is expecting to undertake further development and engineering following the project towards a new generation of gardening robots.

- **Precision spraying** (Pobkrut et al. 2014; Creative Thailand, 2017) aims to identify highly specific weed-infested areas for emphasis spraying (as shown in Figure 21). Given that spraying is highly concentrated, there will be reduced in the use of chemical pesticides. This not only enables farmers to save on the relatively expensive and harmful pesticides but since the spraying is kept to a minimum and only used on infested areas, the soil is also kept healthier, allowing for yield per square meter to increase. The six-wheel robot with e-nose system will run through the farm field to capture data and send data in real-time to a computer for collecting, analyzing, and visualizing the results via Zigbee wireless network. The e-nose system equipped on this robot was operated under real situation at four locations, namely, inside a floor room, lawn, dry ground, and vineyard row, to identify the different characteristics of each place. After that, the drone can automatically or manually spray insecticide from the air.

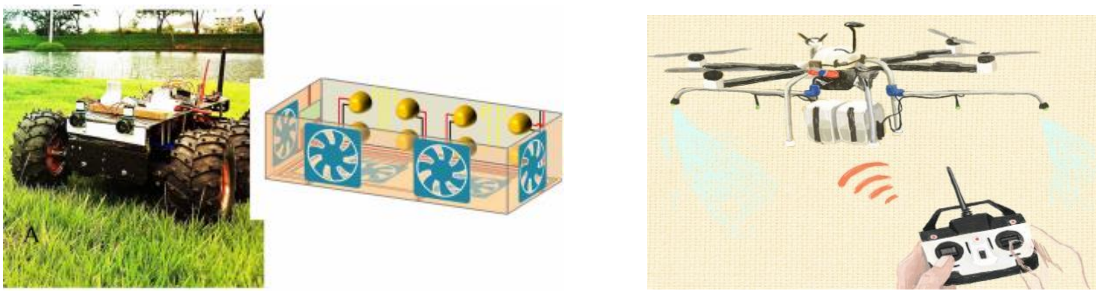


Figure 15: Precision spraying

- **Data processing and analyzing systems (Decision systems)** (Tongrod Nattapong, et al., 2009; Jindarat Siwakorn, et al., 2015; Watthanawisuth N et al., 2010; Sangbuapuan, Norrasing 2013; Kaewmard N. et al. 2014) collect data from sensors, drones and satellites which will help farmers customise better production and harvest plans, enabling them to increase their yield per square meter. The use of this technology will also help farmers to monitor their lands in real time and respond to changes in advance (as shown in Figure 22). Adverse weather conditions will no longer be a significant deterrence when it comes to yield per square meter as the AI will be able to generate algorithms that will predict different weather conditions and allow farmers to put in protective measures in advance.

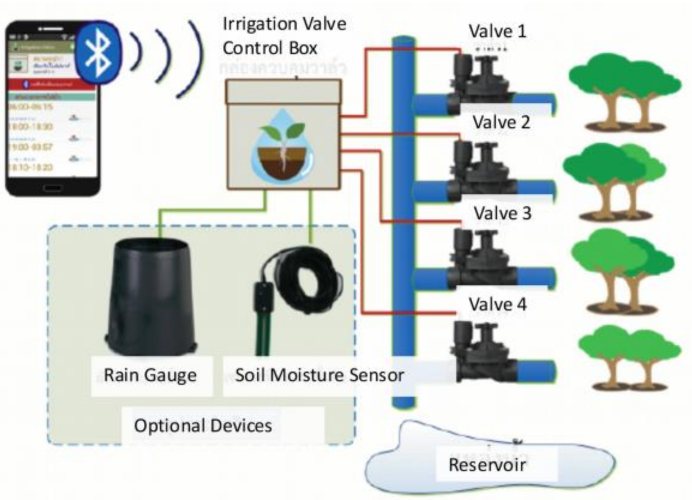


Figure 16: Irrigation Valve Control Box (NECTEC)

5.6 Industry 4.0 approaches and Smart agriculture

AI in agriculture will require a farmer to actively participate for AI to be successful. Thai farmers and their advisors are currently well suited to benefit the most from this emerging technology. AI will be a powerful tool that can help organizations cope with the increasing amount of complexity in modern agriculture. Farmers will benefit not only from the direct on-farm applications of AI, but also from the use of AI in the development of improved seeds, crop protection, and fertility products. Figure 23 shows the automatic of detection of disease in plants using AI.

