CHAPTER 1
NEEDS ANALYSIS

Chapter 1 of the document contains a description of issues related to remote weather monitoring equipment. It also discusses the requirements that need to be fulfilled to address problems in agriculture, one of which is the inaccuracy of weather monitoring that still occurs today. This chapter also includes a needs analysis that can support the resolution of existing problems. The aim is to provide a detailed description of the problems to be studied and serve as a reference in the development and evaluation process in the design of the tool. Therefore, the process of product development will be more directed and focused on overcoming one of the problems in agriculture, especially for analysing weather monitoring.

1.1 The Background of the Problem

Smart Farming, as a contemporary agricultural paradigm, has emerged as a transformative approach for enhancing crop cultivation. Within this context, agricultural productivity is intricately linked to the dynamic atmospheric conditions specific to each location and time. Fundamental parameters such as wind speed, air temperature, humidity, and precipitation necessitate continuous monitoring. Nonetheless, traditional farming methods employed in Indonesia are often characterized by inefficiency, significant resource demands, and unpredictable harvest outcomes resulting from rudimentary weather predictions primarily reliant on the observation of natural phenomena, particularly wind and cloud patterns. This underscores the pressing need for a more sophisticated system that can deliver real-time and precise meteorological data.

Agriculture holds a pivotal role in addressing the multifaceted requirements of society, spanning essential needs such as sustenance, industrial raw materials, energy resources, and environmental stewardship [1]. Yet, the agricultural sector grapples with a formidable challenge posed by climate change, which yields imprecise weather forecasts. Consequently, farmers confront the formidable task of making strategic decisions to mitigate the adverse impacts of capricious weather patterns. Traditional weather monitoring techniques, often constrained by limited scope, accuracy, and timeliness, prove insufficient in effectively addressing this challenge [2]. Given the direct influence of weather conditions on crop growth and yield, the precision and timeliness of meteorological monitoring are of paramount importance for sound agricultural management.

While weather remains an uncontrollable natural phenomenon, it can be systematically observed and analyzed through the practice of meteorological monitoring. In this regard, the development of systems capable of monitoring critical meteorological parameters, such as temperature, humidity, wind direction and speed, becomes imperative. One such exemplar is the AWS node for meteorological monitoring, operational at the Gambung Tea and Quinine Plantation (PPTK) and founded on the NRF24L01 wireless communication protocol [3]. This system integrates multiple sensors for comprehensive data collection, yielding accurate and timely insights into temperature, humidity, precipitation, soil moisture, wind velocity and direction, as well as ambient light levels. These systems have proven to be indispensable tools for equipping farmers with real-time data, enabling informed decision-making, and promoting sustainable agricultural practices in the face of climate change.

1.2 Supporting Information

Agriculture is a sector that has been resilient during the Covid-19 pandemic, growing by 16.24% while other sectors experienced a decline. This is supported by the consumption patterns of the community which prioritize basic necessities (99.99%) according to BPS data. According to FAO's prediction, the world's population will grow to 9.6 billion by 2050, meaning that agricultural production must increase. The development of modern agriculture must be based on integrated principles between management information systems, precision technology, and cyber physical systems.

Smart Farming is a modern farming concept that uses automation technology and big data management to improve agricultural efficiency and productivity. This method is also known as precision agriculture, which emerged to take advantage of advanced technologies such as CPS and IoT. This method allows farmers to optimize the use of resources such as water, fertilizers, and pesticides more accurately. Smart farming technology includes soil sensors, drones, robots, and integrated data management systems. Using smart farming, farmers can improve both the quality and quantity of their harvests.

Cyber-Physical System (CPS) is a key system in implementing the fourth-generation industrial revolution. This system combines automation systems, electronics, internet networks, and machine learning. Implementation of cyber-physical systems in agriculture has long been awaited as it is the backbone of sustainable agribusiness system implementation. With this system, precision agriculture and extensive computation in agriculture can help stakeholders in the agribusiness field to enjoy various benefits optimally. One example of its application is a smart farming system that is conditioned to provide measurable and maximal results without sacrificing soil nutrients because it is well-monitored according to weather condition [4].

