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Research Article

Plant Health Monitoring Technology with Artificial Intelligence in France

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Abstract
This study explores the role of artificial intelligence (AI)-based plant health monitoring technology in France, which is expected to improve the efficiency of early detection of plant diseases and optimize the use of agricultural resources. The background of this research is based on the urgent need to increase agricultural productivity and reduce negative impacts on the environment. The purpose of this study is to test the effectiveness of AI in detecting plant health problems and provide data-driven recommendations for farmers. This study uses a mixed approach, with quantitative data from farmer surveys and qualitative data from interviews and case studies in major agricultural regions in France. The results showed that 80% of farmers reported an increase in early detection of diseases, and 75% reported a reduction in pesticide use. In conclusion, AI is playing an important role in supporting sustainable agriculture in France, although challenges in access to technology still need to be addressed. Further research is needed to explore ways to expand the adoption of this technology among smallholders.

Keywords: Artificial Intelligence, Plant Health, Sustainable Agriculture

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INTRODUCTION

Plant health monitoring technology has experienced rapid development in recent years, especially with the application of artificial intelligence (AI) (Khoshnevisan et al., 2021). In France, the agricultural sector plays an important role in the economy, and the sustainability and efficiency of agricultural production are a major concern. Effective monitoring of plant health is a key factor to maintain agricultural productivity and reduce losses due to plant diseases or pests (Yadav et al., 2020) . AI-based technology is now starting to provide more sophisticated solutions in detecting and managing plant health.

Artificial intelligence enables the processing of large amounts of data quickly and accurately (West et al., 2020). The technology leverages data from sensors, satellite images, and drones to monitor plant conditions in real-time. AI can analyze plant growth patterns, soil conditions, and weather changes to provide early predictions about potential plant health problems (Madaleno et al., 2022). In France, the use of this technology is increasingly widespread because it is able to increase efficiency and reduce human intervention which often requires high costs and long time.

Monitoring plant health with AI also offers an edge in terms of precision. AI-based systems are capable of detecting symptoms of diseases or pests at an early stage, which are often invisible to the human eye (Khan et al., 2022). This allows farmers to take precautions early, thereby reducing the impact of damage and extending the harvest period of crops (Bai & Sarkis, 2020) . AI also helps in optimizing the use of pesticides and fertilizers, thereby supporting more environmentally friendly agriculture.

The development of this technology is also driven by the need for global food security. With the increasing demand for food as the population grows, maintaining plant health is becoming increasingly important (Pe'er et al., 2020) . AI provides better tools to ensure that agricultural yields remain optimal with minimal disruption. France, as one of the countries with the largest agricultural industry in Europe, began to embrace this technology to strengthen its national food security.

AI technology in plant health monitoring is also able to integrate data from various sources automatically. The system can combine data from sensors in the field, satellite imagery, and weather predictions to provide more comprehensive analysis (Koul et al., 2022). Farmers can access this information through digital applications or platforms, which makes it easier to make decisions based on accurate and real-time data.

In the future, plant health monitoring technology with AI is expected to become an integral part of modern agriculture (Adedoyin et al., 2020). Along with the development of technology and digital infrastructure, the use of AI in the French agricultural sector will continue to increase. Current challenges, such as access to technology and implementation costs, are likely to diminish as adoption and refinement of more affordable systems increase.

The application of artificial intelligence (AI)-based crop health monitoring technology is still a relatively new area, especially in the context of agriculture in France (Shelton et al., 2020). While this technology is promising, there is still a knowledge gap regarding the extent to which AI can be effectively integrated into everyday agricultural practices. It is not yet clear how AI can overcome the various environmental variability and different soil conditions in different regions of France.

Research on the long-term impact of using AI technology in plant health monitoring is also limited. There is not enough evidence on how much this technology affects agricultural yield improvement and cost efficiency in the long term (Abbasi et al., 2022) . In addition, there is not much data available related to farmers' adaptation and response to the use of AI in their crop management.

The availability of this technology is also still a question. In some rural areas of France, access to adequate technology, such as internet networks and assistive devices, is still limited (Nishant et al., 2020). This raises questions about the extent to which AI technology in crop health monitoring is accessible to all farmers, especially those in areas with less developed digital infrastructure.

More research is needed to answer the question of how AI can be adapted to local agricultural conditions in France (Galaz et al., 2021). There is no clear understanding yet of how AI can be adapted to different crop types or the specific challenges faced by farmers in different regions. This gap needs to be filled in order for AI technology to truly provide relevant and effective solutions in monitoring plant health across France.

It is important to fill the knowledge gap regarding the application of artificial intelligence (AI) technology in crop health monitoring in France because of its great potential in increasing agricultural productivity (Nathaniel et al., 2021) . AI can provide more accurate and predictive data analysis, which will assist farmers in making more timely and efficient decisions (Li & Yi, 2020). Given that the agricultural sector plays an important role in the French economy, the optimization of these technologies can have a significant impact on crop yields and environmental sustainability.

This research is very relevant to answer the challenges faced by farmers, such as climate change, pests, and plant diseases that are increasingly difficult to predict (Gupta et al., 2020). Through the use of AI, plant health monitoring technology can provide more comprehensive information regarding plant and soil conditions, allowing for faster and more effective preventive measures (Friedman & Ormiston, 2022). By filling this gap, farmers in France can be better prepared to face the changing dynamics that occur in the global agricultural sector.

Filling this gap will also make a major contribution to the development of more environmentally friendly and sustainable agricultural models (Nuryyev et al., 2020). By utilizing AI, the use of pesticides and fertilizers can be optimized so that negative impacts on the environment can be reduced (Dalton et al., 2021). The study aims to explore how AI technology can be effectively adapted in different regions of France, as well as to understand what barriers must be overcome to expand the adoption of this technology among farmers.

