Smart Farming: Implementation of Industry 4.0 in the Agricultural Sector

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ABSTRACT

Agriculture is a center that touches human life as well as other sectors in all countries. With the development of information technology, the agricultural sector also faces challenges and opportunities in realizing world food security. The development of Industry 4.0 was implemented in the agricultural sector as well as other sectors and was promoted to Farming 4.0. Industry 4.0 is a smart factory where smart digital devices are connected and that communicate with raw materials, semi-finished products, products, machines, tools, robots and people. The pace of technological change in the agricultural sector in the industrial era 4.0 is very high. However, these opportunities have not provided significant benefits in the agricultural sector. Farmers and various other actors need to get important information in line with the agriculture value chain. This paper discusses the successful implementation of Smart farming in several countries. With the many capabilities of Smart Farm, it is hoped that it will provide benefits for farmers and other agricultural actors in increasing agricultural production and their welfare.

CCS CONCEPTS

• **General and reference**; • **Cross-computing tools and techniques**; • **Evaluation**;

KEYWORDS

Farming 4.0, Precision farming, Smart farming, Agricultural, Digital Agriculture

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1 INTRODUCTION

Population growth is increasing every year, encouraging the agricultural sector to participate in providing better food results in terms of quality and quantity. With the fourth industrial revolution, it is possible to manage rice fields more efficiently, for example drones can plant more than 500 seeds per hour, compared to farmers who plant about 800 seeds per day.

With the use of precision farming, farmers can monitor their land to find out exactly which ones need irrigation. Several companies in Japan can make fertigation systems, namely systems that can inject fertilizer and water based on data received by sensors in the soil. In addition, the embedding of additional devices on the tractor, allows for farmers to plow remotely (remote). By implementing precision farming, it is possible for farmers to get optimal yields.

The high price of tractor machines and the lack of knowledge of farmers are one of the factors that make them still do everything manually. Digital agriculture is the use of digital technology to integrate agricultural production from the paddock to the consumer. This technology can provide the industry with agricultural tools and information to make better decisions and increase productivity. Smart farming answered all of the above needs by presenting the latest technology at an affordable price and providing adequate counseling for farmers to use the latest technology in the agricultural sector from Industry 4.0.
This paper will focus on deepening industry 4.0 in the agricultural sector. The structure of this paper, which is the second part, introduced implementation of Industry 4.0 in the agricultural sector, framework for digital farming, and discussions along with simulations and conclusions.

2 THE CONCEPTUALIZATION

There are several concepts and theories that were further discussed regarding industry 4.0 and opportunities for the implementation of the agricultural sector.

2.1 Industry 4.0

Industry 4.0 is a transformation from traditional industry to the modern era by using the latest technology that involves automation and data exchange. Elements of Industry 4.0 include [1]: adaptive robotics, data analytics and artificial intelligence, simulation, embedded system, communication and networking, cyber security, cloud technologies, additive manufacturing, virtualization technologies, sensors and actuators, RFID and RTLS, and mobile technologies.

Adaptive Robotics is a combination of a replacement mechanism for human movement carried out by a robot combined with artificial intelligence which makes the robot not only able to calculate, communicate and control movement, but also can make its own decisions and socialize with the surrounding environment. Data

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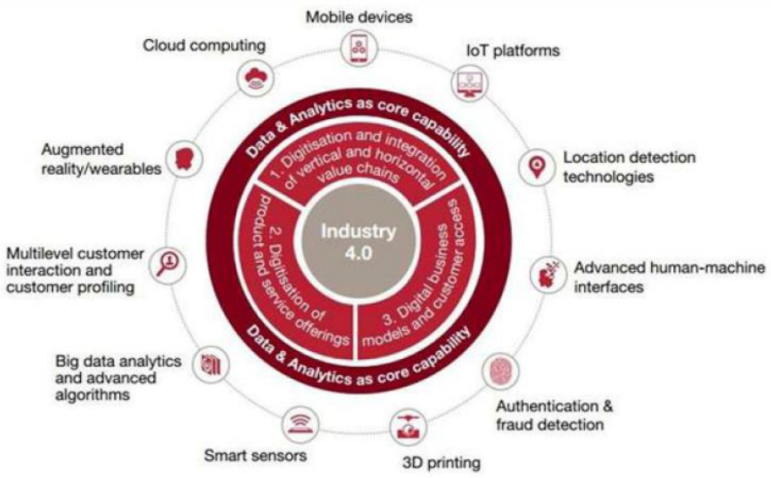

