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Drone-Assisted Climate Smart Agriculture (DACSA): The design of the groundwork flow data for drone operations

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Abstract

The success of precision farming hinges on effective ground support and workflow. In pursuit of this, we undertook a thorough requirement study of the system necessary for precision farming and developed a precision farming data flow model in ground support. The prototype hardware ground support and conceptual data flow provided valuable guidance in the successful realization of Drone-Assisted Climate Smart Agriculture (DACSA). Using open-source software to accommodate a range of data processing algorithms becomes crucial in operationalizing ground support for precision farming. This study has culminated in a comprehensive prototype model for precision farming operations that can be executed with confidence. The management system of flow data for precision farming has been drawn, this platform is specifically crafted to streamline agriculture operations by transforming diverse inputs into useful spatial data. To maintain the growth of the database, it is necessary to incorporate it in the entire crop cycle. The integration of this database can significantly enhance the precision of predicting plant performance. While this innovative approach is still in progress, it has already demonstrated its potential in supporting informed decision-making. For the next, it is imperative that we prioritize research aimed at creating decision-support algorithms that can effectively gather and blend information pertaining to soil, crops, and weather into actionable maps. These maps must incorporate location-specific data and be utilized by agricultural professionals for on-site decision-making. Moreover, they must be well-suited for drone usage in tasks such as monitoring, mapping, or spraying.

Keywords: Ground Support, Precision Farming, Drone, Flow Data, Climate Smart Agriculture.

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1. Introduction

Ground support in the UAV system is the important thing, UAV can work properly only if only completed by the ground support system. The ground support will control and guide the aircraft as long as the operation is running. They monitor the UAS's sensors and cameras to ensure they are recording the necessary data. Additionally, they guarantee that the information is safely transported and kept [1]

Precision agriculture is a field that has been revolutionized by the use of drones. Drones can be used for crop monitoring, detecting diseases early through crop analysis, field contouring, soil mapping, production mapping, and outlier identification Grammatik field [2,3] . Drones are a crucial part of the operation in the precision farming system. Ground support guides the aircraft and acts as a decision-support system for the UAV based on a decision-making process. The ground support is developed similarly to a station, which serves as a backup for the UAV operation planning. In terms of the military, this ground support is sometimes called a Ground Combat Management System.

Data spatial could be an important thing and special because gives more view regarding the plantation condition. Drone spatial data has better quality than satellite data [4,5]. The use of drones in precision agriculture has led to improvements in crop monitoring, scouting, and control Fields [6]

Decision-making can be made more flexible and well-informed through spatial data analysis. The objective of PA is to provide decision support systems based on multiple parameters of crops, i.e., soil nutrients, the water level of the soil, wind speed, intensity of sunlight, temperature, humidity, chlorophyll content, etc. [7]

In the integration system of precision farming, ground support becomes the center of activity and information, the big design of precision farming can be shown in Fig.1 [8] :

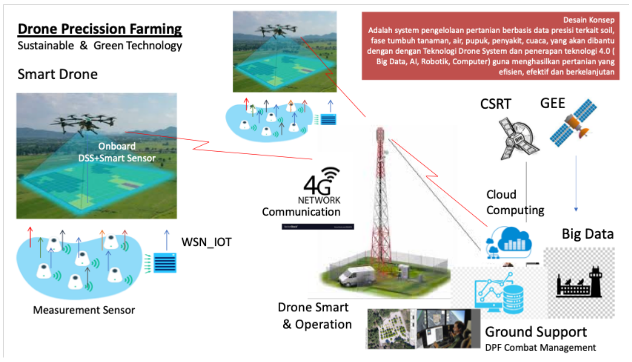


Figure 1. Displays the system integration of precision farming.

Other elements also colored the precision ground support, such as artificial intelligence systems, Applying machine learning using IoT data analytics in the agricultural sector will raise new benefits to increase the quantity and quality of production from the crop fields to meet the increasing food demand. [9]

The concepts of ‘Precision Agriculture’ and ‘Smart Agriculture’ are and will be fully effective when methods and tools are available to practitioners to support this transformation. An open-source software called GeoFIS has been designed with this objective. It was designed to cover the whole process from spatial data to spatial information and decision support [10]. Like in Fig 1, the contribution of communication is important, Information and communication technology (ICT) systems have influenced and shaped every part of modern life, and PA is no exception [11].

This paper shows and studies the requirements and some concepts of groundwork operation for precision farming. This Ground system is intended to run integrated operations in a business model that can be run by agricultural groups, agricultural / plantation industries, or run by agricultural extension workers to provide accessories in certain areas and coordinated by the Ministry of Agriculture.

