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Rainless Day Management using Geographic Information System and Wireless Sensor Networks on Climatology Station Banjarbaru

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Abstract

Information obtained at the Banjarbaru Climatology Station includes seasonal forecasts, rainfall analysis, rainfall properties analysis, rainy day analysis, and monitoring of rainless days in the South Kalimantan region. Monitoring of Rainless Day is a form of data on rainless days that occur in South Kalimantan in sequence. The data is sent by observers to the Banjarbaru Climatology Station office using SMS, WhatsApp, and even by calling the staff of the Banjarbaru Climatology Station so that employees must check every media both SMS, WhatsApp, and telephone to find out the data sent by observers. Related to these problems, a web-based rainless day monitoring application was made. By using the Research and Development (R&D) method to facilitate the management of rainless day data, a geographic information system management system using Google Maps API and MySQL database is built which is integrated with Internet of Things (IoT) technology based on Wireless Sensor Networks (WSN) for data collection in real-time. The system built will provide notifications in the management of areas affected by rainless days in order to deal with drought.

I. INTRODUCTION

The development of the industrial revolution throughout the world changed almost all lines of social life in society and this technological development made humans able to interact anywhere and anytime. The first industrial revolution occurred in 1784 when the first steam engine was invented by an inventor named James Watt [1]. One of the industrial revolution 4.0 is the Internet of Things (IoT) technology [2]. The Internet of Things (IoT) is growing so rapidly in the current era. The Internet of Things (IoT) is a network of physical devices, vehicles, buildings, and other items embedded with electronics, software, sensors, and

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connectivity which enables these objects to connect and exchange data. These connected devices can collect and share data about themselves and their environment, allowing for the automation of various processes and the optimization of decision-making.

IoT devices can include a wide range of devices such as smartphones, smart appliances, industrial equipment, medical devices, and vehicles. These devices can be connected to the internet and to each other and can be controlled remotely or can operate autonomously. The data collected by IoT devices can be analyzed and used to improve efficiency, reduce costs, and enhance the quality of life. The IoT is expected to have a significant impact on various industries, including manufacturing, transportation, healthcare, and energy. It is also expected to have a major impact on consumers, with IoT-enabled devices such as smart home systems and personal assistants becoming more prevalent. The IoT also brings security and privacy concerns. Since the devices are connected to the internet, they can be vulnerable to hacking and other cyber-attacks. In addition, the large amount of personal data collected by IoT devices raises concerns about how that data is used and protected. Overall, the Internet of Things is a rapidly growing field, with the potential to change the way we live and work through the integration of technology into everyday objects, allowing for greater automation and connectivity. Almost all technologies are connected and integrated with the internet, one of which is a smart city for environmental monitoring or what is known as environmental monitoring using a wireless sensor network (WSN)[3], [4]. A wireless sensor network typically operates in the following way:

1. Sensors: The sensor nodes, also called motes, are equipped with one or more sensors that can measure environmental parameters such as temperature, humidity, light, or sound.
2. Data Collection: The sensor nodes collect data from the environment and transmit it wirelessly to the central control unit or to other nodes in the network.
3. Data Processing: The central control unit, or a designated node in the network, processes the data to extract useful information. This can include things like identifying patterns, detecting anomalies, or triggering alarms.
4. Communication: The sensor nodes communicate with each other and with the central control unit using wireless communication protocols such as Zigbee, Z-Wave, or LoRa. This allows the nodes to transmit data over long distances, even if they are not in direct line of sight.
5. Power: Sensor nodes are designed to be low-power devices, typically running on batteries. They use power-saving techniques such as sleeping or adjusting the radio transmission power to conserve energy.
6. Self-organizing: WSN nodes can self-organize themselves in the network, forming a mesh network, where each node can act as a relay for the others, this allows the network to operate even if some nodes fail.
7. Applications: The data collected by the sensor nodes can be used in a variety of applications such as industrial monitoring, environmental monitoring, and healthcare.

Environmental monitoring is a system with integrated using IoT devices to help everyone find out the environmental conditions in an area[5]. This system makes it easy for getting the information from the environmental conditions. The technological development of this industrial revolution also has an impact, namely the phenomenon of global warming [6]. Global warming has presented another issue called climate change. Sometimes these phrases are used interchangeably, but they are different. Climate change refers to changes in weather patterns and seasons around the world [7]. It also refers to sea level rise caused by the expansion of warmer seas and the melting of ice sheets and glaciers.