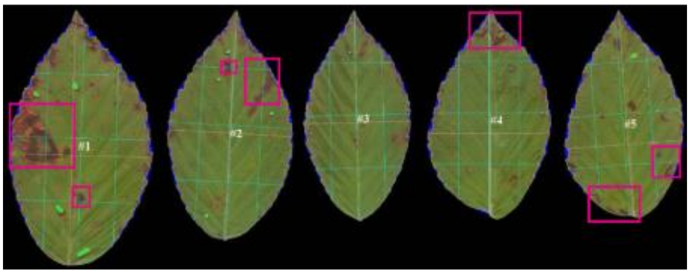
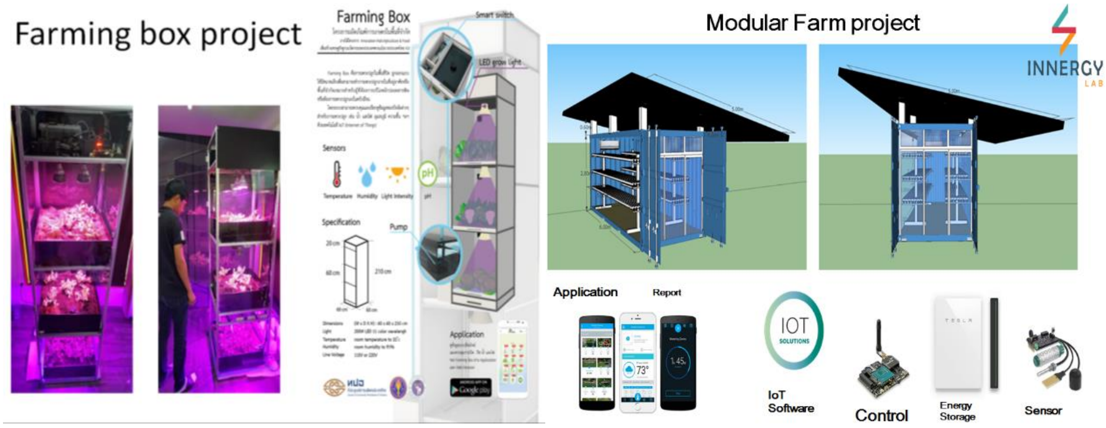


Figure 17: Plant Disease Detection

The automation system is replacing human labour. Most aspects of farming are exceptionally labour-intensive, with much of that labour comprised of repetitive and standardized tasks—an ideal niche for robotics and automation. Automation system like container and modular farm (as shown in Figure 24) which a farm in a container that helps farmers to monitor and to control crop's environment, such as temperature, humidity, light intensity, as an ideal environment of farmers aspect for producing high quality of productivity and increase yields. The system will control the crop's environment based on values that are set.



a. b.

Figure 18: a. Farming Box, b. Modular Farm

The use of such advanced technology and their integration is leading to significant progress in agricultural practices. The Industry 4.0 trend is seen as a transforming force that will profoundly impact the industry. The trend is building on an array of digital technologies: Sensing technologies, Internet of Things, Big Data, Artificial Intelligence, and of digital practices: cooperation, mobility, open innovation. They imply a transformation of the production infrastructures: connected farms, new production equipment, connected tractors and machines. They will enable both increased productivity and quality and environmental protection. However, they also generate modifications in the value chain and business models with more emphasis on knowledge gathering, analysis and exchange.

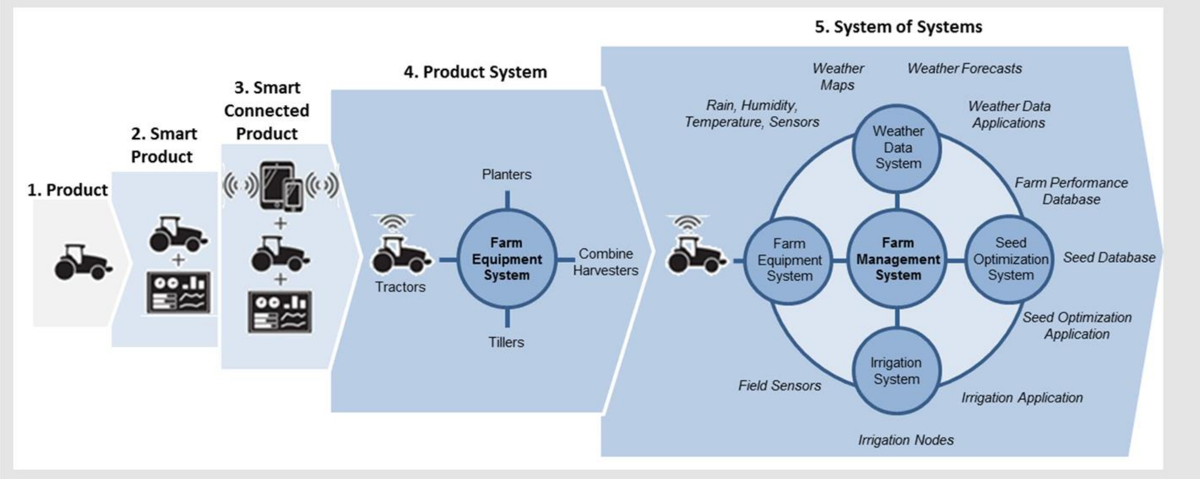


Figure 19: Farming product offering toward an integrated system of systems solution, Agriculture 4.0

Although the prospects of eventually integrating the Industry 4.0 technologies, practices and mindset in the agricultural domain are good, adoption will take time. The sector faces significant challenges, from the standardisation of technologies to the ability to invest in modernising the equipment and supporting infrastructures. The development of Agriculture 4.0 (as shown in Figure 25) requires technological standards to ensure the compatibility of technologies shown in Figure 26.

