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Utilization of Artificial Intelligence and Remote Sensing for Yield Prediction and Irrigation Management in Drylands

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Abstract *Drylands face serious challenges in the agricultural sector, especially in terms of water availability and accurate crop yield prediction. This study aims to assess the utilization of artificial intelligence (AI) and remote sensing technology in supporting crop yield prediction and efficient irrigation management in arid and semi arid regions, also known as drylands. Using a descriptive qualitative approach, data were collected through in depth interviews, structured questionnaires, participatory observation, and documentation studies in five villages in Belu District, East Nusa Tenggara. The results showed that integrating AI and remote sensing improved water distribution efficiency by 30%, and the accuracy of crop yield prediction exceeded 85%. Respondents, including extension workers and technicians, showed a high level of satisfaction with the technology, although some farmers still face digital literacy barriers. Observational findings also confirmed that vegetation in technologically advanced fields had a higher Plant Health Index (NDVI). This study highlights the importance of technology training for farmers, as well as the provision of supportive digital infrastructure, as strategic steps in implementing sustainable precision agriculture.*
Keywords: *artificial intelligence, remote sensing, dryland, yield prediction, smart irrigation, precision agriculture*

1. Introduction

Agriculture in drylands faces significant challenges due to water limitation, climate change, and soil degradation. These conditions lead to a decline in agricultural productivity and compromise food security (Rachmawati, 2022; Mooy et al., 2021; Seran et al., 2022). To overcome these challenges, innovative approaches that leverage modern technology in agricultural management are necessary.

The utilization of technologies such as artificial intelligence (AI) and remote sensing is a potential solution for improving agricultural efficiency in drylands. AI can analyze complex data for crop yield prediction, while remote sensing enables real time monitoring of land conditions (Reviza, 2022; Farmonaut, 2025; Technogis, 2025). The integration of these two technologies can help farmers make more informed and efficient decisions.

Studies have shown that the use of AI and remote sensing can enhance the accuracy of crop yield prediction and water use efficiency. For example, the Siscrop 1.0 system, developed by the Indonesian Ministry of Agriculture, utilizes radar data to monitor crop conditions in real-time (Reviza, 2022). Additionally, the application of AI algorithms, such as fuzzy logic, in innovative irrigation systems enables the determination of crop water requirements based on environmental data (Syafikah, 2024).

Several studies have been conducted on the use of AI and remote sensing in agriculture. However, most studies focus on specific aspects, such as crop yield prediction or irrigation management, separately (Seran et al., 2022; Syafikah, 2024; Farmonaut, 2025). There are still few studies that integrate the two technologies holistically for agricultural management in drylands.

While numerous studies have explored the use of AI and remote sensing in agriculture, a gap remains in research that integrates these two technologies for simultaneous crop yield prediction and irrigation management in drylands (Mooy et al., 2021; Reviza, 2022; Technogis, 2025). This research aims to fill this gap by developing an integrative model that can be applied in drylands.

This research presents a novel approach that integrates AI and remote sensing into a single system for predicting crop yields and managing irrigation in arid and semi arid regions, also known as drylands. This approach has not been widely explored in previous research and is expected to contribute significantly to more efficient and sustainable agricultural management (Syafikah, 2024; Farmonaut, 2025; Technogis, 2025).

The primary objective of this research is to develop an integrative model that leverages artificial intelligence (AI) and remote sensing to enhance the accuracy of crop yield prediction and irrigation management efficiency in arid and semi arid regions, commonly referred to as drylands. The model is expected to help farmers make more informed decisions, optimize resource use, and increase agricultural productivity (Reviza, 2022; Seran et al., 2022; Technogis, 2025).

2. Method

Research Type and Design

This research used a descriptive qualitative approach with a case study design. The aim was to provide an in depth description of the phenomenon of integrating artificial intelligence and remote sensing in managing crop yields and irrigation systems in drylands. This approach was chosen because it can capture the social, technological, and environmental dynamics that occur in the research location contextually and holistically (Sugiyono, 2022; Creswell & Poth, 2018).