Global warming causes climate change, which poses serious threats to life on Earth in the form of widespread flooding and extreme weather as well as rains and droughts [8] Global warming refers to the gradual increase in the average temperature of the Earth's atmosphere and oceans, primarily caused by human activities such as the burning of fossil fuels, deforestation, and industrial processes. The primary greenhouse gas responsible for global warming is carbon dioxide, although other gases such as methane, nitrous oxide, and fluorinated gases also contribute. The effects of global warming can be widespread and severe. Some of the most significant impacts include:

1. Rising sea levels: As the Earth's temperature increases, ice and snow melts, causing sea levels to rise. This can lead to coastal flooding and erosion and can also contaminate groundwater and make it difficult for coastal communities to access fresh water.
2. Extreme weather events: Global warming can lead to more frequent and severe heatwaves, droughts, and storms. These events can damage crops, cause wildfires, and lead to power outages.
3. Loss of biodiversity: As temperatures rise, plants and animals are forced to move to new areas to find suitable habitats. Some species may not be able to adapt quickly enough and could become extinct.
4. Damage to human health: Rising temperatures can lead to increased air pollution, which can cause respiratory problems and other health issues. Heatwaves can also lead to heat stroke and other heat-related illnesses.
5. Economic impacts: The effects of global warming can disrupt agriculture, damage infrastructure, and disrupt tourism and other industries, leading to economic losses.

It is important to take action to mitigate the effects of global warming, such as reducing greenhouse gas emissions, protecting, and restoring carbon sinks, and investing in clean energy. International agreements like the Paris Agreement aims to limit the global temperature rise to well below 2°C above pre-industrial levels, and to pursue efforts to limit the increase to 1.5°C.

Many researchers Indonesia especially work on seasonal forecasts to monitor rainfall and dry seasons. the phenomenon of rainless day can lead to drought and can even cause land fires. south Kalimantan, one of the provinces on the island of Kalimantan, which is famous for its forests, is one of the biggest contributors to land fires. this happens because of low rainfall and due to land burning. this if not managed properly will have bad consequences in the future, especially increasing global warming throughout the world, especially in Indonesia in general and south Kalimantan in particular The BMKG data shows the level of rainfall in South Kalimantan in 2022, followed by the BMKG South Kalimantan climate page where rainfall data from July to September still has some areas where rainfall is quite low. If this is not managed properly it can cause problems in the future. We show the BMKG data in figure below:

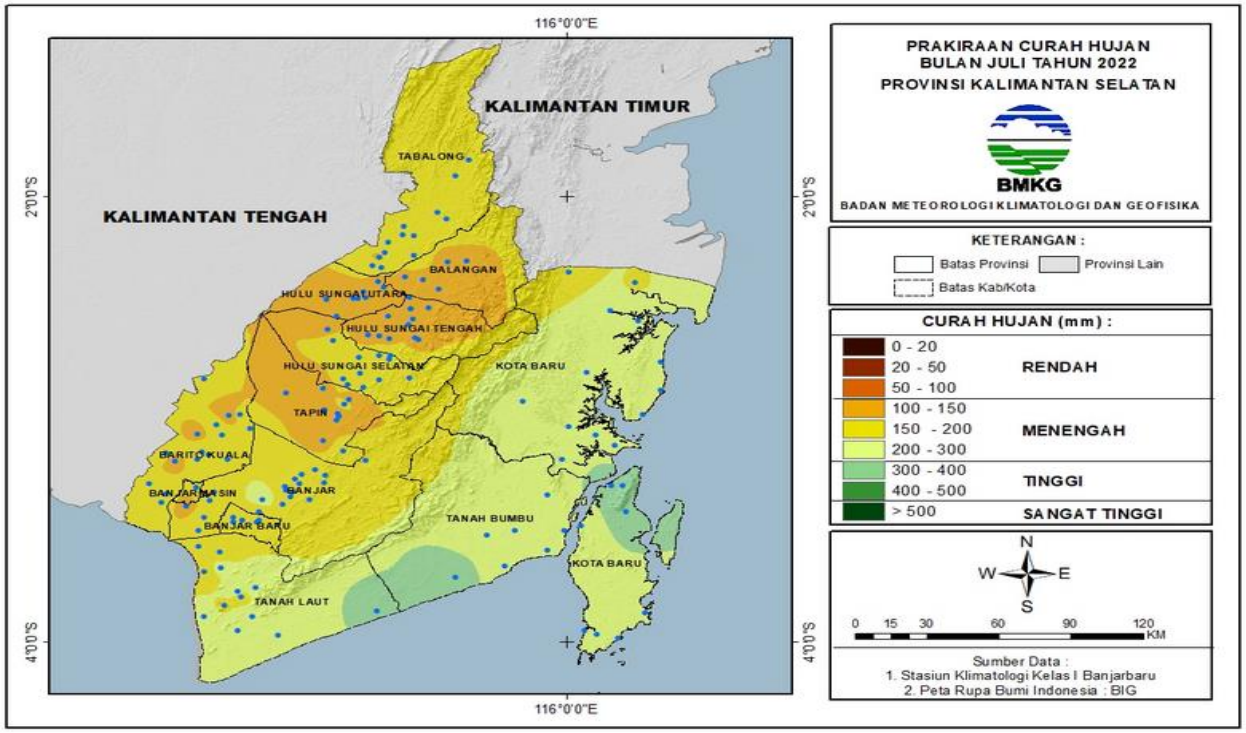

Figure 1. BMKG data forecast

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The Meteorology, Climatology and Geophysics Agency (BMKG) is a non-departmental government agency whose main task is to carry out government tasks in the fields of Meteorology, Climatology, Air Quality and Geophysics. South Kalimantan has three BMKG stations, namely the Syamsudin Noor Banjarbaru Meteorological Station, the Gusti Syamsir Alam Kota Baru Meteorological Station, and the Banjarbaru Climatology Station. One of the tasks performed at the Banjarbaru climatology station is data management of rainfall and rainless day in South Kalimantan. A day without rain refers to a day where there is no precipitation, or in other words, no rain, snow, sleet, or hail. This type of weather is typically associated with clear, sunny skies and dry conditions. A day without rain is typically considered to be pleasant weather, suitable for outdoor activities such as hiking, swimming, and other leisure activities.

In some regions, a day without rain can also be a cause for concern, as it can lead to dry conditions that can increase the risk of wildfires, droughts, and other natural disasters. In these areas, a lack of precipitation can have a significant impact on agriculture, water resources, and the environment. It's worth noting that, the concept of a day without rain may vary depending on the location and the climate. In some places, a day without rain might be rare, while in other places it could be a common occurrence. In summary, a day without rain is a day where there is no precipitation and typically associated with clear, sunny skies and dry conditions. Hence, it can also be a cause for concern in some regions where it can lead to dry conditions that can increase the risk of natural disasters.

Monitoring Rainless day is data on rainless day that occurred in South Kalimantan consecutively. The data is obtained from rain posts throughout the South Kalimantan region. Each post has an observer whose job is to observe rainfall and consecutive rainless day that occur in their respective areas. The data is sent to the Banjarbaru Climatology Station. Observers send observational data still using SMS media, WhatsApp and even by calling to Banjarbaru Climatology Station employees so that employees have to check in every medium both SMS, WhatsApp and telephone to find out the data sent by observers.

Based on this background, the authors designed a web-based "Rainless Day Monitoring Application at the Banjarbaru Climatology Station using Information Geography System integrated with Wireless Sensor Networks technology to collecting the data" so that observers can send data online and Banjarbaru Climatology Station employees can monitor rainless day in every area in South Kalimantan so that they can provide early warning of potential drought in the region.

II. METHODS

Our project for supporting this research, it is necessary to put forward cover the basic theory of management for collecting the data of RAINLESS DAY. In developing this research, we built an RAINLESS DAY data management system based on a monitoring system where the process is to collect data from various sources. we using the data from WSN and observer for obtaining the data and it will be collected the real data to the system [9]. Broadly speaking, the stages in a monitoring system are divided into three major processes, namely: the process of collecting monitoring data, the process of analyzing monitoring data and the process of displaying monitoring data. We use Research and Development (R&D) methods[10]. R&D are research methods used to produce certain products, and test the effectiveness in the products. According [11], Research and Development (R&D) is a research method used to produce certain products, and test the effectiveness of these products. Based on the definition above, it can be explained that the R&D method is a research method used to produce certain products and to perfect a product according to the references and criteria of the product, this method will made new product through various stages and validation or testing. Research and Development (R&D) refers to the process of investigating, experimenting, and creating new products, services, or processes. It is an essential aspect of innovation and is used in various industries such as technology, pharmaceuticals, and manufacturing. R&D is typically divided into two categories: basic research and applied research. Basic research is focused on understanding the fundamental principles of a subject and is often conducted in universities or government-funded institutions. Applied research is focused on developing new products or processes and is typically conducted by companies or organizations. The R&D process typically includes idea generation, research,

design, testing, and implementation.[12], [13]. The researcher conducts research first to collect the amount of data needed, then develops the system and tests and evaluates the system created.