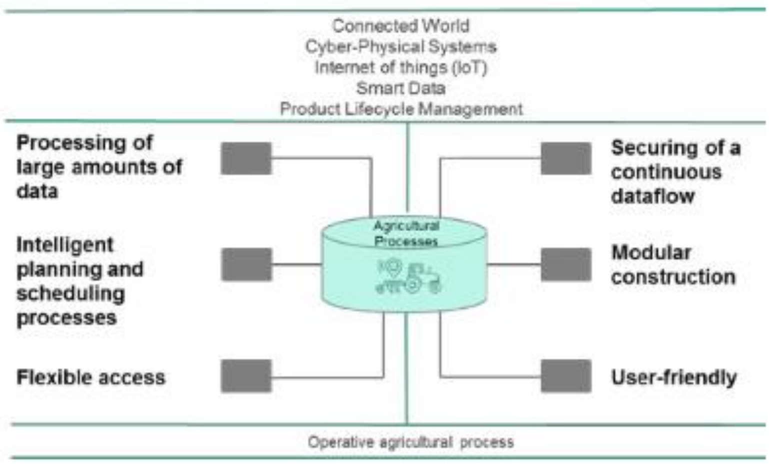


Figure 20: Requirements of Agriculture regarding Industry 4.0 (Anja-Tatjana, Braun et al., 2018)

6 Challenges and Opportunities for the adoption of Smart Farming

Challenges

World agriculture has become considerably more efficient in the past decades. Production systems as well as crop and livestock breeding programs improvements have resulted in a significant increase of food production. However, the agricultural sector encounters massive challenges including the shrinking of arable lands and farm sizes mainly due to rapid urbanization and diminishing human resources interested in agriculture. Effective policies and framework of the government is one of the main challenges of Smart Farming in the partner countries. Adaptation and mitigation agendas are the limitations to implement Smart Farming. Policies supporting conventional agriculture practices are dominant over those supporting smart agricultural strategies. Farm subsidies and policies do not incentivize farmers to adopt Smart Farming. A conducive policy environment across agricultural, environmental and economic frontiers and ground-breakings institutional arrangements are needed.

The other major challenges that the agricultural sector faces are impact of climate changes, natural disasters, post-harvest losses, diseases, etc. In countries like Nepal, youths are travelling abroad for better income opportunities, so lack of effective manpower is also a challenge. It is necessary to increase the interest of youths in agriculture by providing the essential trainings and skills required for efficient farming with optimum returns.

Adaptation to climate change in the agricultural sector and allied sectors is another major current and future challenge for adopting Smart Farming. The majority of the population is still dependent on highly climate-sensitive agriculture. Agricultural sector is strongly affected by current climate variability, uncertainty and extreme events. Evidence indicates that the adverse effect of global warming being felt. Rise in average temperatures, changes in rainfall patterns, increasing frequency of extreme weather events such as severe droughts and floods, and shifting agricultural seasons have been observed across the different agro-ecological zones. In recent years, long drought spells during the monsoon and increased temperatures and unseasonal heavy rains during winter have caused serious distress to agriculture-dependent communities in many farms in countries like Nepal and Bhutan. If the Sustainable Development Goals (SDGs) of ending poverty, achieving food security and promoting sustainable agriculture are to be realized, climate change adaptation interventions need to be implemented in earnest. In Nepal, a study carried out by the Climate and Development Knowledge Network (CDKN) revealed that the direct losses due to climate change in agriculture are equivalent to around 0.8% per year of current GDP and there will be a US$2.4 billion adaptation deficit by 2030 in three sectors including agriculture. Also, most of the agricultural production in Nepal is undertaken by smallholders resulting in more number of farmers in non-commercial farming. The other challenge is the high cost of implementing modern tools and technology.

Farmers, in these countries, face difficulties in access to capital and technical information to adopt new practices and expand agricultural landscapes. High investment to modernize farming practices and the lack of knowledge and technical support limit farmers to participate in Smart Farming. Socio-economic status of the farmers also limit the widespread adaption of Smart Farming. Illiteracy, economic status, culture, and land tenure affect in its effective adaption. Meteorological drought and the steep terrains are also the other primary challenges in the adaption of Smart Farming in mountainous countries like Nepal and Bhutan.

Similar to other developing countries, smallholder farmers in Thailand face challenges like low productivity of crops, lack of access to financial services, inadequate safety nets such as crop insurance, high cost of inputs, institutional neglect of extension services and an inability to sell their product at prevailing market price. Thai smallholder farmers are usually part of an informal value chain –

that is, they sell their products to an intermediary or local market and do not participate in further value-added components of the supply chain.

When we consider the adaption of Smarting Farming in the European countries, a key barrier is the role of financial or cost factor. The expense of establishing production facilities, as technology developers transform themselves into technology producers, often means that profits are hard to obtain and increase the costs of the innovative product or service. Other key factors in this region includes the impact of uncertainty and risk perceptions, market failures (such as information asymmetries), and internal and external stakeholder pressures. Principle-agent issues such as landowners refusing efficient technologies for tenant farmers can also be identified, as well as cultural barriers such as consumer habits and expectations and the credibility and authority of advisers or consultants limit the adoption of Smart Farming.

