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IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE AND BLOCKCHAIN IN AGRICULTURAL SUPPLY CHAIN MANAGEMENT

Yandra Arkeman[1], Nizmah J Hidayah[2], Aries Suharso[3], Faza Adhzima[3] and Try Kusuma[3]
[1]Department of Agricultural Industrial Technology, Faculty of Agricultural Technology,
IPB University, Bogor Indonesia
[2]Doctoral Student, Agro-Industrial Engineering Study Program, Postgraduate School,
IPB University, Bogor, Indonesia
[3]Doctoral Student, Department of Computer Science, IPB University, Bogor, Indonesia
Correspomding author: yandra@apps.ipb.ac.id,aniznizmah@apps.ipb.ac.id

ABSTRACT

Today's agricultural sector cannot avoid the need for advanced digital technology, such as robots, artificial intelligence, and the Internet of Things to deal with various agricultural problems that can disrupt national stability. Agro-industrial supply chain management ensures that agricultural products reach consumers in quantity, quality, and safety required. The supply chain includes from farm to consumer, to table, from farmer to processing producer, and distribution to the consumer, as well as other long chains that cover from upstream to downstream. Some of the problems that need to find solutions include a lack of information on raw materials needed in processing, transparency of product sources, information on production processes, information on logistics distribution to consumers, and lack of traceability and traceability (products, quality, documents, costs, halal status, and value chain). Digital transformation along the supply chain must be carried out immediately through: (1) implementation and improvement of traceability systems using blockchain technology, and (2) blockchain integration with smart and rapid tests or Internet of Things (IoT) using Artificial Intelligence (AI) to enhance blockchain intelligence. Smart and rapid tests are needed to detect and identify the substance levels of a product, while the IoT architecture applied along the supply chain connects various supply chain actors to share data. Machine learning and cloud computing are used for data processing and communication networks for information transfer. Blockchain and AI-based digital systems allow consumers to track transaction history and product status in just a few seconds. Blockchain integration with AI will bring about a more reliable system called a smart blockchain.

Key words: agricultural supply chain management, artificial intelligence, blockchain.

INTRODUCTION

The development of human civilization in the 21st century is marked by the Industrial Revolution 4.0 where there has been rapid progress in digital technology in various fields, combining automation technology with cyber technology "cyber-physical system". Innovations such as internet-connected robots, AI (Artificial Intelligence), cloud computing, microchips, machine learning, deep learning, cloud analytics, blockchain, nanotechnology, quantum computers, biotechnology, 3D printing, and autonomous vehicles.

The Industrial Revolution 4.0 not only has tremendous potential in overhauling the industry but also changing various aspects of human life. The concept of the industrial revolution 4.0 brings together physical industrial resources with the development of digital technology. In the agricultural sector, which is the main sector providing food for the lives of many people, digital transformation is a necessity in overcoming upstream and downstream challenges. In agricultural management, combining digital technology with potential local wisdom resources will renovate the agro-industry to become an efficient upstream-to-downstream production value chain business model. The successful impact of agricultural development with advanced technology 4.0 has an impact on increasing income and availability of staple food for the community.

In precision agriculture, the use of the right resources and the application of digitalization technology to agricultural production systems is an important part of agricultural development in Indonesia. The application of Artificial intelligence (AI) and blockchain technology in the agricultural industry helps address the availability of world food needs with innovative and efficient production systems. Blockchain technology combined with AI enables tracking, information tracking, and transparency in the food supply chain so that data can be tracked in real-time.

Artificial Intelligence and Blockchain: State of the Art

A. *Artificial intelligence (AI)*

*Artificial intelligence (AI)*is the part of computer science concerned with the design of computer systems that mimic human intelligence. The system takes input data, processes it, and produces an output which that can perform many complex tasks even more difficult for humans with very large data capacities.AI itself is the forerunner of today's intelligent machine development by imitating human abilities. Including machine learning and deep learning which are sub-fields of AI. The following are types of artificial intelligence:

- Adaptive learning and systems
  The ability to adapt behavior and develop general rules based on experience (Adamu and Awwalu 2019).
- computer vision
  The ability to analyze perceived scenes by relating them to internal models that represent "knowledge of the world" (Karn 2021).
- Robots and sensors
  A combination of most or all of the above abilities with the ability to move over terrain and manipulate objects (Chen et al. 2021).
- Understanding language
  The ability to "understand" and respond to natural language (Mah et al. 2022).
- Problem-solving/expert system
  The ability to formulate problems in appropriate representations, plan solutions, and know when and how to get new information (Rao 1999).
- *Speech recognition*
  Users can communicate with the computer using voice. An example is the voice search feature provided by Google (Smadi et al. 2015).