We analyze the current system on rainfall data at the Banjarbaru Climatology Station sent by observers at each rain post in South Kalimantan via various media such as SMS, WhatsApp or telephone to employees at the office. The system that is running still uses manual data that has not been properly systemized and managed. The existing system at the Banjarbaru Climatology Station is currently not documented and managed using a system. All data is collected at predetermined points in an area depending on observations from observers in the field. The data obtained from observers is still manual data where data is entered using the Microsoft Excel program that has been provided. This data is then stored on the computer and is not managed and managed very well. Data that has been input by observers via excel files will then be processed by officers from the Banjarbaru Climatology Station to then be analyzed for data processing from monitoring rainless days in each area. The results of the data will be processed into a data analysis using a geographic information system program which is then used to update the data to the public via a website or bulletin. Our design system and the system currently running at the Banjarbaru Climatology Station are shown Figure 2.

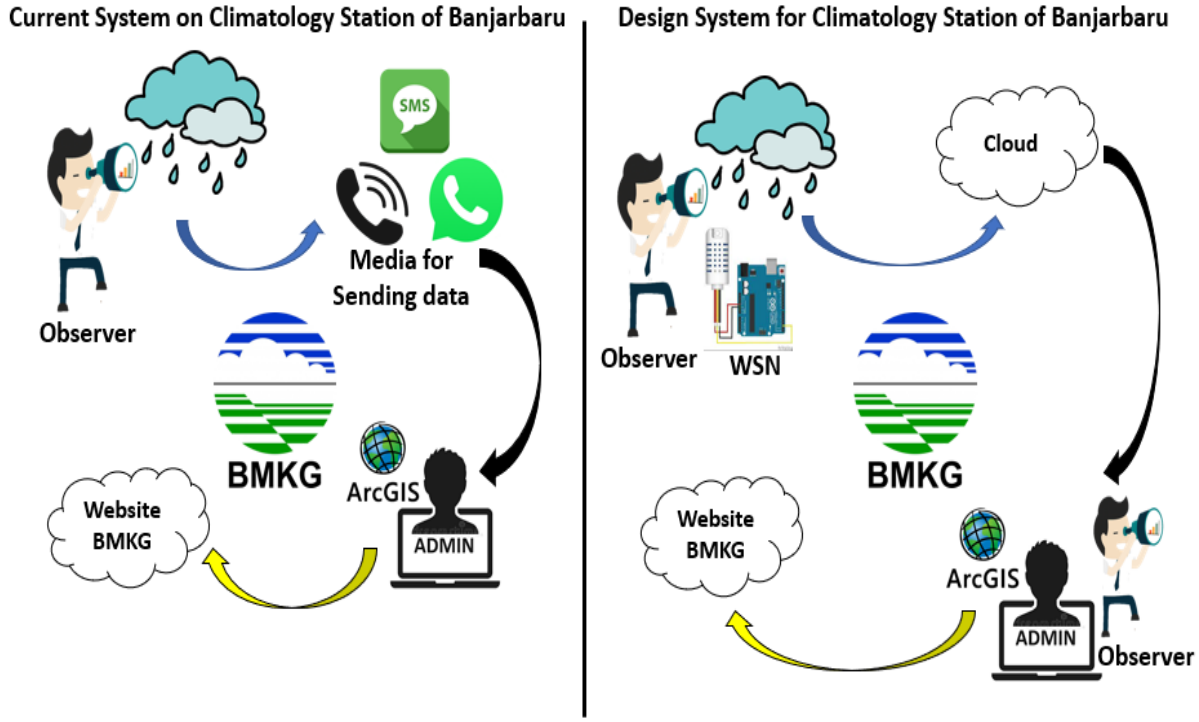

Figure 2. Design System and Current System

From figure 2, We show our designed system using WSN technology. A wireless sensor network (WSN) is a network of small, low-power devices that are equipped with sensors and wireless communication capabilities. These devices can be used to collect and transmit data from the environment, such as temperature, humidity, light, and sound. They can also be used to control devices or systems, such as turning lights on or off, adjusting the temperature of a room, or opening and closing doors. WSNs can be used in a variety of applications, including industrial monitoring, environmental monitoring, and healthcare. They typically consist of a large number of small, inexpensive devices that are deployed in a specific area, and a central control unit that collects and processes the data from the sensors.