2. Methods

The research began with seeing the data that would be integrated into the system. It was assumed that the system would be capable of obtaining more than three types of data resources, including data from drones, online sources, and manually collected data. The processor becomes the priority first because this part will become the center of data running and processing. After that hardware design can be started.

The design of a data workflow in the ground support of a precision farming system involves several steps and considerations. While there may be variations depending on specific systems and technologies used, here is a general outline of the workflow

To design ground support for drone precision farming, it is also important to consider the following factors:

1. Sensor: The sensors used in drones for precision agriculture are critical to the success of the operation, the sensors should be able to capture high-quality images and data that can be used for analysis.
2. Data Analysis: the data collected by drones should be analyzed to provide insight into the health of the crops [12,13,14]. The analysis can be used to detect diseases early and take corrective action.
3. Weather conditions: the weather conditions can affect the performance of the drones. Considering the weather conditions when designing ground support for drone precision farming is important.
4. Hardware cost: The cost of hardware used in drone precision farming can be high. It is important to consider the cost of the hardware when designing ground support for precision farming.

In general, the design that will be caried out consider the flowchart design which can be seen as follows [1,15–17] :

Table 1. Step of design

Step	Action	Remark
1	**Data Collection**	This step involves collecting data from different sources, including sensors, drones, satellite imagery, and weather stations. The collected data can provide information on soil conditions, crop health, weather patterns, and more.
2	**Data Processing**	After collecting data, it must be processed and analyzed by cleaning, calculating and extracting insights. Techniques include machine learning, statistics,

		and image processing.
3	**Data Integration**	In this step, relevant data sources such as historical data, crop models, and market information are integrated with processed data. This allows for a comprehensive understanding of the farming system and informed decision-making.
4	**Decision Support**	By utilizing integrated data, decision support systems are able to offer farmers valuable recommendations and insights. These systems aid in optimizing irrigation schedules, fertilizer application, pest management, and other agricultural practices. The ultimate objective is to enhance efficiency, productivity, and sustainability within the farming industry.
5	**Data Management**	For a precision farming system to succeed, proper data management is crucial. This includes structured data storage and organization, as well as protocols for data privacy, security, sharing, and collaboration.
6	**Monitoring and Feedback**	It is necessary to continuously monitor the farming system and use feedback loops to evaluate the effectiveness of implemented strategies, which can then be used to refine and improve the precision farming system over time.

3. Result and Discussion

3.1 Conceptual and Requirement

The main concept of the system is how to install Climate-Smart Agriculture as an all-encompassing paradigm. Some smart agriculture applications are still only partially implemented, resulting in an incomplete and insufficient data management flow.

To use CSA (Climate-Smart Agriculture) effectively, it is important to focus on three types of data: (1) soil data, (2) plant data, and (3) climate data. Soil data can be collected through direct measurements using sensors that measure temperature, humidity, electronic conductivity, and more. This data can be collected manually or automatically through the Lora WAN sensor network on a periodic basis.

The second data is data related to plants, for this the data to be collected is data in the form of images. This data comes from drones that will do periodic aerial photo mapping or data from satellites that can be paid or free (for example by taking from Google Earth Engine)

The third type of data pertains to climate and is derived from numerical recordings collected by weather stations installed in fields or plantations. This data is regularly updated as the weather plays a crucial role in making corrections and providing future detection. Additionally, weather data will be included in the predictions generated by the ground support system.

In the planning stages, three types of data will be inputted to create spatial data. These inputs will be processed simultaneously to complement existing agricultural knowledge related to healthy plant growth. Implementing precision agriculture (PA) in real-world settings faces numerous challenges. Apart from hardware and software readiness, the preparedness of farmers and plantation managers plays a crucial role. Several issues hinder the effective implementation of PA, such as:

Table 2. Several issues implementation of PA

Aspect	Remark	Design implementation
High Cost and Complexity	The advanced technology required for precision farming can be expensive to acquire and maintain. This includes the cost of sensors, drones, GPS systems, and other equipment. Additionally, implementing and managing the complex workflows and data analysis processes can require specialized knowledge and expertise [18]	For this aspect, his approach is done functionally. 1 computer is done to display Big Data specifically, 1 computer is used for processing and 1 computer is used for operations, while to store data is used by servers. In general, the design becomes expensive and quite complex when faced with real users such as farmers
Data Quality and Integration	Precision farming relies heavily on accurate and reliable data. However, ensuring data quality can be challenging due to variations in data	The design has not yet made accommodations for it.