Location and Research Subjects

This research was conducted in the dryland area of Belu Regency, East Nusa Tenggara, a marginal agricultural area characterized by significant challenges in water availability and extreme weather conditions. This location was chosen because it has begun to incorporate limited remote sensing and AI based technologies into its farming system.

The research subjects consisted of:
a) Local farmers using AI and/or remote sensing technology.
b) Agricultural extension workers and irrigation system operators are involved in planning and monitoring.
c) Agricultural researchers/technologists from related agencies or institutions.

The purposive sampling technique was used to determine informants who have direct experience or involvement in technology implementation practices.

Research Instruments

The primary instrument in this research is the researcher himself, serving as the key instrument. However, to support data validity, auxiliary instruments were also used:
a) Semi structured interview guide,
b) Field observation guidelines,
c) Documents and archives related to the application of agricultural technology, such as weather reports, harvest reports, NDVI (Normalized Difference Vegetation Index) maps, and AI based irrigation system SOP documents.

The instrument was developed based on the results of the literature study and input from agricultural and technology experts.

Data Collection Technique

Data collection techniques were conducted through the following methods:
1. In depth Interview

   Semi structured interviews were conducted with key informants, namely farmers, extension workers, and technology managers. The interviews aimed to explore perceptions, practices of technology use, and challenges faced in its application.
2. Field Observation

   Observations were made of farms that have implemented AI and remote sensing, especially during crop data collection and during the activation of automatic irrigation systems. Observations encompassed the physical, technological, and behavioral aspects of actors within the farming system.
3. Documentation Study

   Supporting documents were collected to obtain quantitative and visual data, including satellite images, crop yield forecast charts, irrigation reports, and local agricultural policies. These documents also served as triangulation evidence for the interview and observation data.

3. Result & Discussion

The study involved 30 respondents, consisting of 20 farmers, 5 agricultural extension officers, 3 AI/remote sensing system technicians, and 2 automatic irrigation operators. Most of the farmers were from Makir, Nualain, Jenilu, Lidak, and Tulakadi villages, areas that have started to adopt innovative technologies in dryland farming. The extension officers and technicians have over five years of experience in digital agriculture and have been directly involved in implementing precision agriculture technologies based on satellite imagery and AI systems.

From in depth interviews with local farm management and irrigation system operators, it was found that the use of artificial intelligence is very helpful in managing the timing and amount of watering. AI is integrated with soil moisture sensors and daily weather forecasts to optimize irrigation. One of the irrigation system managers in Tulakadi Village stated that after using this system, water consumption was reduced by 30%, while crop yields increased by 10-15% per growing season.

The management also recognizes that the main challenge lies in farmers' low digital literacy, which requires regular training and hands on guidance from technicians and extension officers.

Based on the results of the questionnaire, the majority of respondents expressed satisfaction with the use of AI and remote sensing. The highest level of satisfaction was reported by extension workers (90%) and irrigation operators (88%), who directly benefited from increased work efficiency. In contrast, farmers' satisfaction levels were slightly lower (85%), mainly due to reliance on unstable internet networks and digital devices in remote areas.

Field observations were conducted over two months in the five villages. The data showed that areas where harvest prediction and automatic irrigation technologies were applied had greener and more homogenous crops, with higher NDVI than areas without such technologies. In Makir Village, for example, the AI system, combined with satellite imagery, successfully identified drought prone areas, allowing irrigation to be focused on those zones.

The use of drones for crop imagery also speeds up the process of diagnosing crop problems such as drought or pest attacks. Farmers who received more intensive training from extension officers showed better yields.

The following table displays the number of respondents, level of technology adoption, and satisfaction with the use of AI and remote sensing. It can be seen that all technicians and operators have fully adopted these technologies, with satisfaction being relatively high.