observer and microcontroller for data sensing where all collected data will be sent to the cloud. The data collected through the sensor is data from humidity, temperature, soil moisture, and data obtained from the rain sensor. This sensor device is embedded in a device called a microcontroller which will be connected to a Wi-Fi device which will later send the data to the network to be stored on a cloud computer. Officers

and observers from Banjarbaru Climatology Station can access the system anywhere and anytime, because officers can analyze data from observers and sensors with access to the cloud. The analyzed data can be saved to the BMKG website where this data will be processed through a geographic information system-based application where the results of this analysis will be stored on the BMKG website. Rainless day is a condition where rainfall on that day is below one millimeter [14]. Rainless day can be used as an early warning of potential drought due to the absence of rain and is commonly used in the management of water resource systems. Rainless day are often associated with climate change and must also be watched out for forest and land fires because long periods without rain can facilitate forest fires.

Table 1. Category and Criteria of Rainless Day

Category RAINLESS DAY Criteria	**Criteria**
1 – 5	Very Short Day
6 – 10	Short Day
11 – 20	Middle Day
21 – 30	Long Day
31 – 60	Very Long Day
>61	Extreme Drought Day
HH	Rainy day

Rainless day are usually updated daily. Dasarian is a period of 10 (ten) days[16]. In one month divided into 3 (three) bases, namely:

1. Dasarian I: the 1st to the 10th.
2. Dasarian II: the 11th to the 20th.
3. Dasarian III: the 21st to the end of the month.

III. RESULTS AND DISCUSSIONS

In this research, rainless day data management system is proposed by building a website based on sending data and monitoring rainless day based on RAINLESS DAY data sent by observers and a wireless sensor network at each rain post. So that this system is enough for the Banjarbaru Climatology Station office staff to see the data collected by officers through the website of incoming rainfall data from each rain post.

The theory of management for managing a rainy day is often referred to as "contingency planning." It is the process of preparing for and responding to unexpected events or unforeseen circumstances that may affect an organization's operations. The main goal of contingency planning is to minimize the negative effects of these events and to ensure that the organization can continue to function as normally as possible. There are several steps involved in contingency planning:

1. Identifying potential risks and hazards: This includes analyzing the organization's operations and identifying potential risks that could disrupt them.
2. Developing a response plan: This includes outlining the steps that will be taken to respond to the identified risks and hazards.
3. Testing and reviewing the plan: This includes conducting simulated exercises to test the plan's effectiveness and making any necessary revisions.
4. Implementing the plan: This includes putting the plan into action and ensuring that all necessary resources are in place.
5. Monitoring and maintaining the plan: This includes continually monitoring the organization's operations to ensure that the plan is effective and making any necessary revisions.

Contingency planning is an ongoing process that should be reviewed and updated regularly, as the risks and hazards that organizations face may change over time. It is important to have a plan in place to minimize the negative effects of unexpected events such as a rainy day, and to ensure that Banjarbaru Climatology Station can continue its operation as normally as possible. We designed a web-based internet of things system including google maps for the Rainless Day Monitoring Application at the Banjarbaru Climatology Station. Our IoT system using the rain sensor, Soil moisture, temperature, and humidity sensor which can be seen in figure 2.