The benefits of AI include automated decision-making, recurring tasks, and reducing human errors. AI fuels the development of technologies like big data, the internet of things (IoT), and robotics, AI Tools *Neural Networks, Fuzzy Logic, Expert Systems, Genetic Algorithms, Cellular Automata,* and others

B. *Cloud Computing, Big data, and Machine learning.*

Cloud computing is a combination of the use of computer technology in data storage and management, and internet-based (cloud) development, where users are given access rights (login) to use the cloud. Big data or data with large volumes in real-time provides information that can increase the productivity and efficiency of using the data (Behari et al. 2016; El-Seoud et al. 2017).

Machine Learning is a scientific field regarding computer algorithms that are used to automatically improve the performance of computer programs based on data. The way it works is to collect, process, and compare data (from small to large) to look for patterns and analyze the differences. Data processing with data ingestion, data mining, data mapping, and data science.

In the agricultural sector, AI, cloud computing and big data, and machine learning are used predictive properties of algorithms for smart farming. Wind speed prediction is needed to increase the amount of energy generated. Power demand and price forecasting accuracy are considered as one the most important research problems in electrical engineering today and in the future. The predictive nature of various algorithms makes them the best instrument for meeting energy and power engineering challenges (Arumugam et al. 2022). The data can be used and drawn as predictions about rainfall patterns, water cycles, and fertilizer requirements and is used by farmers to make smarter decisions, such as what crops to plant for better profits and when to harvest. This ultimately increases the volume of agricultural output and financial returns.

C. Blockchains

Blockchains can be interpreted as a distributed ledger that tracks every activity in the blockchain from the transactions of every entity involved. The application of blockchain technology can provide benefits for all supply chain actors, from small producers, processors, and distributors to consumers(Zheng et al. 2017; Usman et al. 2021). Blockchain technology helps improve supply chain efficiency by providing a tracking system for all events that occur in the supply chain and product quality. The principles used by blockchain are:

1. Blockchain is a peer-to-peer data storage technology in the form of a distributed system.
2. Every peer or authority who has a real identity can make transactions and verify the information directly with other parties, without going through a third party.
3. *Blockchains* has a consensus data verification system and a named transaction record security system *cryptography*
4. *Blockchains* that we use in Indonesia can be connected to blockchain networks in other countries.

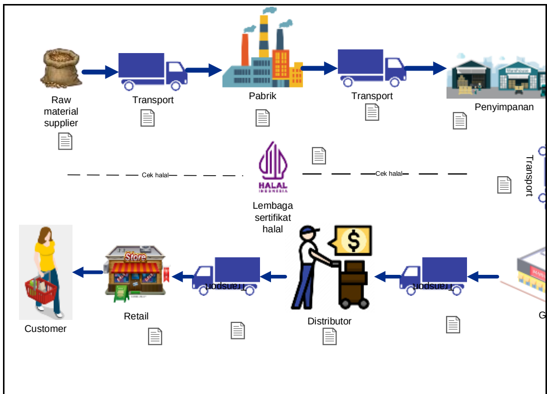

Fig. 1. Conventional supply chain business model

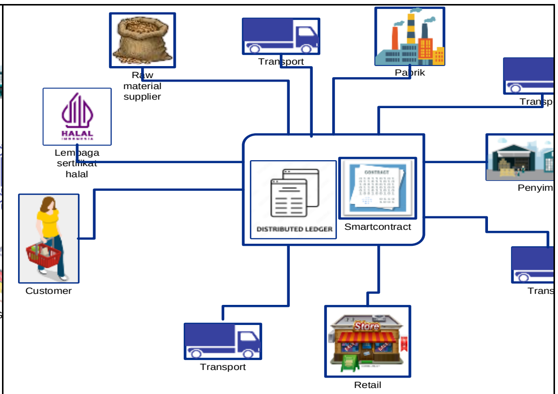

Fig. 2. Blockchain business model

Differences between conventional supply chain business models and blockchain business models:

Conventional supply chain management business model

- The length of the value chain in marketing (Gosier, distributor, and retail)
- Value chain information from procurement to consumers is not well documented because the system is still centralized
- a centralized system will be vulnerable to falsification of information on every activity in the value chain
- The mix between halal and non-halal materials, and equipment is very large and cannot/difficult to trace
- Halal traceability will be difficult because of the falsification, which results in delays in the halal audit process

Blockchain supply chain business model

- *Blockchains* making the system integrated so that the value chain in marketing can be shorter, namely only located at the retailer
- Value chain information from procurement to consumers using a distributed system
- Where the information is Trusted, Transparent, and Traceable (3T), it helps make it easier for auditors to track product halalness in all activities in the value chain.