Opportunities

Smart Farming reduces the ecological footprint of farming. Minimized and specific application of inputs mitigates leakage problems. Continuous monitoring of the farm is possible through a network of sensors developed integrating current technologies. Similarly, theoretical and practical frameworks to connect the states of plants, animals, and soils with the needs for production inputs, such as water, fertilizer, and medications, are in reach with current ICT globally.

Smart Farming can make agriculture more profitable for the farmers. Decreasing resource inputs will save the farmer money and labor, and increased reliability of spatially explicit data will reduce risks. Optimal, site-specific weather forecasts, yield projections, and probability maps for diseases and disasters based on a dense network of weather and climate data will allow cultivation of crops in an optimal way. Site-specific information also enables new insurance and business opportunities for the entire value chain, from technology and input suppliers to farmers, processors, and the retail sector in developing and developed societies alike. If all farming-related data are recorded by automated sensors, the time needed for prioritizing the application of resources and for administrative surveillance is decreased.

Smart Farming also has the potential to boost consumer acceptance. In principle, optimizing management also permits increased product quality. These products are not only healthier but can also sell at higher prices, a key strategy in using land more efficiently. In addition, the transparency of production and processing will increase along value chains because ICT allows registration as to which farm produced a certain product under which circumstances. This offers the potential for new, more direct forms of interaction among farmers and consumers.

There are significant opportunities to pursue adaption of Smart Farming in the partner countries. Low cost smart technologies, which are simple and user friendly, can be developed locally using indigenous human resources. The technology can be made crop specific or for wide range of crops. Farmers can be trained by developing a group of trainers. Easy access of internet these days, facilitate implementation and use of the smart technology. Smart mobile phones, which are widely used even in

the rural areas, make it possible to use mobile apps to deliver information to the farmers.
With Bhutan going for 100% organic agriculture and in view of the import of vegetables containing heavy pesticide residues, the demand for domestically produced and organic vegetable is growing in the country. While farmers in the area, who are predominantly rice producers, are now beginning to cultivate and sell vegetables, there is a shortage of vegetables during the off season and consumers have to depend on the imported vegetable. In view of this, there is a huge opportunity to produce off-season vegetables. However, farmers lack the technology and resources for off-season vegetable production. As vegetables are more suited to cultivation in controlled environments and the use of technologies, there is a huge opportunity to promote smart technologies for the pilot will promote off-season vegetable cultivation to increase self-sufficiency in vegetables and reduce import.
In Bhutan, guided by the primary objectives of reducing turnaround time (TAT), enhancing accessibility, and strengthening accountability, the Public Service Delivery (PSD) is one of the key activities within the Government's efforts to strengthen delivery of public services through the ICT medium. The momentum began with the G2C Initiative, which began as a project in 2010. The inventory of the services served as the basis for automation efforts, resulting in taking more than hundred services onto the technology platforms. These online services are made available to the rural communities through the 195 Community Centers. This platform could be also used in Bhutan, to deliver information to the farmers.
There is possibility of learning from the implementation of Smart Farming practices in European partners and implement the similar practices in the Asian partners. A Smart Farm-Lab can be set up as “Center of Excellence in Smart Farming” to strengthen and sustain a link between HEIs and farmers in Asian countries.

7 References

AIOTI. (2015). SMART FARMING AND FOOD SAFETY INTERNET OF THINGS APPLICATIONS. AIOTI, 49.

AKIS. (2018). SMART-AKIS RECOMMENDATIONS FOR MAINSTREAMING SMART FARMING IN EUROPE ARE NOW PUBLIC - FEDECOM.

ALENYA RIBAS, G., DELLEN, B., FOIX SALMERON, S., & TORRAS, C. (2012). ROBOTIC LEAF PROBING VIA SEGMENTATION OF RANGE DATA INTO SURFACE PATCHES. PROCEEDINGS OF THE 2012 IROS WORKSHOP ON AGRICULTURAL ROBOTICS: ENABLING SAFE, EFFICIENT, AFFORDABLE ROBOTS FOR FOOD PRODUCTION, 1–6.

ATCHARA SUKGRUENG, KESARAPORN SUTATAPONG, NONTHIPAK PHIRIROT. 2561. STRATEGIES FOR BUILDING COMPETITIVE ADVANTAGE EXECUTIVE JOURNAL OF EXECUTIVE JOURNAL, YEAR 38, ISSUE 1 JANUARY - JUNE 2018. PAGE 91-100

BHUMISAK RASRI, "THAILAND'S AGRICULTURAL DEVELOPMENT POLICY TOWARDS INDUSTRIAL LINKAGE," OFFICE OF AGRICULTURAL ECONOMICS, JULY 5, 2017

BRADICICH, T. (2015). THE 7 PRINCIPLES OF THE INTERNET OF THINGS (IOT). RETRIEVED NOVEMBER 20, 2017, FROM HTTP: // BLOG. IICONSORTIUM.ORG/2015/07/THE-7-PRINCIPLES-OF-THEINTERNET -OF-THINGS-IOT.HTML BASED