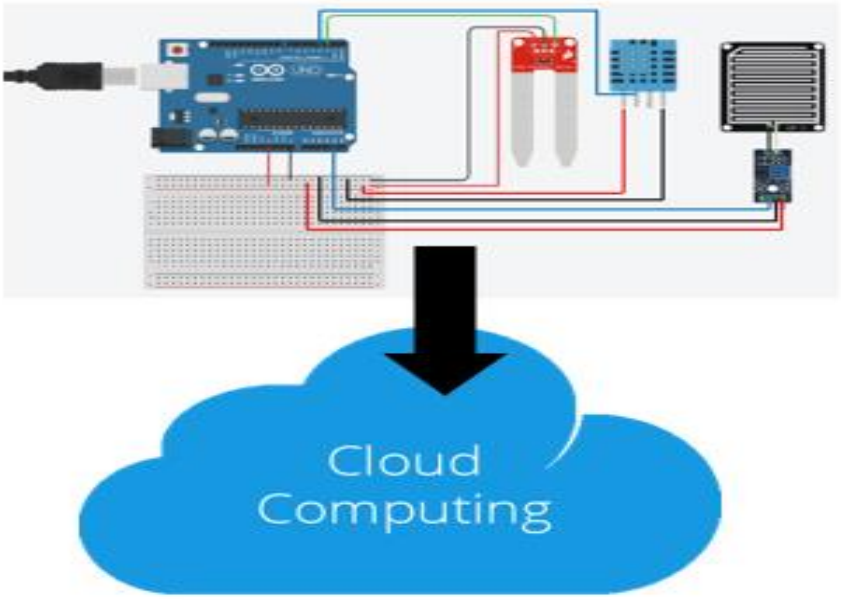

Figure 3. IoT for Sensing Data Rainless Day

From figure2 we are using the device and sensor for collecting the real data from point area RAINLESS DAY. This device put on area RAINLESS DAY for collecting the real-time data for monitoring each area to store in the system. All stored data can be monitored by observer and officer. Stored data from the system can be analyzed by officer in Climatology Station of Banjarbaru using ArcGIS to be stored and broadcasted in every point of Area monitored by WSN technology through the website BMKG. All of specification of the hardware and software in this research can be seen in table below:

Table 2. Specification Hardware and Software

No	Hardware & Software	Specification
1	Microcontroller	Arduino Uno
2	Sensor	• DHT 11 • Soil Moisture • Rain Sensor
3	Wireless Connection	Wifi ESP 8266
4	Server	Dell Vostro Core i3 DDR3 GB
5	Access Point	TP-Link EAP 110
6	Web Server	Xampp 7.4.3

Our application for web-based system in IoT and for Observer has 2 user levels, namely admin and observer. Each user must login to the system to enter the application. Admin can manage user data, district data, sub-district data, rainfall data and RAINLESS DAY data, for observers can only input rainfall data and rainless day data into the system. an observer monitors field conditions at a predetermined point to get data on rainless day where at that point an IoT-based device is also placed which is used to monitor in real-time. Although the data sent also uses an IoT device, the observer still comes at any time to validate the point that has been determined on the measurement of the rainless day data. the results of this monitoring will be inputted by the observer into the system without having to send data through media such as SMS, WhatsApp or telephone. the observer simply inputs data from the results of field observations where this data will be compared to the data sent by the sensor device that has been placed before.

In this system also users from admin or officers and observers can monitor the spread of rainless day in the system. Observer access can save area point observation data to the system for rainless day data. This system allows observers to directly save data into the system without having to send information to officers at the Banjarbaru Climatology Station. at admin officers or officers at the Banjarbaru Climatology Station the use of the system is different from observers in the field because at this level admin officers can perform data processing and analysis where data inputted by observers can later be processed and analyzed using a geographic information system so that the data obtained in this system can be managed properly. system processed and analyzed by admin officers. The system that is processed and analyzed by the admin officer will be sent to the BMKG website to inform the public of the processed data from observations of rainless day made by observers at a predetermined point. this is to reduce the risk of drought and possibly cause land fires. The system for storing the data from observer can see in figure 3.