Blockchain reliability has 3T characteristics(Iansiti and Lakhani 2017), that is :

- All transaction records (records or BLOCK) before being stored must be validated by all members (peers) visible to all entities involved (Transparent)
- The current record is linked to the previous record and the next record (such as a chain or CHAIN) and is locked with a highly secure cryptographic system (such as a password) so that the record is irreversible. (trusted)
- Because they are well structured (block & chain), transaction records are easy to trace both backward and forwards (tracing, tracking, and traceable)

METHODOLOGY

System design. The general method used in research systems consists of several stages, namely problem-solving, architectural design, program implementation, and evaluation (Fig. 3).

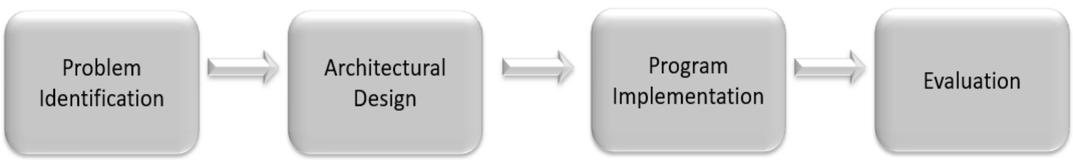

Fig. 3. The general method of system design development

Developing a system design begins with identifying backgrounds and problems, Requirement analysis provided comprehensive information to develop a system design of AI and blockchain. the stages of system design development are problem identification, architectural design, program implementation, and evaluation. (Fig. 4).

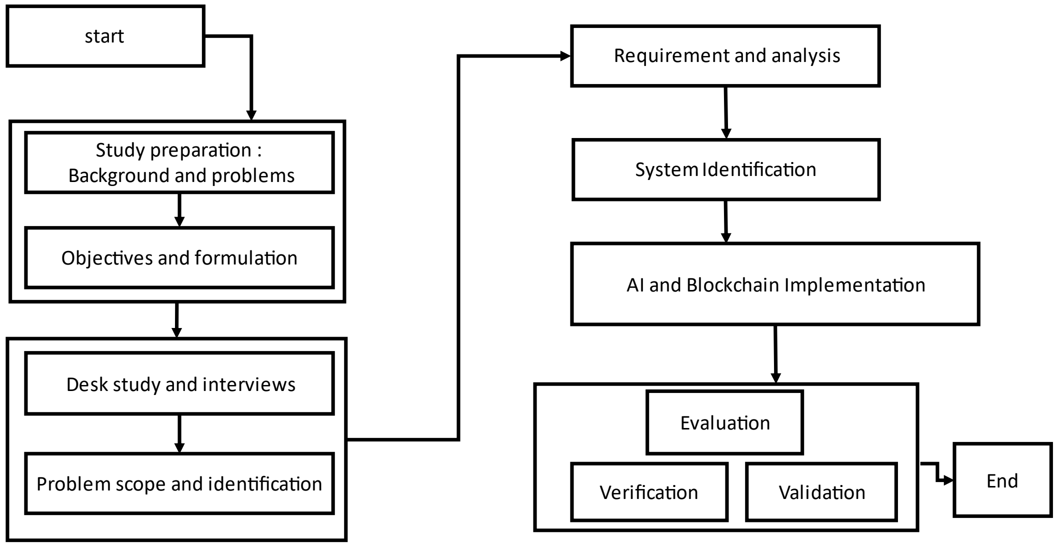

Fig. 4. System design implementation flowchart

Artificial intelligence focuses on image, text and voice-based applications, leading to the groundbreaking development of self-driving cars, speech recognition algorithms and recommendation systems. alternative graphic-based machine learning systems that deal with three-dimensional spaces, which are more structured and combinatorial than images, text, or sound. In particular, function-based learning to produce conceptual designs. use of neural networks to evaluate existing designs encoded as graphs, extract significant building blocks as subgraphs, and combine them into new compositions. exploring the application of generative adversarial networks to come up with completely new and unique designs (As et al. 2018).

Designed the system architecture into two main components, i.e., hardware and service. The hardware-oriented design included IoT devices, servers, and smartphones. In contrast, the service-oriented design included client, system management, and cloud services (Surasak et al. 2019). Blockchain system development needs to be preceded by a system requirements analysis to determine the components needed in the blockchain system. Requirements analysis also helps with the coding process. Two Unified Modeling Languages (UML) diagrams, namely use case diagrams and sequence diagrams, are used to analyze system requirements. The results of their study show that the blockchain system requires two inputs, namely (1) the structure of the supply chain and the activities that occur within it, and (2) four stakeholders (farmers, collectors, agro-industry, and exporters) (Iswari et al. 2019).