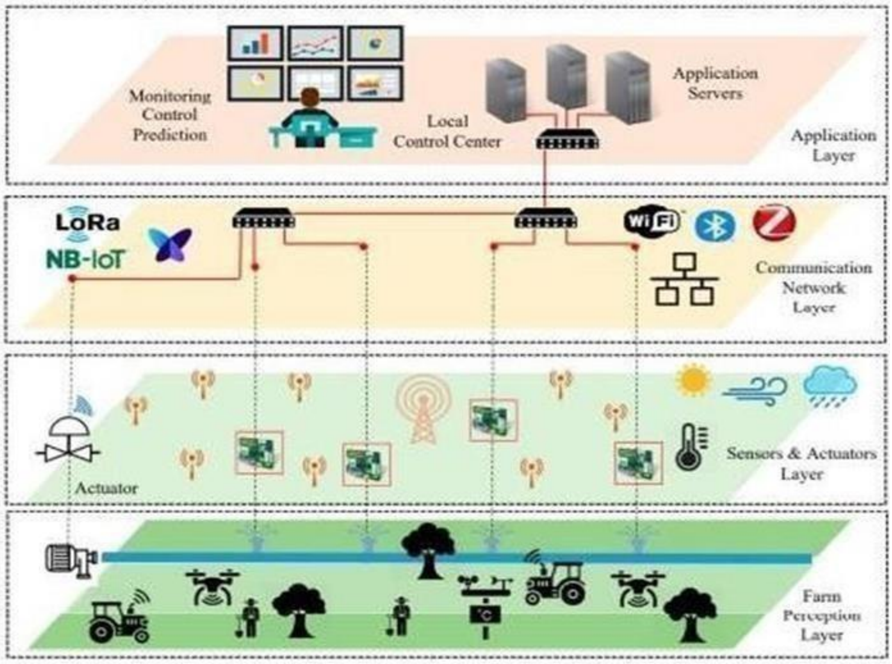

Figure 1 Application of CPS in Agriculture

In figure 1, the application of Cyber-Physical System (CPS) in smart agriculture requires a communication network between monitoring nodes and an internet gateway that can reach a considerable distance therefore cyber-physical systems generally work on Internet- of-Things devices. The long-distance communication system required is expected to provide arrange of 0.5 to 1 kilometer, encrypted, and low-power transmission possibilities. It requires regulation on the frequency band and power used. In reality, monitoring and control nodes will exchange data about local weather conditions, which is enough to ensure agricultural product success rates of more than 100% without human intervention. With the addition of intelligent systems, suitable agricultural conditions can be implemented using extensive computing and machine learning on each node or on the display side of the Cyber-Physical System (CPS) being applied. Predicting pests and treating them can also be done by adding a connected agricultural robotics system.

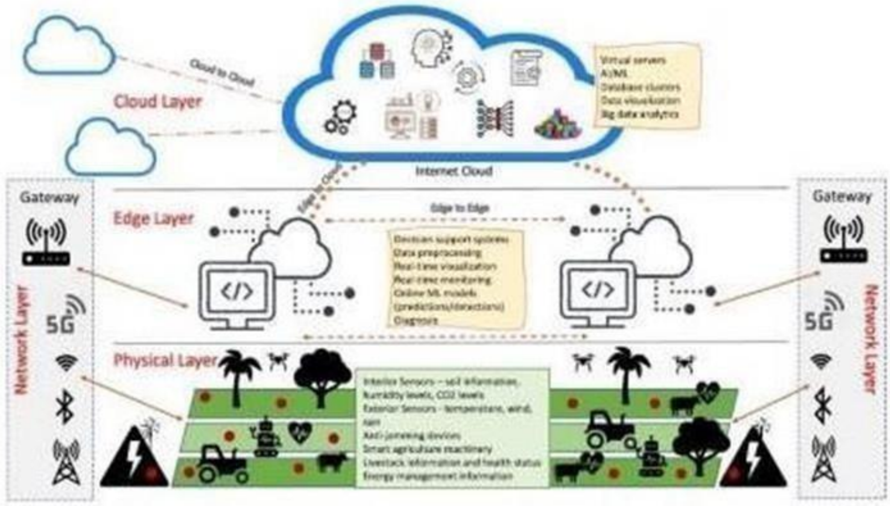

Figure 2 Agricultural Ecosystem Architecture

Picture 2 depicts a multi-layer architecture for a smart farming ecosystem. The proposed architecture adapts and extends the widely discussed IoT and Cyber Physical System (CPS) multi-layer architectures. These architectures acknowledge the use of cloud and edge services, as well as their unlimited capabilities to fully leverage data generated by smart devices in the physical layer. Our smart farming architecture also reflects the various user applications that can be envisaged at different layers. It also takes into account the large amount of data collected at the edge or cloud layers, and highlights the need for various multi-cloud or edge-cloud scenarios overall the architecture consists of four layers: the physical layer, the edge layer, the cloud layer, and the network communication layer. The latter encompasses all three preceding layers and connects them.