Figure 1: Industry 4.0 Framework [2]

Analytics and Artificial Intelligence, is a data source that is used to develop and involves machine learning concepts to make the data useful for process automation and become a stand-alone process. Simulation, a process that involves imitating the actual process conditions involves virtualization so that the decision-making process can be according to demand and the design failure rate can be reduced.

Embedded System, supporting technology for organizing and coordinating network systems between physical infrastructure and computing capabilities. This system allows the connection between digital and physical devices with other devices to achieve centralized action. Communication & Networking, a smart communication and network system that allows communication between machines and networks in the manufacturing industry via the internet network. Cyber Security, a form of securing data circulating in a network from the threat of system hacking that can disrupt the process. Data security issues include data privacy, data authorization, and other threats. Cloud Technologies, data-driven technology that is always available when needed, enabling manufacturing processes to be performed and linked on demand and not limited by distance and time. Additive Manufacturing, an emerging technological innovation that can produce three-dimensional objects from digital models, especially those using polymer, ceramic and metal raw materials. An example of its application to 3-dimensional (3D printing) product printing.

Virtualization Technologies (VR & AR), integration of computer-supported reflection with real- environments equipped with the required information. This technology utilizes the ability of human perception of space and reality using digital virtualization. Sensors & Actuators, is a basic technology that provides input signals that are used and connected to a microcontroller to interact with the real world. RFID & RTLS Technologies, Radio Frequency Identification and Real-Time Location System, which are used in manufacturing to improve transportation, logistics and storage performance enabling automated decision making. Mobile Technologies, a remote communication tool that allows virtualization and process management to be done in a simple and space-free device.

In general, the application of technology in industry 4.0 can be illustrated in Figure 1.

2.2 Precision Farming

Precision farming was initiated in the early 1980's to improve the application of fertilizers by varying rates and blends as needed within fields. It relate to machinery, sensor, GPS, software, and remote sensing [3]. According to Berger [4], precising farming can improve farmer livelihoods and ensure the sustainable food production. It emphasizes that precision agriculture is the future of farming.

From several Industry 4.0 technologies that can be implemented in the agricultural sector, we choose to focus on one technology as the first step in our business planning, namely precision farming. Only then gradually developed by integrating other technologies in the next business plan. Precision farming refers to a management concept that focuses on observing, measuring and responding to changes that occur in plants, fields and animals using Geographic Information Systems (GIS) & Unmanned Aerial Vehicles (UAV), or commonly known as Drones.

The benefits obtained from implementing precision farming include:

- increase farmer profits, by increasing crop yields and animal performance, reducing costs and labor and optimizing process inputs
- contribute to the sustainability of agricultural production by increasing occupational safety and reducing the environmental impact of agricultural practices [4].