BUREAU OF PROMOTION AND TRAINING, KU 2560. DEMONSTRATION OF THE USE OF YAMAHA RMAX FOR SOWING, FERTILIZING, SOWING AND SPRAYING IN AGRICULTURE. RETRIEVED ON 30 JANUARY 2019 FROM HTTP://WWW.ETO.KU.AC.TH/WMVWEB /VCMA007.HTML

BUSSE, M., DOERNBERG, A., SIEBERT, R., KUNTOSCH, A., SCHWERDTNER, W., KÖNIG, B., & BOKELMANN, W. (2013). INNOVATION MECHANISMS IN GERMAN PRECISION FARMING. PRECISION AGRICULTURE, 15(4), 403–426. HTTPS://DOI.ORG/10.1007/S11119-013-9337-2

CARDINAEL, R., CHEVALLIER, T., GERMON, A., JOURDAN, C., DUPRAZ, C., BARTHES, B., … CLAIRE, C. (2015). AGROFORESTRY FOR A CLIMATE-SMART AGRICULTURE-A CASE STUDY IN FRANCE. CLIMATE SMART AGRICULTURE CONFERENCE, 186. MONTPELLIER.

CHAKKRIT HANVICHA, (2016). INTELLIGENT FARM TECHNOLOGY. HAT YAI ACADEMIC JOURNAL 14 (2) JUL-DEC 2016, PAGE 201-210

CHAMAIPORN P., 'THAILAND DIGITAL POLICY,' COMPUTER TECHNICAL OFFICER :SENIOR PROFESSIONAL, MINISTRY OF DIGITAL ECONOMY AND SOCIETY, OCTOBER 2016

CHANAGIED, S. BANGKOK BANK PUBLIC COMPANY LIMITED, KHON KAEN PROVINCE (2019, FEBRUARY 2). INTERVIEW.

CHANGNIAM, V., & SINTAWEEWARAKUL, W. (2018). INCREASE EFFICIENCY ORGANIZED AND MANAGEMENT LAYING HENS FARMS BY DESIGN, DEVELOP AND USE APPLICATION FOR RECORDING, EVALUATION AND REPORT THE PRODUCTIVITY DATA OF LAYING HENS FARM ON ANDROID SYSTEM.

CREATIVE ECONOMY OFFICE (PUBLIC ORGANIZATION) OR CREATIVE ECONOMY AGENCY (CEA). 2018. SMART FARMING THAT IS POSSIBLE AND NOT FAR BEYOND REACH SEARCHED ON 30 JANUARY 2019 FROM HTTPS://HR.TCDC.OR.TH

CREATIVE THAILAND, 'THAI INNOVATIONS FOR SMART FARMER 4.0,' 15 OCTOBER 2017

DEPARTMENT OF AGRICULTURE EXTENSION, 'GUIDE TO DEVELOP SMART FARMERS AND SMART OFFICERS,' JULY 2013

DESJEUX, Y., GUYOMARD, H., & LATRUFFE, L. (2007). AGRICULTURAL POLICIES IN FRANCE : FROM EU REGULATION TO NATIONAL DESIGN.

DEVA FARM, WEBSITE: HTTPS://HR.TCDC.OR.TH/TH/ARTICLES/INDEX?CATE_ID=&PAGE=82, 1 OCTOBER 2016, (RETRIEVED ON 10 FEBRUARY 2019)

DIGIFERMES. (2018). THE DIGIFERMES® NETWORK -.

Division of Research Administration and Educational Quality Assurance, 'Thailand 4.0 : The Model to Drive Thailand to stable, sustainable and wealthy,' November 2016

Doron, L. (2016). FLEXIBLE AND PRECISE IRRIGATION PLATFORM TO IMPROVE FARM-SCALE WATER PRODUCTIVITY. International FIGARO Conference. Brussels: Netafim .

DTC Enterprise Co., Ltd. 2561. Agricultural Resource Management System (Smart Farm Solution). Retrieved on 30 January 2019 from http://www.dtc.co.th

Ekkarin Phingpracha. The Thailand Research Fund (TRF). (2019). Smart Farmer - Ban Kangpla village. Retrieved on 31st January 2019 from www.bangkokbiznews.com/blog/detail/643964

Esbrí, M. Á. (2014). FOODIE: Farm-Oriented Open Data in Europe. Connecting a Digital Europe through Location and Place. Proceedings of the AGILE'2014 International Conference on Geographic Information Science. Castellón.

Esther Mietzsch, et al., 'Smart Food and Agribusiness: Future Internet for Safe and Healthy Food from Farm to Fork,' Collaborative Project - Large-scale Integrated Project (IP), April 2013

F.G. Palis, G.R. Singleton, M.C. Casimero, B. Hardy, "Research to Impact: Case Studies for Natural Resource Management for Irrigated Rice in Asia," International Rice Research Institute, ISBN: 9789712202599, 2010

Farm Europe. (2017). A Smart CAP for EU Precision & Smart farming – FarmEurope.

Global Smart Farming Market- Analysis and Forecast (2018-2022). (2018). Retrieved from BIS Research website: https://bisresearch.com/industry-report/global-smart-farming-market.html

Innovate UK blog, Smart farm - A new approach to farming?, https://innovateuk.blog.gov.uk/2018/02/15/smart-farm-a-new-approach-to-farming/

ITU, T. S. S. O. (2015). Overview of Smart Farming based on networks.