	collection methods, sensor accuracy, and data integration from different sources. Integrating data from various systems and platforms can also be complex, requiring compatibility and standardization [17]	
Data Privacy and Security	Precision farming involves collecting and storing large amounts of sensitive data, including farm operations, crop yields, and financial information. Ensuring data privacy and security is crucial to protect farmers' confidential information from unauthorized access or cyber threats [19]	The design has not yet made accommodations for it
Limited Connectivity and Infrastructure	Precision farming often requires a reliable internet connection and access to advanced infrastructure, such as high-speed networks and cloud computing. However, in rural areas, where farming is prevalent, there may be limited connectivity and inadequate infrastructure, which can hinder the implementation of precision farming workflows ; https://dataloop.ai/blog/precision-agriculture-challenges/	When developing a monitoring system, there are two techniques that can be employed: designing for a mobile station or a fixed station. Our study places greater emphasis on utilizing a stationary station approach. This involves using the station to monitor nearby areas that warrant attention, with an operational assessment to follow.
Farmer Adoption and Training	Encouraging farmers to adopt and embrace precision farming practices can be a challenge. It may require education and training to help farmers understand the benefits and overcome any resistance or scepticism towards new technologies and workflows. Providing ongoing support and assistance to farmers in using and interpreting the data can also be crucial for successful implementation [15] [20]	This design is intended for Engineers, not farmers, who are intended to operate this design. Farmers are positioned as users of this system who will conduct evaluations as part of the idea used in the adoption of technology. or at least be aware of where the farm is that has to be noticed. In order for the entire ground system to be institutionally operated, whether it falls under a ministry, local government, or division of agricultural corporations.
Regulatory and Policy Considerations	Precision farming may be subject to regulations and policies related to data privacy, land use, environmental impact, and more. Compliance with these regulations and navigating the legal landscape can pose challenges for farmers and organizations implementing precision farming workflows [15]	The design has not yet made accommodations for it

Collaboration	Farmers can collaborate with other farmers, researchers, and industry experts to share knowledge and best practices. By working together, farmers can learn from each other's experiences and overcome common challenges associated with implementing precision agriculture technology [19]	Collaboration is necessary for implementation, particularly among individuals who will manage ground support. This can be achieved with academic institutions or with researchers from governmental or educational bodies. The primary goal of this collaboration is to communicate the results to farmers so that they can take quick, meaningful action in response to the outcomes seen in the level of support on the ground.

The design addresses challenges related to the implementation of precision farming technology, although there are still outstanding issues such as data quality, accuracy, and regulatory compliance.

3.2 Hardware Implementation

In its implementation, there are three important parts of the ground segment: the monitoring system, the server system and the drone system equipment including the support automation system.

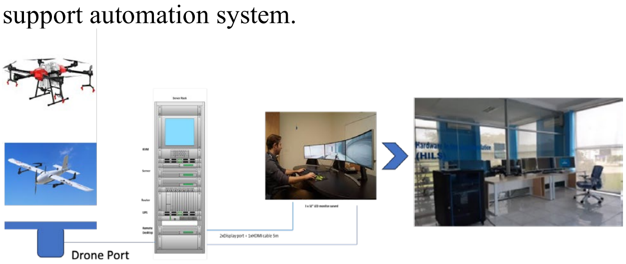


Figure 2. Hardware System and Ground Support Prototype at Aeronautic Research Center BRIN

The current drone system will be linked to a server that will store aerial photo captures using a drone port system that will enable automatic access to data downloading. This port system will also make it simpler to send preprogramming access for automatic flight operations as a result of the decision support system. The result of the decision-support process depends on a variety of variables, such as the identification of production irregularities, droughts, health issues, etc. Even so, the user has the option to operate the drone manually.

There are two drones connected to drone ports that enable automatic data transfer. The drone can then perform monitoring and technical tasks, such as spraying. The drone used is a VTOL designed for data collection, with separate drones for medium-range spraying, each with unique specifications.