1.3 Constraint

One aspect that needs to be considered regarding the implementation of remote weather monitoring devices is that it requires a lot of money to purchase infrastructure devices as well as operational costs to run the system. The system's Infrastructure devices may have technical limitations regarding range, measurement accuracy, and data storage capacity. Technical adjustments are required to make the system work effectively and efficiently. The data generated by these systems may contain highly sensitive and critical information. Therefore, adequate data protection is required to prevent unauthorized access or data theft. The implementation of a new system such as this requires training and upskilling of the farmers or operators who will operate the system. An effective training program is needed to ensure that the system can be operated properly and provide maximum benefits.

1.3.1 Economic Aspect

The economic analysis of the need for remote weather monitoring devices for market share includes the agricultural sector, tourism sector, transportation and transportation, and the energy industry. In the agricultural sector, this device can assist farmers in planning the timing of planting, irrigation, and harvesting so as to increase productivity and efficiency in agricultural activities. In this case, what must be considered is the cost of production, operation and maintenance which has an impact on the affordability of remote weather monitoring devices. This opportunity, it is necessary to analyze the design of product needs to support the selling value of our tools. From the market needs that we observed, cost issues get the highest rating in the use of remote weather monitoring tools.

To overcome this cost problem, we designed a tool that is more economical than conventional weather monitoring tools that already exist. The price of the tool design is highly dependent on the selection of components used. The selection method of economical components, this has no impact on the workings of the tool created. Although choosing economical components can save costs, it is also necessary to consider the impact on the quality of data generated by weather monitoring tools. Cheaper components may have higher inaccuracies or unreliability, which may affect the validity and usefulness of the data collected. Be sure to select components that meet the required quality standards to avoid additional costs.

1.3.2 Manufacturability Aspect

In the manufacturing aspect, the prototype design of the remote weather monitoring device can be designed using SolidWorks software. In this design, we applied a simple design concept to optimize production costs so that the device can be affordable for many people. In addition, we used components that are widely available in the market to enable sustainable production. In addition to focusing on production cost efficiency, we also adopted emerging technologies that are still relevant in today's world. We avoid using technologies that are near the end-of-life so that the weather monitoring equipment can utilize the latest technology available. By using the latest technology, we can ensure that the weather monitoring equipment has optimal performance and is able to meet the needs of remote weather monitoring and power supply.

1.4 Requirements to be Fulfilled

Based on the analysis conducted, we have identified a set of key requirements that must be met to address the current issues. These requirements will be outlined in two primary phases: a system plan and a general specification plan. These system and specification plans will form a solid foundation to tackle the existing challenges and ensure the successful development of the system in accordance with the identified needs. Furthermore, this process will enable effective project monitoring and control and the management of necessary changes throughout the system development phase.

a. Design a weather monitoring tool that has a remote communication module to transmit data wirelessly with accuracy.
b. The product is capable of transmitting data at a high speed so that information can be sent and received quickly in real-time and responsively.
c. The weather monitoring nodes are equipped with battery or solar cell power supply available in the local market to ensure stable and continuous power availability.
d. The product is equipped with an intuitive and user-friendly user interface.
e. Cyber-Physical System (CPS) designed for weather monitoring monitoring system that can collect, store, and analyze data accurately and accessibly.

1.5 Goal

Considering the necessary requirements, the primary objective of proposing the solution is to provide an efficient and innovative technical solution that aligns with the established needs. The determination of this solution is designed to enhance operational efficiency and deliver substantial benefits to users while ensuring an optimal level of compliance with the prevailing regulatory framework. Achieving these goals will have a positive impact on the planning, implementation, and management of the appropriate solution, while creating significant added value in the context of the relevant economic and manufacturing sector.

a. Designing a Cyber-Physical System (CPS) with long-distance communication for accurate and real-time weather monitoring in Smart Farming.
b. Implementing the Cyber-Physical System (CPS) for long-distance weather monitoring in Smart Farming using components and tools found in the local market.
c. Testing the parameters of the Cyber-Physical System (CPS) for weather monitoring in Smart Farming