ITU-T Study Group 20, 'Overview of Smart Farming based on networks,' International Telecommunication Union, June 2015 [Website: http://handle.itu.int/11.1002/1000/12520] (accessed on Jan 2019)

Jampour, M., Jampour, M., Ashourzadeh, M., and Yaghoobi, M. (2011). A fuzzy expert E-Learning International Conference on Information Technology. Las Vegas, NV, USA

Jindarat, Siwakorn, and Pongpisitt Wuttidittachotti. "Smart farm monitoring using Raspberry Pi and Arduino." Computer, Communications, and Control Technology (I4CT), 2015 International Conference on. IEEE, 2015.

Jumaon, V. People who have travelled to agriculture in Israel, (2019, February 10). Interview.

Kaewmard, N.; Saiyod, S., "Sensor data collection and irrigation control on vegetable crop using smart phone and wireless sensor networks for smart farm," Wireless Sensors (ICWiSE), 2014 IEEE Conference on , vol., no., pp.106,112, 26-28 Oct. 2014

Kasikorn Thai Research Center. 2017. Drone for agriculture ... strength to create new alternatives in the agricultural age 4.0. Economic base. Search on 30 January 2019 from http://www.thansettakij.com/content/216961

Kornya Aksornniam, Supanee Na Songkhla, Wisut Lueangnawee, and Theerakiet Kerdcharoen. (2012). Change Thai farmers to intelligent agriculture. Examples of Kran-Monte vineyards, Pak Chong district, Nakhon Ratchasima province. Agricultural Journal, 36 (7), 82-101.

KUMVICHAI, L. YOUNG, SMART FARMER, THAP PHRIK SUBDISTRICT, ARANYACHAT DISTRICT, SA KAEO PROVINCE. (2019, JANUARY 19). INTERVIEW.

KWAKHONG, P. ASST. PROF. OF FACULTY OF ENGINEERING. CHEMICAL ENGINEERING, UNIVERSITY OF KHON KAEN. (2019, JANUARY 20). INTERVIEW.

LADAWAN KUMPA, "SUSTAINABLE AGRICULTURE DEVELOPMENT UNDER THE NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLAN NO. 12 (2017-2021)," OFFICE OF THE NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT BOARD, AUGUST 28, 2017

LAO-ANANTANA, P. INSTRUCTOR OF ELECTRICAL ENGINEERING DEPARTMENT, UNIVERSITY OF KASETSART. (2019, JANUARY 25). INTERVIEW.

LEESEETHAUN, K. THE STAFF OF THE DIGITAL AGRICULTURE COMMUNITY PROTOTYPE PROJECT. (2019, FEBRUARY 11). INTERVIEW.

LIBELIUM COMMUNICATION. (2015A). PRECISION AGRICULTURE: PREDICTING VINEYARD CONDITIONS, PREVENTING DISEASE | LIBELIUM.

LIBELIUM COMMUNICATION. (2015B). PRECISION FARMING TO CONTROL IRRIGATION AND IMPROVE FERTILIZATION STRATEGIES ON CORN CROPS | LIBELIUM.

LIBELIUM COMMUNICATION. (2016). SMART STRAWBERRIES CROP INCREASES THE QUALITY AND REDUCES THE TIME FROM FARM TO MARKET | LIBELIUM.

LÖPRICH, C. (2018). AGRICULTURE IN EUROPE: GREENER PRACTICES AND A BRIGHTER FUTURE FOR THE SECTOR,EPC POLICY BRIEF.

MDES (2017B). HOME. BANGKOK, MINISTRY OF DIGITAL ECONOMY AND SOCIETY. HTTP://WWW.MDES.GO.TH/VIEW/10/HOME

MIETZSCH, E., KLÄSER, S., STRAND, R., BREWSTER, C., MAESTRE, C., OOSTERHEERT, L., ... MARTINI, D. (2011). PLAN FOR STANDARDISATION FOR LARGE SCALE EXPERIMENTATION WP 600 DUE DATE OF DELIVERABLE: 2013-01-31 DOCUMENT IDENTIFIER: SAF-D600.2-PLANFORSTANDARDIATION-FINAL-2.DOCX.

MINISTRY OF AGRICULTURE AND COOPERATIVES, "STRATEGIC OF AGRICULTURE AND COOPERATIVES 20-YEAR (2017-2036)," DECEMBER 2016

MINISTRY OF DIGITAL ECONOMY AND SOCIETY, "DIGITAL ECONOMY AND THAILAND 4.0," AUGUST 28, 2017

MOAI, "2016-2025 VISION AND STRATEGIC PLAN FOR ASEAN COOPERATION IN FOOD, AGRICULTURE AND FORESTRY," 10 SEPTEMBER 2015

MOAI. (2016). STRATEGIC PLAN OF ACTION FOR ASEAN COOPERATION ON FORESTRY (2016-2025).

NAUVARAT SUKSAMRAN (2018, APRIL 21). SMART VINEYARD, FINER WINE. BANGKOK POST. RETRIEVED ON 29TH JANUARY 2019 FROM HTTPS://WWW.BANGKOKPOST.COM/NEWS/SPECIAL-REPORTS/1449754/SMART-VINEYARD-FINER-WINE.