Table 3. Drone Specification

VTOL Specification	Sprayer Drone 15 lt
• Wingspan 2430 mm • Fuselage length 1450 mm • Fuselage height 180 mm • 1x Cruise 5015 kv210 Disc Motor • 1x 12s 60A ESC • 4x VTOL5015 kv170 Disc Motor • 4x 12S 40A Brushless ESC • 1x Wire Package • 2x VTOL Propeller CW&CCW 2070 • 1x Cruise Propeller APC2013 • 1x 12S 10A 5V BEC • 5x Fixed-wing Servo 3054 • Coverage up to 1000 Ha • It is preferable to have the ability to load a multispectral camera, RGB camera, or Lidar, if possible.	• Tank Capacity : 10 liters • Number of Rotors : 4 • Body : Design Foldable • Total Drone Weight without payload : 12 Kg • Total Drone weight with Payload : 24.5 kg • Transmission Frequency : 2.4 GHz • Transmission Distance : 10 km • GPS System : Yes

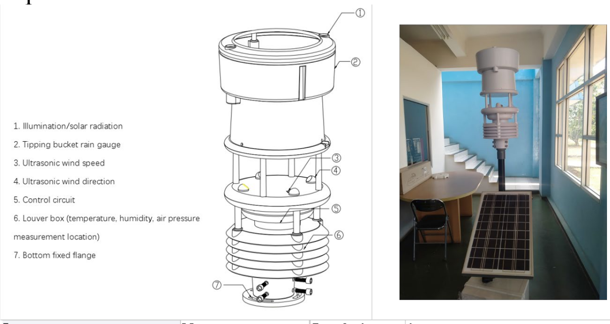
The ground database is made up of a server, router, KVM switch, UPS, and remote desktop united in a single server rack. The system features three-layer monitors that display drone data, drone missions, and data from wireless sensor networks in the field. The documentation below displays the outcomes of integrating the ground data base.:

Table 4. Server Specification

Processor	Xeon E-2226G
Memory	16 GB
Hard disk capacity	4TB + 1.2TB
Operating System	Ubuntu

Database dan Application	LoRaWAN
Display	3x LED Monitor 31.5" Curved
KVM	KVM console with 17inchi LCD
UPS	APC UPS SMC1500I-2UC
Router	Mikrotik CRS326-24G-2S+RM

Other hardware that supports is a weather system that will get local weather data around the station, this station is able to capture up to a radius of 2 km. The drawings and specifications are as follows :



Parameters	Measure range	Resolution	Accuracy
Wind speed	0-60m/s	0.01m/s	(0-30m/s) ±0.3m/s or ±3% (30-60m/s) ±5%
Wind direction	0-360°	0.1°	±2°
Air temperature	-40-60°C	0.01°C	±0.3°C (25°C)
Air relative humidity	0-100%RH	0.01%	±3%RH
Atmospheric pressure	300-1100hpa	0.1hpa	±0.5hpa (0-30°C)
Solar Radiation	0-2000W/M2	1W	±3%
Rainfall	0-200mm/h	0.2mm	±0.4mm(≤10mm),±4%(>10mm)

Figure 3. Weather Station and Parameter range measurement

3.3 Flow Work Systems

Regulating the flow of data is crucial in the design of ground support systems as it controls input, processing, and output. The following figure depicts the initial design of the input image that will be processed by the system [8]:

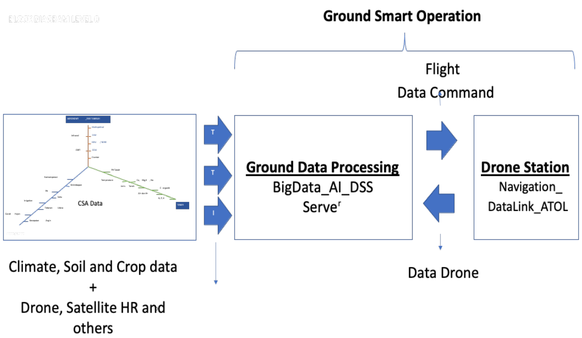


Figure 4. Flow Data Ground Support System

The key data for analysis encompasses soil, plants, and climate, as depicted in Figure 3. Additionally, spatial data collected from drones and satellites is accessible at no cost. The database will analyze this information as spatial data, offering up-to-date insights for monitoring, identification, and decision-making. The particular data inputs to be processed are as follows:

Table 5. Data inputs to be processed

Soil Data	Plant Data	Climate Data
Ph Tanah	Drone Data Multispectral	Rainfall
Nitrogen	Drone Data RGB	Mouisture
Phospor	Sentinel 2 Satelit	Temperature
Kalium	Pleiades Satelit	Irigation Parameter
Electronic Conductivity	GEE Source	
Magnesium		

Basically, the data used in precision agriculture is quite complicated and dynamic. For instance, soil conditions are highly reliant on weather dynamics and soil contour conditions, and each soil component will react differently to changes in the weather before being combined with a particular plant. The decision support method changes substantially depending on what information you want to examine and prioritize because these data have a strong interdependence. The development process is carried out in stages as a result.