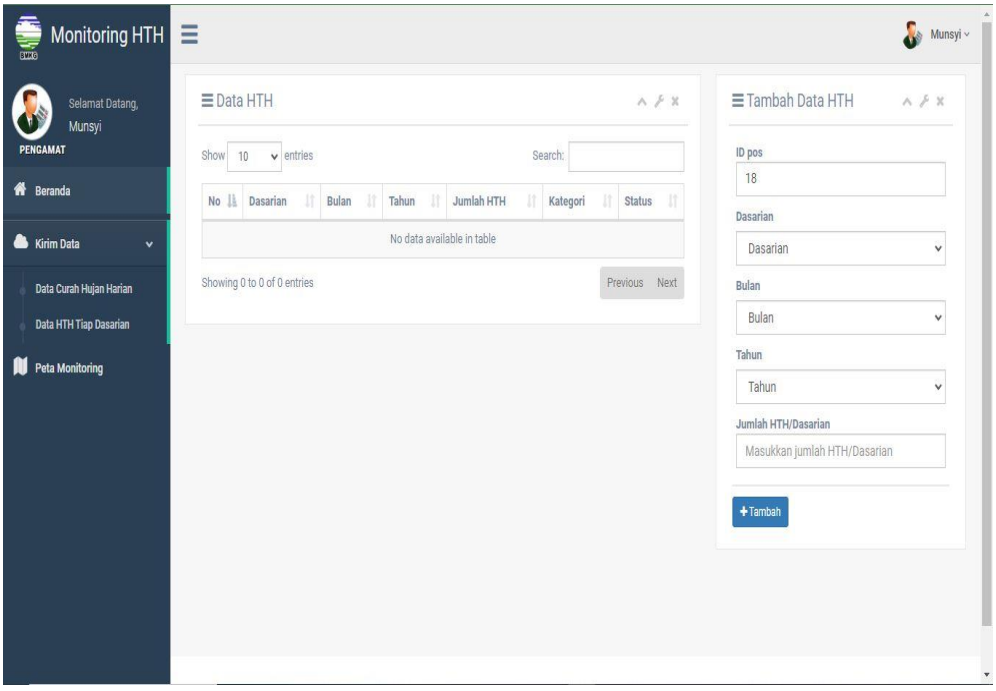

Figure 4. System Interface for stroing the Data

IoT system give the real time data for observer and officer for monitoring the data of point in rainless day area. This system helps for observer and officer to predict and manage drought levels in point areas that have been monitored for RAINLESS DAY in Climatology Station of Banjarbaru. Our system for monitoring the rainless day can be seen in Figure 4.

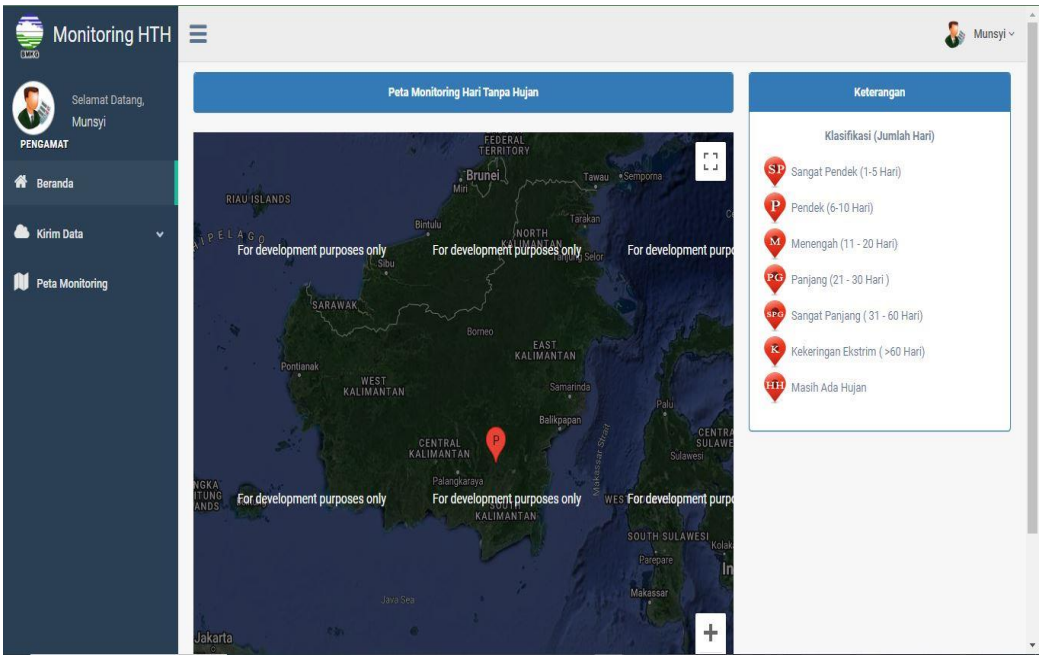

Figure 5. System Monitoring Point of Rainless Day Area

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the report conducted at the Climatology Station of Banjarbaru, it can be concluded that a web-based Application for Monitoring Rainless day using Internet of Things technology based on WSN and mapping using the google maps API used as a media for managing and monitoring Rainless day as well as a media for sending data online both Rainfall data and Rainless day data. This application has two user levels, namely admin and observer. Admin can manage user data, district data, sub-district data and rain post data while observers can add ch data and rainless day data. Admin can also confirm ch data and rainless day data sent by observers. this system will make an observer in Climatology Station of Banjarbaru can manage the data wherever and whenever.

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