2.3 Implementation of Industry 4.0 in the Agricultural Sector

In particular on its application in the agricultural industry, International Crops The Research Institute for the Semi-Arid Tropics

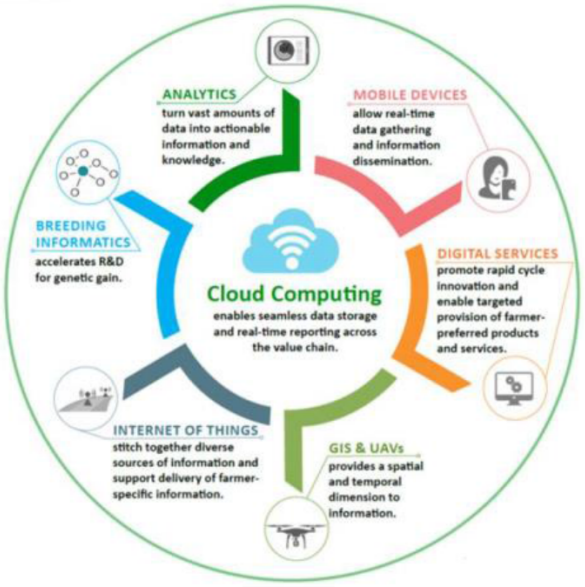

Figure 2: ICRISAT Framework for Digital Farming development [5]

(ICRISAT) introduces a framework work for agricultural development using digital technology. as shown in Figure 2.

The available technologies that can be used for development in agriculture include:

- Digital Service, is a variety of facilities provided by digital technology that serves to provide convenience in the flow of data and information through one door and can be accessed from all locations. This system supports sustainable innovation and offers farmers to use services that are tailored to their needs.
- GIS & UAV, Geographics Information System (GIS) & Unmanned Aerial Vehicles (UAV) are media used to monitor geographical conditions from an aerial view. This device can provide assistance for farmers to monitor land conditions from the air and enable data taken for further analysis.
- Internet of Things, is an internet-based technology that helps each device communicate in meeting the targets to be achieved. This technology can be used by farmers to send data and receive data from the equipment used or other parties.
- Breeding Informatics, technology and innovation in agriculture that is used to develop agricultural products that are tailored to the needs. The adoption of information technology makes the development of agricultural products better and easier to do.
- Analytics, processing data obtained from other devices as well as production and agricultural performance which is used to determine further decisions needed to achieve targets.
- Mobile Devices, mobile devices that are easy and light to move from one location to another. This device is used and connected to the data center so that the information received by farmers is real-time data and is in accordance with the actual conditions needed.

Figure 3: Application of smart farming in Japan [6]

3 DISCUSSION

3.1 Farming in Japan

The Japanese government uses Artificial Intelligence and the Internet of Things (IoT) to regulate the irrigation system of agricultural land in Japan, known as "Fertigation". This system uses a pipe line in the farm to deliver dripping water and fertilizer directly to the roots of the plant. The data is obtained from light sensors and soil condition sensors which are then processed by AI which can then determine the amount of water and fertilizer needed for each location of agricultural land.

Research conducted in Japan regarding the application of smart farming has shown that the application of information systems in the agricultural industry has a positive impact [6]. In terms of production, the process of planting until the harvest period can be shortened, besides that the yield and quality can be controlled from the start so that the product will arrive at the market in accordance with the time and quantity that has been determined with good quality and the agreed price without being affected by price fluctuations. which is common in conventional marketing and farming processes [6]. Other impacts will also be felt on the transportation process of agricultural products from land to markets and from land to consumers. Digitally managed distribution and storage processes can have an impact on economic development. If it is detailed in more detail about how digital technology is used in the agricultural industry, one of its applications can be seen in Figure 3.

Data in the agricultural industry can be in the form of manual input by farmers or producers, data generated by agricultural equipment, and data obtained from installing sensors on all aspects of agricultural land. All this data will be stored in a single data center that can be accessed by every party involved in the agricultural industry who will use the data in determining further processes [7].

The stored data can be collaborated with other industries and other devices through the internet network. Visualization and data control can be accessed by all related parties using mobile devices or computers for further data processing (Figure 4).