Implementation of artificial intelligence (Ai) and blockchain in agricultural supply chain management

The concept of agriculture in the future will not only increase agricultural production (push strategy) to be sent to the market (domestic and export) regardless of whether the market needs these commodities or not, but must be built with a pull strategy. Agro-industry must be established a lot to boost the agricultural sector. With this approach, agricultural products will be accommodated by the industry to be used as materials with higher added value required by the market. The problem of overproduction of agricultural commodities will never occur because regardless of the amount of these agricultural commodities, the industry will absorb them at reasonable prices and farmers will be more prosperous (Arkeman 2021). The strategic role of agro-industry is to connect the agricultural sector on the upstream side, and the industrial sector on the downstream side. To accelerate upstream and downstream connectivity, agricultural digitization is the right step so that farmers and producers, and industry can expand market share both domestically and abroad. Digital technology can increase farmers' technical knowledge, enabling more efficient calculations of the use of fertilizers, seeds, or other agricultural inputs; and improve farmer decision-making through information on weather, crop management, market conditions, or livestock data (World Bank Group 2020).

Currently, the world's population reaches 7.9 billion and the World Bank estimates this number will continue to grow to reach 9.7 billion in 2050 and 11.2 billion in 2100. Requires an increase in agricultural and food production by 70% to meet the needs, so the intervention of computational tools and forecasting strategies of artificial intelligence and machine learning as the integration of a predictive multidisciplinary approach to improve the food and agriculture sector (Ben Ayed and Hanana 2021).

To catch up with demand, consumer needs must be met with safe supply, advanced digital technology is part of the agro-industrial system by transforming raw materials into agricultural products that are ready to be used and have added value, both from an economic aspect, social and environmental.AI is applied to increase productivity and efficiency, as well as to address labor shortages and environmental sustainability concerns (Lakshmi and Corbett 2020). The problems in the supply chain are the long flow of supply chain information, lack of transparency, less extensive marketing reach, and documentation activities that are not good enough so blockchain-based digitization using the System Development Life Cycle (SDLC) method and the Unified Modeling Language results in a more systematic, documented and effective flow of supply chain information (Iswari et al. 2020).

AI influences production process factors, information sharing, and supply chain integration (Supply Chain Integrity), and AI positively influences Supply Chain Risk Management, which can mitigate supply chain risks by increasing visibility, risk, sourcing, and distribution capabilities. five critical areas of AI usage; (i) transparency, (ii) ensuring, last-mile delivery, (iii) offering solutions to upstream and downstream supply chain stakeholders, (iv) minimizing the impact of disruptions, and (v) facilitating dynamic procurement strategies (Modgil et al. 2021). The concept of AI is used to observe the quality of food and agricultural products with techniques that are fast and do not spoil the product. The expert system approach, artificial neural network (artificial neural network), and fuzzy logic (AI consisting of an expert system, artificial neural network (ANN), and fuzzy logic) determine the quality of food to produce high and optimal results, the best modeling and effective in accurate time monitoring technique (real-time) (Mohd Ali et al. 2021).

The development of smart technology in the potato agro-industry sector shows the success of optimal and adaptive system design, the use of the Internet of Things (IoT) in remote sensing is carried out to predict the amount of crop production and production capacity (Yusianto *et al.* 2020).

Artificial neural networks using the Hadoop framework predict efficient agricultural yields using metaheuristics, exploring ANN models with multi-temporal satellite data systems in areas that have the potential to produce corn and soybeans.(Saranya and Nagarajan 2020). An example of the convergence of precision agriculture is where farmers respond in real time to changes in plant growth with nanotechnology and artificial intelligence (AI) controlling the nutrient cycle and crop productivity (Zhang et al. 2021).

The advantages of blockchain can identify existing stakeholders in the supply chain in each ecosystem from upstream to downstream so that it can transform an inflexible and uncertain supply chain system into an efficient performance supply chain with transparency and trust between stakeholders so that integration, collaboration, and accuracy of accurate data information (Ekawati et al. 2021).

A new method was developed using an internal camera on a camera-based smart device for estimating lycopene content and grading tomatoes by classifying color values. This method detects quickly and does not harm the fruit. Traditional methods for determining the lycopene content in tomatoes usually rely on destructive sampling followed by chemical analysis, which is not only expensive but also time-consuming (Ye et al. 2018).

Growing applications of precision agriculture include driverless tractors for tillage, drones for the monitoring of fields and plantations, and even a combination of bioinformatics and genetic algorithms for searching for superior seeds. The harvest and post-harvest processes are automated using fast and non-destructive quality testing methods. The agricultural product collection system can determine the shortest vehicle route with ant colony optimization techniques. Blockchain and big data technologies increase the transparency of goods and monetary flows along the value chain of agricultural products(Arkeman 2021).

Robotics and artificial intelligence technology, an intelligent packaging system, an adaptive inventory system with a non-linear model for perishable agro-industrial products, an intelligent vision system for product sorting, non-destructive quality testing for final product quality assessment, intelligent bioreactors, intelligent agro-logistics systems using blockchain technology and agent-based modeling techniques to study changing consumer preferences and many others(Arkeman 2021).