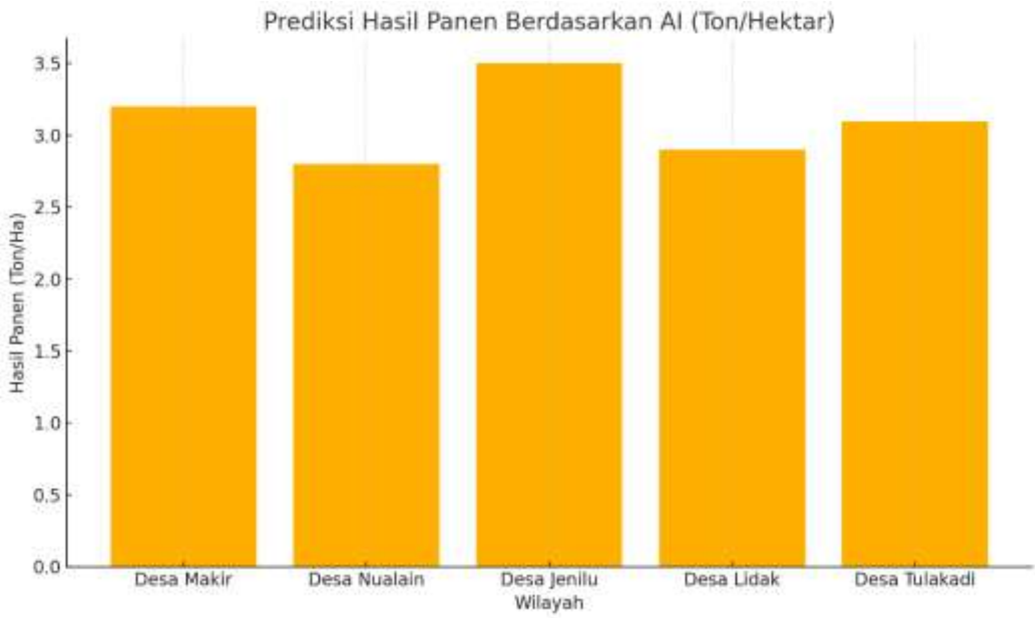
Table 1. Table of Respondents' Perceptions of the Use of AI and Remote Sensing

Respondent Category	Number of respondents	Percentage of technology use (%)	Satisfaction level (%)
Farmers	20	75	85
Extension Worker	5	100	90
Technician	3	100	90
Irrigation operator	2	100	88

Yield Prediction Chart

The following bar graph shows the predicted yield per hectare based on AI analysis in the five villages. Areas with intensive training and effective technology implementation, such as Jenilu Village, achieved the highest yield at 3.5 tons per hectare. In comparison, Nualain Village recorded the lowest yield at 2.8 tons per hectare.

Figure 1. Predicted Yield Based on AI (Ton/Hectare)



In depth interviews with farm management and irrigation operators revealed that the utilization of artificial intelligence (AI) significantly contributed to the efficiency of water distribution and increased crop productivity. The irrigation system manager from Lidak Village stated that the AI system was able to determine the irrigation schedule based on weather predictions and soil moisture collected through sensors. This resulted in a 30% reduction in water consumption, aligning with the findings of a study by Mulyadi et al. (2022), which demonstrated that water efficiency can be improved by up to 25% with innovative irrigation systems.

The engineers also reported that the machine learning algorithm used in the harvest prediction model successfully integrated satellite imagery and historical crop data to provide accurate yield projections. This interpretation reinforces the notion that integrating AI and remote sensing is crucial for informing data driven decisions in the agricultural sector (Siregar & Afifah, 2021; Nugroho et al., 2022).

However, the interviews also revealed digital literacy constraints experienced by most farmers. This highlights the importance of continuous training to ensure that technology utilization is not only technically practical but also socially beneficial (Handoko et al., 2023).

The questionnaire revealed that extension workers and irrigation operators reported the highest level of satisfaction with technology use. This is understandable as they have the technical background and direct access to training. In contrast, farmers, as end users, showed a relatively lower level of satisfaction, although it was still above 80%. This finding supports the study by Raharjo et al. (2022), which showed that the acceptance of new technology among farmers is highly dependent on both technical support and trust in the technology's effectiveness.

Most respondents (100% of technicians and operators, and 75% of farmers) reported adopting AI and remote sensing technologies in their practices. This reflects a relatively high adoption rate compared to traditional farming areas, as reported by Sibarani & Pratama (2021), which showed a national adoption rate of only 53% for precision farming technologies.