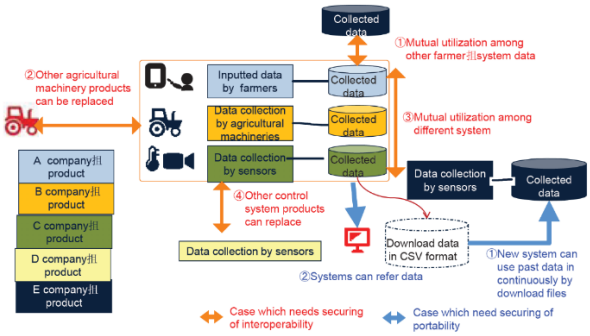

Figure 4: Example of data process flow [7]

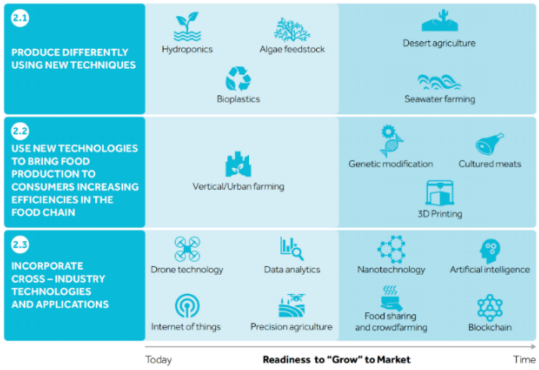

Figure 5: Map of technology and its application [8]

3.2 Farming in United Arab Emirates

The application of smart farming in a country where most of the area is desert is a very suitable solution. A company engaged in agriculture has implemented the vertical farming method, which is the application of agricultural land that does not require a large area of land and is arranged vertically into several layers of plants in a room arranged in such a way as to resemble natural conditions suitable for certain plants.

Other technologies used are temperature, humidity and irrigation settings that are carried out remotely using Internet of Things (IoT) technology and several sensors are installed so that with limited land it is possible to plant several types of agricultural crops and monitoring of crop conditions can be done from other locations.

Specifically for its application in the agricultural industry, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) introduced a framework for agricultural development using digital technology with the illustration in Figure 5.

The following is a connection diagram between devices that can be used in the agricultural industry to meet production needs more optimally and efficiently. It is shown in Figure 6.

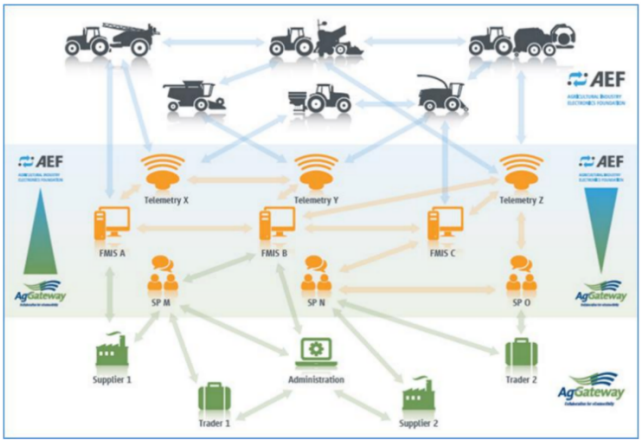

Figure 6: Network adopted by European Agricultural Machinery (CEMA) [9]

3.3 Precision Farming Business Opportunity in Indonesia

As an agricultural country where most of the population works in agriculture with the third largest contribution to GDP after the manufacturing and trade sector [10], the business opportunity for implementing Precision Farm in Indonesia is very large. Precision Farming can be offered to large-scale plantations such as oil palm plantations, tea, rubber, as well as to rice farming, vegetables, and others.

3.4 Smart Farming Data Management

Developments that can be carried out by a company engaged in agriculture and adopting technology in industry 4.0 include the application of smart farming, which means that apart from implementing smart irrigation, this industry will also use remote control for its agricultural equipment, as well as land planning and planting. digitally.

When the existence of industries that use smart farming are widely known by farmers, the application of agricultural block chains will also be realized. Blockchain means that all aspects related to the agricultural industry will be managed digitally and can be collaborated with other industries with certain data security which leads to the application of market prices that are appropriate and acceptable to both the industry and buyers.