Image-based meat purity detection methods that can be operated on Android device, so the proposed computationally method is Convolutional Neural Network (CNN). The method can do the learning process independently with object extraction and classification. While the other capabilities that can handle image deformation such as rotation and scale. Molecular Technology can be used as an accurate alternative solution to authenticate/ensure DNA content. Molecular technology with a rapid test method for identifying contaminants in meat and processed food is the Polymerase Chain Reaction (PCR) technique. Both conventional PCR, Multiplex PCR, and the latest is Real Time PCR. This technique is an analytical technique used to detect DNA in one type of living thing and is less precise when used to detect commercial food products consisting of a mixture of several types of meat (Yulianti et al. 2021; Purwantoro et al. 2022).

Digital transformation along the supply chain must be carried out immediately through: (1) implementation and improvement of traceability systems using blockchain technology, and (2) integration of blockchain with smart and rapid tests or Internet of Things (IoT) using Artificial Intelligence (AI) to increase intelligence blockchains. Smart and rapid tests are needed to detect and identify the substance levels of a product, while the IoT architecture applied along the supply chain connects various supply chain actors to share data. Machine learning and cloud computing are used for data processing and communication networks for information transfer (Dwivedi et al. 2021).

Case Study AI And Conceptual Design with Blockchain

Clustering types of diseases of rice plants based on leaf image, results of clustering types of diseases of rice plants are optimized using fuzzy c-means (FCM) and genetic algorithm (GA).

Occasionally, rice plant diseases can threaten growth and even cause crop failure. The damage to leaves can be identified and identified by the application of clustering image processing techniques to identify the types of diseases present in rice leaves. Machine learning for identifying rice diseases is the fuzzy C-means (FCM) approach. The advantage of the FCM method is that it can reach convergent cluster centers and has an unsupervised nature. The disadvantage of this method is that local optima occur frequently and are sensitive to the initial cluster centers, so changing the initial clusters can strongly affect the results (Chaghari et al. 2018).

Many researchers have proposed and implemented optimization algorithms to address the shortcomings of this method. One of the proposed optimization algorithms is the Genetic Algorithm (GA). GA method can be used as an alternative method that can be applied to the optimization process to avoid local optimum(Mas`udia and Wardoyo 2013). Image processing and computer vision have the potential and play a very important role in technology in the field of agriculture (Kurniawati et al., 2009). Computer vision can be used to analyze all kinds of data, not just images from cameras (Nixon and Aguado 2012).

Recognition using the artificial sense of human vision and limited knowledge of rice disease types would be time-consuming, laborious, and inefficient. Therefore, machine learning methods are helpful for help to make predictions on large amounts of data and a learning algorithm (GA) is proposed. The GA-FCM optimization evaluation results show that the addition of cluster groupings achieves the best cluster centroids more precisely compared to FCM, and the proximity of the optimized model using GA-FCM shows a larger range of cluster centers. Additional variation patterns for distances and cluster-centers

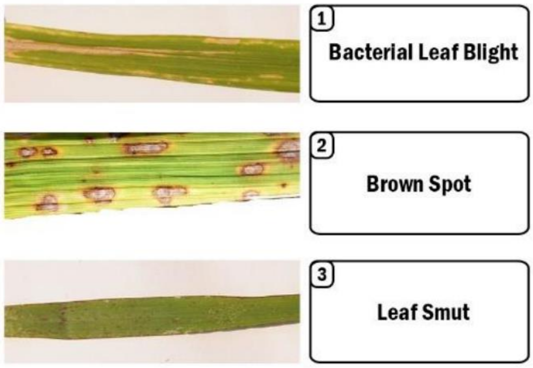

Fig. 5. Image of rice leaf on rice leaf diseases

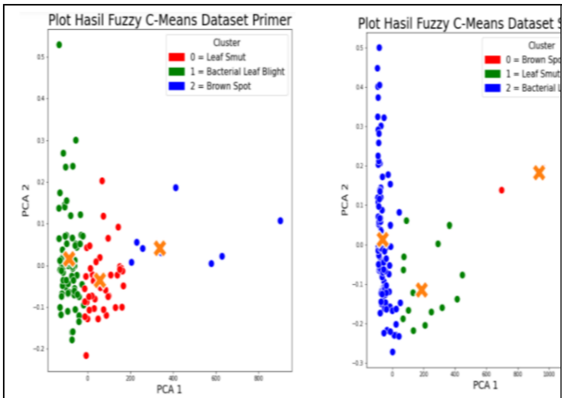

Fig. 6. Identification of the type of disease (FCM)