NFU REPORT, DELIVERING A BOLD AND AMBITIOUS FUTURE FOR FARMING - DOMESTIC AGRICULTURAL POLICY A FRAMEWORK FOR SUCCESS HTTPS://WWW.NFUONLINE.COM/ASSETS/100873, 2019

NISSAN THAILAND. (2018). NISSAN TO EXTEND ITS 'HONOR THE KING'S LEGACY' PROJECT TO CONTINUE PROMOTING THE TEACHINGS OF THE LATE KING BHUMIBOL ADULYADEJ. RETRIEVED ON 29TH JANUARY 2019 FROM HTTPS://EN.NISSAN.CO.TH/NEWS/HONOR-THE-KING-LEGACY-PROJECT.HTML

OFFICE OF THE PLANNING IN AGRICULTURE, NATURAL RESOURCE, AND ENVIRONMENTAL, "SUSTAINABLE AGRICULTURE," APRIL 2011

ONG KENG HO, "STRATEGIC PLAN OF ACTION ON ASEAN COOPERATION IN CROP (2016-2020)," ASEAN, MARCH 7, 2014

Penree, S. Chairman of the Organic Farming Enterprise Group, Ban Kut Chiang, with Ban Dong Subdistrict, Ubolratana District Khon Kaen Province. (2019, January 27). Interview.

Philip Chen, C. L., & Zhang, C.-Y. (2014). Data-intensive applications, challenges, techniques and technologies: A survey on Big Data. Information Sciences, 275, 314–347. https://doi.org/10.1016/j.ins.2014.01.015

Phithit Chitsaran, Suk Sawat, Natthawut Sithit and Thepthit Bunditwattanawong (2017). Development of smart chicken egg farms based on fuzzy logic and Raspberry Pi. Journal of Science, Technology and Environment Research Unit for Learning, Year 8, No. 2 (2017), page 356-367.

Pivoto, D., Waquil, P. D., Talamini, E., Finocchio, C. P. S., Dalla Corte, V. F., & de Vargas Mores, G. (2018). Scientific development of smart farming technologies and their application in Brazil. Information Processing in Agriculture, 5(1), 21–32. https://doi.org/10.1016/j.inpa.2017.12.002

Pobkrut, Theerapat, and Teerakiat Kerdcharoen. "Soil sensing survey robots based on the electronic nose." Control, Automation and Systems (ICCAS), 2014 14th International Conference on. IEEE, 2014.

Porametee Vimolsiri, 'Thailand 20 Year Strategic Plan and Reforms,' Thailand Focus 2017

Rumana Bukht and Richard Heeks, 'Development Implications of Digital Economies; Digital Economy Policy: The Case Example of Thailand,' Centre for Development Informatics, Global Development Institute, SEED, University of Manchester, Arthur Lewis Building, Manchester, M13 9PL, UK

Ruthaichanoksutjit. (2559). Insight into "Smart Farmer", just a new concept or will transform Thai agriculture, search on 29 January 2019 from https://scbsme.scb.co.th/sme-inspiration-detail. / SCB _SmartFarmer)

Saeloe, S. IT Manager, Pan Rajdhevee Group Public Co., Ltd. (2019, January 30). Interview.

Salami, P., & Ahmadi, H. (2010). Review of Farm Management Information Systems (FMIS). In New York Science Journal (Vol. 3).

Sandeep, L., and Gopal, S. (2015). Kumar, can be used to automate raspberry pi based on internet ofthings. International Conference on Advances in Computing, Communications and Informatics. Kochi, India.

Sangbuapuan, Norrasing., "Information and communication technology policy framework for improving rice farmers in Thailand." Application of Information and Communication Technologies (AICT), 2013 7th International Conference on. IEEE, 2013.

Sao bangkae 22. (2561). How to be rich in 365 days growing organic vegetable by Kaewpanao Organic farm. Retrieved on 31st January, 2019 from https://www.technologychaoban.com/agricultural-technology/article_51266

Sasiwimon Boonruang, 'Vineyard trusts its sensors,' 10 February 2010, Website: http://www.granmonte.com/news/2010/11/VineyardTrustsItsSensors.pdf, (Retrieved on 10 February 2019)

SBuksuntear, M. Chairman, Ban Nong Hoi Chiang Mai Rice Growing Enterprise Group, Loeng Tai Subdistrict, Kosum Phisai District Maha Sarakham Province, (2019, January 28). Interview.

SCHUTTELAAR & PARTNERS, 'SMART FARMING IS KEY FOR THE FUTURE OF AGRICULTURE,' 19 JUNE 2017, HTTPS://WWW.SCHUTTELAAR-PARTNERS.COM/NEWS/2017/SMART-FARMING-IS-KEY-FOR-THE-FUTURE-OF-AGRICULTURE

SIRIPAK, S. FORMER RETIRED CIVIL SERVANT, BAN PET SUBDISTRICT, MUANG DISTRICT, KHON KAEN PROVINCE. (2019, FEBRUARY 9). INTERVIEW.