The support from the farming community also really determines the application of digital technology. For some countries with high population levels and very large income dependence on the agricultural industry, the application of digital technology is more focused on communication between agricultural processes starting from planning, production control, packaging, marketing, and sales [6].

Figure 7 provides an overview of the implementation of smart farming for countries with a high level of community work needs in the agricultural sector. Village development planning is a starting point that can be developed to gain community acceptance. Workers from villages can be trained and developed to use digital technology in managing agriculture. Then other contributions can

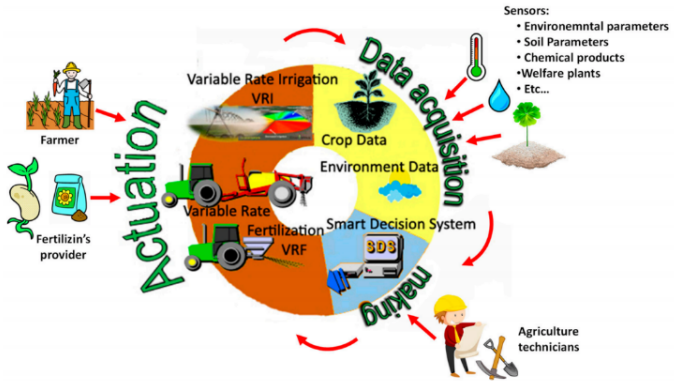

Figure 7: Data management cycle in Smart Farming [11]

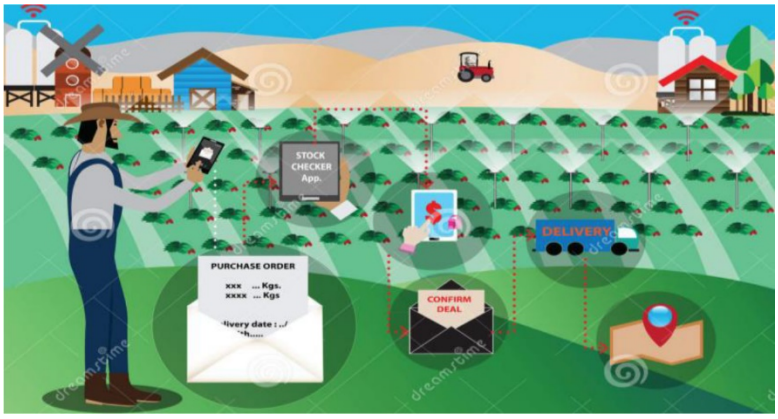

Figure 8: Smart Farm Concept for Digital Marketing [12]

be made to support research programs related to agricultural development tailored to the needs of each agricultural area with diverse agricultural commodities.

3.5 Smart Farm Concept for Digital Marketing

Nowadays, more and more customers are making purchase transactions using Mobile Commerce. Farmers can use mobile devices that are connected to customers as well as partners, so that the amount of stock availability of products to be purchased in real time will be known and can influence buying decisions. In addition, showrooming techniques can also be developed, namely creating a virtual shop [12]. Shopping activities in stores/markets take up a lot of time so that the existence of a virtual store allows customers to see the condition of agricultural products/products virtual (Figure 8).

4 CONCLUSION

The discussion of this paper has opened our insight about the importance of precision farming. The implementation of Farming 4.0 has been running in several countries but needs to be more evenly distributed throughout the world where the agricultural sector is the source of life for all mankind. Farmers are the backbone in adapting to these changes. Of course, this implementation is not easy given the need for a number of investments, technological uncertainty, and high organizational risk. In this environment, farmers must continuously strive to maintain and increase productivity to meet demand.

Digital technology has the potential to inform and empower farmers to meet challenges and seize opportunities for growth. For future research, researchers can approach agricultural actors to provide solutions for more efficient and effective digital farming implementations.

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