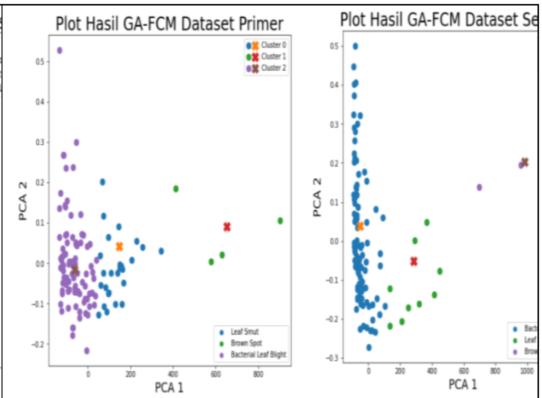

Fig. 7. Identification of the type of disease (GA-FCM)

Random forest prediction model for drought sugarcane land using satellite image data

One of the productivity problems of rainfed sugarcane farming is prolonged drought, lack of rainfall, and lack of water supply in the soil during the vegetative growth phase.(Reyes-González et al. 2018).In addition, high temperatures during the ripening phase can reduce the conversion of sucrose to fructose and glucose(Mishra and Singh 2010). Climate change can also cause diseases and pests (Li and Yang 2015).

It is necessary to monitor drought conditions to schedule proper irrigation based on the response of plants to drought at different stages of vegetation (Mahan et al. 2012). Measuring crop response to drought is difficult and complex Similarly detecting and integrating crop water deficits is still complex based on single crop responses (Hull et al. 2018).

Grouping of four methods for monitoring plant response to drought (Ihuoma and Madramootoo 2017), that is:

(1) groundwater measurement;
(2) Groundwater balanced approach;
(3) Plant-based approach;
(4) Remote sensing method.
the best remote sensing approach is based on the vegetation spectral index obtained from Unmanned Aircraft Vehicle (UAV) hyperspectral sensors, aircraft, and satellite imagery in space. Considering that sensor rental costs are relatively inexpensive, the determination of indicators of leaf moisture status and plant stomata conductance is high. Non-destructive, non-labor intensive, and suitable for automation. So remote sensing methods are widely adopted as irrigation scheduling decisions.

Classification and prediction of sugar cane fields that experience drought have quite complex challenges, this is due to the need to build sufficient resolution land cover maps under conditions of rare satellite visits and lack of cloud-free data. This greatly affects the quality of classification and prediction.

The developed machine learning model is capable of predicting the drought level of sugarcane fields in the PTPN X Kediri region, East Java Indonesia, which can then be developed into an early warning system as an effort to support precision agriculture 4.0 for sugar cane farmers and sugar mills to schedule patterns irrigation in rainfed sugarcane fields. The research objectives are:

- Overcoming the lack of cloud-free satellite image observation data by combining some Landsat-8, Sentinel-2, and MODIS satellite imagery data for the 2017 - 2020 period

- Develop a good workflow for processing satellite image data before the classification process (Pre-Process) by applying the Pan-Sharpening image sharpening stage and Watershed image segmentation patterns and determining satellite image features based on Gray Level Co-occurrence Matrices (GLCM) •contrast, •energy, •homogeneity, •entropy

- Designing a prediction model for drought in sugarcane fields using the Ensemble Learning RF concept mapped crop drought with hyperspectral index through machine learning classification method for persistent cloud areas with high temporal dynamics of land cover types. To overcome the main problems in monitoring satellite imagery-based remote sensing, image processing methods along with machine learning can be adopted in classifying land use land cover (LULC) to the phonology of certain plants (sugarcane).