In general, the data processing flow can be seen in figure 4, below:

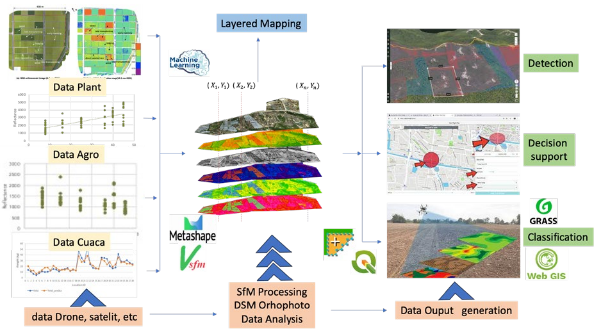


Figure 5. Flow Data Design

First, it is crucial to note that Fig.4, which serves as a flow of the data for the foundational database, is derived from soil data. To ensure their accuracy and calibration, these soil data undergo meticulous laboratory testing. It should be emphasized that initially, we monitored changes in ground data using the Internet of Things (Lora WAN) network. Although WSN will be used for data calibration, this data must first be calibrated with laboratory data in order to be used as the foundation for design. Using this method, spatial soil data will be gathered.

By merging satellite data of both high and medium resolutions, valuable information about plants can be collected. Drones, on the other hand, can cover a much larger area and provide highly detailed and precise data that is particularly useful in Indonesia's cloudy conditions. Their versatility and capability to carry various camera types, including multispectral, hyperspectral, and lidar, make them an invaluable tool in precision farming systems.

For agricultural land up to 1000 - 5000 ha, the use of drones can be more effective than using data from satellites. In addition to more flexible temporal resolution, the spatial resolution of drones is much better at a relatively low cost than satellite data.

The third set of data pertains to weather. For instance, temperature and precipitation variability can impact both the quantity and quality of a crop [21]. Weather data can be additional information especially related to the impact of weather on plants and soil, rule decisions can be made and made more accurate, especially for plants that pass through the season. Weather data can be collected in real-time from diverse sources and tools, such as on-site IoT sensors and robots, drones, and satellite imagery, and combined into a data platform to provide a decision support system that supports farmers and managers in managing and optimizing agriculture-related processes [22] .The decision support system precisely calculates the water required for the irrigation of crops under different climatic. Conditions [23]_Making decisions can be done with different data and combinations by evaluating, contrasting, constructing, or synthesizing these different data. The system is designed to provide a variety of spatial data and to enable processing by very sophisticated artificial intelligence or machine learning systems while retaining the knowledge of agricultural professionals.

Through spatial data analysis, our system can expertly detect, classify, and offer decision-making support. The system's prowess lies in its intelligent data processing, enabling it to draw precise and informed conclusions. Furthermore, basing decisions on this data can lead to optimal outcomes. The precision of the data processing system hinges greatly on the frequency of incoming data being corrected. The more frequently the data is updated, the greater the level of accuracy that can be attained. Drones are increasingly being recognized for their dependable multi-temporal data provision in this regard.

Utilizing Open Source Geospatial Software (OS Geo) can greatly enhance the data processing process outlined in Figure 5. This software boasts an impressive array of well-established programs, such as Quantum GIS (qGIS), Visual SFM, Agisoft Metadata, WebGIS, PostGIS, and GRASS. We aim to leverage this valuable open-source software further as needed. Open Source (OS) software refers to applications that allow users to access, modify, and implement their source code. The popularity of open-source geospatial software continues to grow, with predictions of increased usage and services in the future. [13]

Given the current situation, drones and autonomous systems will play an increasingly important role in data mining. Drones can perform a variety of tasks, including collecting image data, verifying data, and performing technical operations in agriculture. This will lead to the implementing the Drone-Assisted Climate Smart Agriculture (DACSA) system, which is a positive development for both the drone and agricultural industries.

4. Conclusion

The management system of flow data for precision farming has been drawn, this platform is specifically crafted to streamline agriculture operations by transforming diverse inputs into useful spatial data. To maintain the growth of the database, it is necessary to incorporate it in the entire crop cycle. The integration of this database can significantly enhance the precision of predicting plant performance. While this innovative approach is still in progress, it has already demonstrated its potential in supporting informed decision-making.

For the next, it is imperative that we prioritize research aimed at creating decision-support algorithms that can effectively gather and blend information pertaining to soil, crops, and weather into actionable maps. These maps must incorporate location-specific data and be utilized by agricultural professionals for on-site decision-making. Moreover, they must be well-suited for drone usage in tasks such as monitoring, mapping, or spraying.

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