SITTHITOOL, R. 2016. THAI'S GOV PUSHES SMART FARMER POLICY AS MAIN AGENDA TO UPGRADE FARMERS' COMPETENCY. RETRIEVED ON 29TH JANUARY, 2019 FROM HTTP://THAITRIBUNE.ORG/CONTENTS/DETAIL/296?CONTENT_ID=18601&RAND=14586726

SMART FARM THAILAND. (2562). SMART FARM, SEARCHED ON 31 DECEMBER 2019 FROM HTTP: // SMART FARMTHAILAND .COM / PRECISIONFARMING / INDEX.PHP / PRODUCT / MICRO-CLIMATE-MONITORING / 83-SMART-FARM.

SMART FARM THAILAND. 2560. PRODUCT INFORMATION. SEARCHED ON 30 JANUARY HTTP://SMARTFARMTHAILAND.COM/PRECISIONFARMING/INDEX.PHP/PRODUCT/MICRO-CLIMATE-MONITORING/83-SMART-FARM

SOITONG, K. 2010. SMART FARMER: A FARMER-TO-FARMER EXTENSION APPROACH FOR WIDESPREAD ADOPTION. IN RESEARCH TO IMPACTS: CASE STUDIES FOR NATURAL RESOURCE MANAGEMENT FOR IRRIGATED RICE IN ASIA LOS BAÑOS (PHILIPPINES): INTERNATIONAL RICE RESEARCH INSTITUTE. (EDS. F. G. PALIS, G. R. SINGLETON, M.C. CASIMERO, AND B. HARDY). SUITE 1009, SECURITY BANK CENTER, 6776 AYALA AVENUE, MAKATI CITY, PHILIPPINES. PP. 233-243.

SRISWASDI, WATCHARA, ET AL., "A SMART MOBILIZED FERTILIZING EXPERT SYSTEM: 1-2-3 PERSONALIZED FERTILIZER." WORLD CONFERENCE ON AGRICULTURAL INFORMATION AND IT, TOKYO, JAPAN. 2008.

SURIYAN VICHITLEKARN AND POUCHAMARN WONGSANGA, "ASEAN AND AGRICULTURAL COOPERATION," PUBLISHED BY DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ) GMBH, JUNE 13, 2017

TERENCE J. CHULAVACHANA, 'FACTORS FOR "SMART FARM" CONCEPT READY; CAN THAILAND PUT THE PIECES TOGETHER INTO A SUCCESSFUL DRIVE?' JANUARY 15, 2013

THAIHEALTH 2017, WEBSITE: . PDF, (RETRIEVED ON 13 FEBRUARY 2019)

THAILAND INVESTMENT REVIEW, SMART FARMING THE FUTURE OF AGRICULTURE IN THAILAND. VOL. 28, NO.2, MAY 2018.

THE GOVERNMENT PUBLIC RELATION DEPARTMENT, 'POLICY TO REFORM THAILAND'S AGRICULTURE SECTOR,' HTTP://THAILAND.PRD. GO.TH/EWT_NEWS.PHP?NID=3496&FILENAME=INDEX, 16 JULY 2016 (RETRIEVED ON JANUARY 2019)

THEERAKIET KERDCHAROEN. (2007). INTELLIGENT FARM EPISODE 1. UPDATE JOURNAL, 22 (241), 93-96

THEERAKIET NUMJARN, 2015. "AGRI-CHARIYA AGRICULTURE" ... THE FUTURE OF THE WORLD FOOD FUTURE, (15 SEPTEMBER 2015). ECONOMIC BASE. RETRIEVED ON 30 JANUARY 2019 FROM HTTP://WWW.THANSETTAKIS.COM / 2015/09/15/11202

TONGROD, NATTAPONG, ADISORN TUANTRANONT, AND TEERAKIAT KERDCHAROEN. "ADOPTION OF PRECISION AGRICULTURE IN VINEYARD." ELECTRICAL ENGINEERING/ELECTRONICS, COMPUTER, TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY, 2009. ECTI-CON 2009. 6TH INTERNATIONAL CONFERENCE ON. VOL. 2. IEEE, 2009.

TRIMBOT2020. (2018). TRIMBOT2020 PROJECT – CUTTING HEDGE RESEARCH.

Unquestionable agricultural issues. 2018. SMART FARM with digital agriculture Searched on 30 January 2018 from https://www.rakbankerd.com/agriculture/hilight-view.php?id=132&s=tblheight

Vi-anantana, P. A Brand Builder and Consultation on Product Value Added, (2019, January 27). Interview.

Vichitlekarn, S., & Wongsanga, P. (2017). ASEAN and agricultural cooperation.

Vimolsiri, P. (2017). Thailand 20-Year Strategic Plan and Reform.

Watthanawisuth, N., et al., "Real-time monitoring of GPS-tracking tractor based on ZigBee multi-hop mesh network." Electrical Engineering/Electronics Computer Telecommunications and Information Technology (ECTI-CON), 2010 International Conference on. IEEE, 2010.

What is Smart Farming? - Smart-AKIS. (n.d.).

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J. (2017). Big Data in Smart Farming – A review. Agricultural Systems, 153, 69–80. https://doi.org/10.1016/j.agsy.2017.01.023