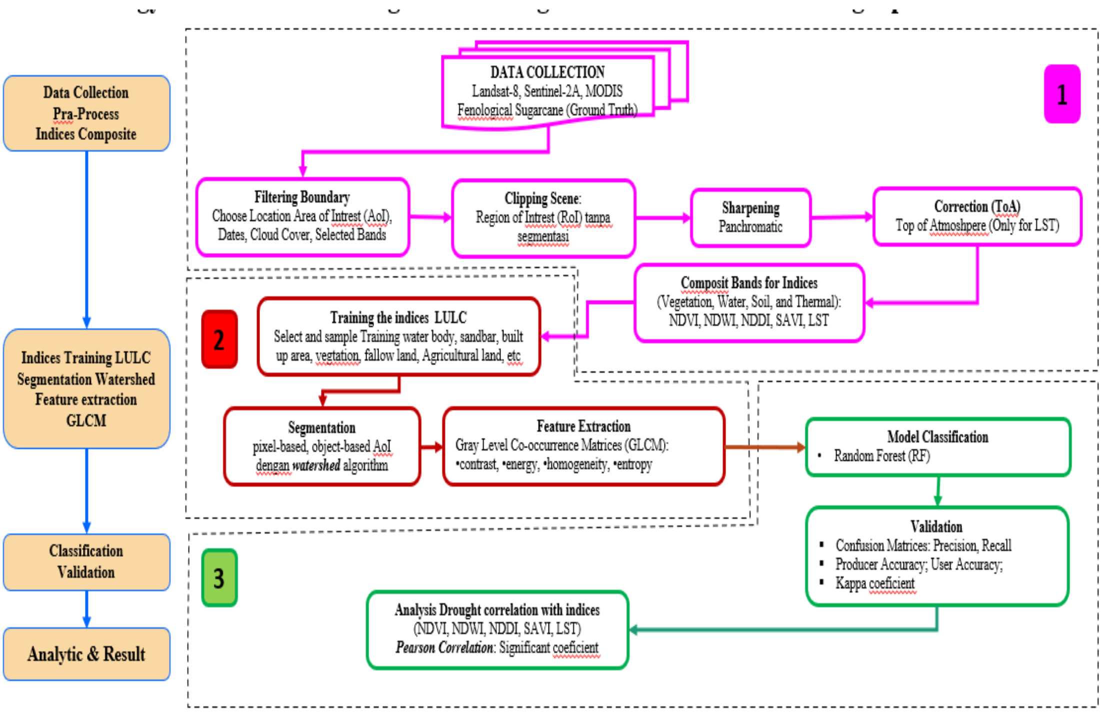

Fig. 8. Classification of sugarcane drought based on remote sensing optical data

Fig. 9. RGB Composite, NDVI, LST

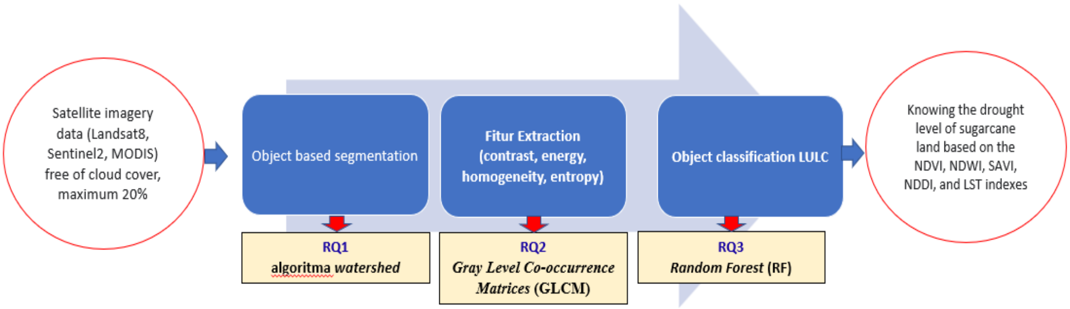

Fig.10. The workflow of the sugarcane field drought prediction model using remote sensing methods

Multi-drone coordination for precision farming using k-means clustering algorithm, ant colony optimization, genetic algorithm & 3-opt

Environmental issues regarding the use of pesticides for plants and their effects will potentially pollute the environment which can experience movement and degradation(Scholtz and Bidleman 2007; Liu et al. 2015).

Reducing the negative impact of environmental pollution using pesticides, applying pesticides to plants according to the dosage or dosage. Effective fertilizer or pesticide spraying drone operating system on a very wide agricultural land based on plant health level data. Drones with camera payloads can be used for plant health monitoring(Neupane and Baysal-Gurel 2021; Hafeez et al. 2022). The multispectral camera capability installed on the UAV produces data that is more analytical and effective compared to satellite data(Bollas et al. 2021).

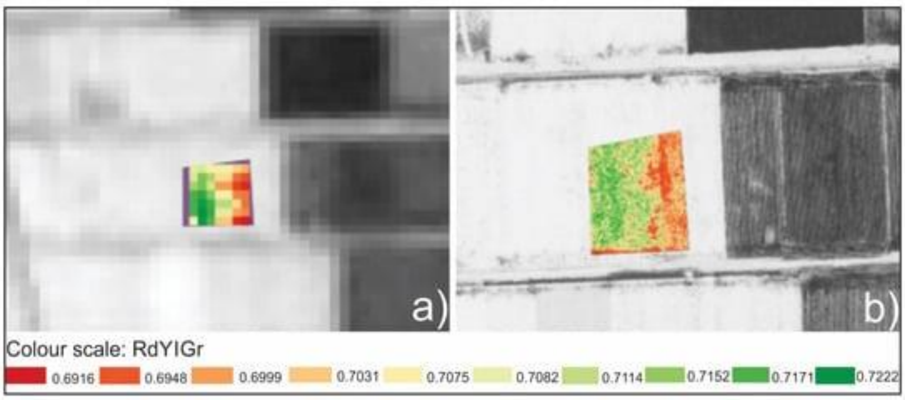

Fig. 11. Comparison of image data (a) Sentinel-2 data and (b) UAV multispectral data at a scale of 1:1000
(Bollas et al. 2021)