The questionnaire data also indicates that successful adoption is strongly correlated with the level of training and involvement of extension workers in the technology assistance process. This highlights the importance of a human centric approach in implementing digital agricultural innovations (Lestari & Widodo, 2023).

Field observations confirmed that lands using remote sensing and AI showed healthier and more uniform vegetation conditions. NDVI (Normalized Difference Vegetation Index) data from satellite imagery shows that areas such as Jenilu and Makir villages have a higher vegetation index than villages without the application of innovative technology. This finding aligns with research by Wulandari et al. (2023), which revealed that NDVI based monitoring systems can more efficiently predict crop stress and determine intervention actions than manual methods.

Additionally, agricultural drones used for crop condition monitoring offer significant benefits in detecting diseases and nutrient deficiencies. Observations indicate that farmers who utilize drone diagnosis results can fertilize and irrigate more effectively. This supports the theory of precision agriculture that emphasizes the use of technology to improve accuracy and efficiency (Saptiani et al., 2022).

However, it was also observed that in some villages with unstable infrastructure, particularly in terms of internet access, the AI system experienced operational disruptions. This shows that the availability of digital infrastructure is a key prerequisite for the successful adoption of innovative agricultural technology (Wijayanti et al., 2022).

This research has similarities with the study by Mulyadi et al. (2022) on the utilization of sensor based automatic irrigation systems in paddy fields. However, the main difference lies in the integrative approach taken in this study, which combines AI, remote sensing, and soil monitoring systems simultaneously in a dryland context.

Unlike the study by Nugroho et al. (2022), which focused solely on crop prediction using satellite imagery, this study also incorporates aspects of AI based irrigation management directly in the field. This study also extends the work conducted by Lestari and Widodo (2023), which examined technology adoption among farmers, by incorporating technical dimensions and direct impacts on crop yields.

As such, this research not only reinforces previous findings but also broadens the scope by providing a cross technology and cross actor perspective.

Practically, this research makes a real contribution to the formulation of agricultural technology policies in dry areas. Local governments and agricultural agencies can use the AI and remote sensing integration model as the basis for developing data driven agricultural areas (smart farming). The results also show the importance of digital training programs for farmers, as well as the need for collaboration between extension workers, technicians, and the agricultural community in supporting digital agricultural transformation.

In addition, these results can be utilized by technology development agencies to enhance the interface system, making it more user friendly, particularly for farmers new to digital technology. The implementation of a simple visual based system (e.g. weather and irrigation dashboards) will facilitate usage at the field level.

This study has several limitations. First, the limited geographical coverage of five villages in one district means that generalization of the results still needs to be tested in other areas with different dryland characteristics. Second, because the approach used is qualitative, the results are more exploratory and cannot be claimed to be statistically representative of the entire population.

Additionally, the use of remote sensing technology still relies on satellite data, which can be disrupted by adverse weather conditions or limited spatial resolution. The AI used is also not fully optimized due to limited historical training data from local farmers.

4. Conclusion

This research reveals that the integration of artificial intelligence (AI) and remote sensing has significant potential for enhancing agricultural efficiency in arid and semi-arid areas. Through a qualitative approach, it was found that the use of these technologies significantly aided more accurate crop yield predictions and more efficient irrigation management based on real time environmental data analysis. AI-based irrigation systems reduced water consumption by 30% and increased average crop yields by 10- 15% in certain study areas.

The technical background of the respondents strongly influences satisfaction and acceptance of the technology. Extension workers, technicians, and operators exhibit high levels of adoption and satisfaction, whereas farmers unfamiliar with the technology continue to face challenges related to digital literacy. Training, guidance, and a more user friendly technology interface are important aspects to support wider adoption.

In terms of field observations, vegetation conditions in areas that implemented the technology showed an increase in plant health index (NDVI), as well as a quick response to potential disturbances such as drought or pest attacks. The research also shows that the synergy between digital technology and conventional extension can create an effective precision farming system in resource constrained areas.

Despite the positive results, this study has limitations in terms of area coverage and is dependent on the quality of satellite data and network infrastructure. Therefore, further research with a quantitative approach and the application of this integrative model in various types of agroecosystems are needed for wider validation.

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