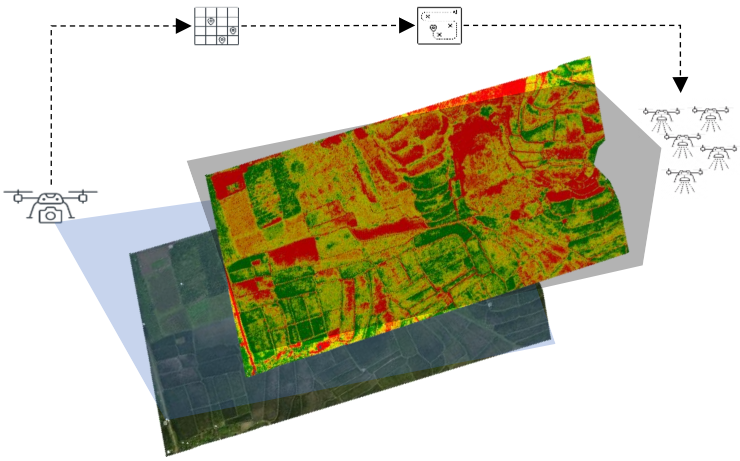

Fig. 12. Illustration of the operating system concept to be implemented

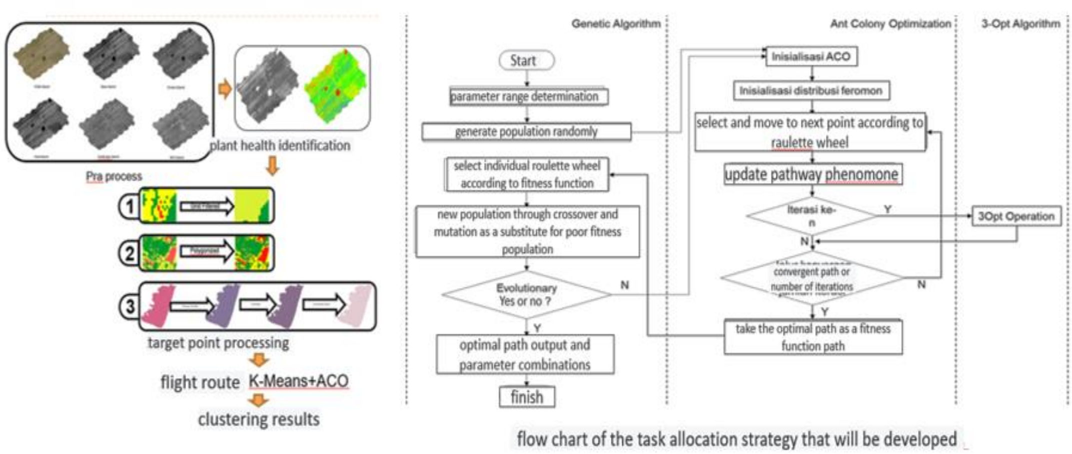

Fig. 13. Research stages

1. K-Means Clustering is used to group spraying target points into several groups, depending on the size of the area and the number of drones available
2. Genetic Algorithm to update the parameters contained in Ant Colony Optimization
3. Ant Colony Optimization functions to allocate drones to each area group (the result of the K-Means Clustering process)
4. 3-Opt is used to optimize the results of Ant Colony Optimization (local optimization) calculations

This method is used to create a point database with plant health level parameters, as well as to produce a task allocation strategy for several drones which are expected to be able to design flight routes effectively.

The application of AI when connected to the blockchain as a traceability application and data integration will produce applications with the highest intelligence in solving problems in agriculture. Presently, Supply chain Management (SCM) has been also growing in Agriculture and Healthcare. Blockchain offers excellent capability of supply chain management in a transparent and distributed manner. The IoT, AI can be integrated with the Blockchain to expand the performance of the real-world application. Integration of IoT, AI and Blockchain fulfill the dynamic requirement of supply chain stakeholders in Agriculture (Singh and Singh 2020; Dwivedi et al. 2021).

Combining artificial intelligence and blockchain technology, decentralized AI applications and algorithms are built with access to identical visions of a trusted and shared data platform to store knowledge, record and make decisions. This platform is useful when keeping reliable records of all AI algorithms before, during and after the learning and decision making process (RegPac 2022)

CONCLUSION

With digitalization in the agro-industry, it is very easy for the government and stakeholders to ensure product availability, both for domestic and foreign consumers. With the development of blockchain and AI technology, it can innovate super smart tools for agroindustry. Integration of machine learning, AI, and blockchain supported with information systems, creating a quality monitoring system to deliver real-time information and quality predictions. The system increases the ability of supply chain actors in making related decisions. The integration of blockchain technology and AI in the development of intelligent systems and applications in supply chain management introduces new solutions for food safety and transparency, trust, and traceability. The use of blockchain technology and AI can improve quality monitoring, and halal status and control production effectively and efficiently using smart devices. Further research is needed to combine AI with blockchain into a smart application or platform to overcome problems on the agro-industrial supply chain management.

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