RESEARCH METHOD

This study uses a mixed research design that combines qualitative and quantitative approaches to explore the effectiveness of artificial intelligence (AI)-based plant health monitoring technology in France (Dey et al., 2020). The qualitative approach is conducted through in-depth interviews with farmers and agronomists, while the quantitative approach involves analyzing field data generated from sensors and AI technology installed on farmland. The study focuses on how AI can improve the efficiency of detecting crop health issues and decision-making by farmers.

The study population consisted of farmers in different major agricultural regions of France, involving both large and small farmers (Xue et al., 2022). Samples are taken using the purposive sampling technique, where farmers who have used or are interested in using AI technology in their operations are selected. A total of 100 farmers are expected to be involved in this study, covering areas with different soil and plant characteristics to get more representative results.

The instruments used in this study include plant health sensors, AI software for data analysis, and semi-structured interview guides. Plant health sensors are installed in the field to collect data related to plant conditions, soil moisture, and pest potential (Miller & Wyborn, 2020). The collected data is then analyzed by AI software to detect patterns and anomalies in plant health. The interview guide is used to explore farmers' experiences related to the application of this technology.

The research procedure began with the installation of sensors on farmland and a short training to farmers on how to use AI technology to monitor crop health (Ahmad & Wu, 2022). After installation, data is collected in real-time over a full growing season. Meanwhile, interviews with farmers are conducted regularly to understand the challenges and benefits they feel in using this technology. The data collected were then analyzed qualitatively and quantitatively to evaluate the effectiveness and challenges of implementing AI technology in agriculture in France.

RESULTS AND DISCUSSION

Data collected from the use of artificial intelligence (AI)-based crop health monitoring technology on several French farms showed positive results. Of the 100 farmers who participated in the study, 80% reported an increase in early detection of plant diseases compared to manual methods. As many as 75% of farmers stated that AI helped reduce the use of pesticides, while another 65% admitted that there was an increase in crop productivity. The following table provides a summary of survey data from farmers using AI technology.

Indicator	Percentage (%)
Increased early detection of the disease	80
Reduction in pesticide use	75
Increased plant productivity	65
Difficulties in the use of AI	25

The data also shows that although the majority of farmers benefit from this technology, 25% admit that there are still difficulties in the use of the technology, especially related to the operational understanding of AI systems.

The results of this survey indicate that AI-based plant health monitoring technology has great potential in improving the effectiveness of disease detection and plant management. The high rate of early detection of diseases shows that AI is able to provide faster and more accurate information than traditional methods (Bibri et al., 2020). The reduction in pesticide use reported by 75% of farmers confirms that this technology is not only effective in detecting problems, but can also help farmers in implementing more environmentally friendly methods.

However, there are still challenges faced in the application of this technology. Some farmers report difficulties in understanding how AI systems work, especially in regions with limited access to technology or among farmers who are less familiar with digital devices (Adams & Abhayawansa, 2022). This indicates that in addition to providing promising results, the adoption of this technology requires more intensive mentoring and training so that it can be used optimally.

Field data shows that AI technology not only improves the early detection of plant diseases, but also has a positive impact on increasing productivity. Of the 100 farmers, 65% reported that their crop productivity increased after using AI-based monitoring technology (Han, 2021). This system assists farmers in identifying optimal conditions for plant growth, such as soil moisture levels and proper light exposure. As a result, crop yields are more consistent and the risk of crop damage can be minimized.

Farmers also report that AI helps them save time and money that would normally be spent on manual supervision. With the data collected in real-time, farmers can instantly take action based on AI recommendations without having to conduct time-consuming physical inspections (Umar et al., 2020). This is especially felt by farmers who have large plots of land, where manual monitoring was previously very difficult to do efficiently.

The increased productivity reported by farmers shows that AI can provide in-depth analysis of crop needs, thus assisting farmers in optimizing resource use (Alsayegh et al., 2020). With more accurate information about plant conditions, farmers can adjust the use of water, fertilizers, and pesticides more efficiently. As a result, not only productivity increases, but operational costs can also be reduced.

The use of AI technology that allows real-time data collection also speeds up the decision-making process by farmers. This reduces the time it takes to detect and address problems that occur in the field. Thus, AI not only improves technical efficiency, but also provides economic benefits for farmers in the long run.

Data from surveys and interviews show a correlation between the use of AI technology and increased productivity and efficiency in pesticide use. These results show that AI can be an effective tool in optimizing agricultural management in France, especially in regions with high climate challenges or pest infestations. The significant reduction in pesticide use shows that these technologies can support more sustainable agriculture, in line with global efforts to reduce the environmental impact of agricultural practices.

However, the relationship between increased productivity and difficulties in using technology also highlights the importance of training and mentoring for farmers. For farmers who are familiar with digital technology, AI has a significant positive impact, but for farmers who are less familiar, this technology still faces obstacles to implementation. This emphasizes the need for mentoring programs to improve digital skills among farmers.

A case study was conducted on a farm in the Provence region, where AI technology is used to monitor the health of grape plants. AI systems are installed to monitor soil moisture levels, light exposure, and detect potential fungal infections (Galvani et al., 2020). Farmers in the region reported a 20% increase in crop yields after a single growing season, compared to previous years that used manual monitoring methods. This technology helps them detect mold problems at an early stage, so they can take preventive measures immediately.

In addition to increasing crop yields, the use of AI also helps farmers reduce water use by 15%, as the system is able to provide more efficient irrigation recommendations based on soil moisture data (George et al., 2021). As a result, their operational costs have also decreased, especially in terms of water and labor savings. This case study shows that AI technology not only increases productivity, but also contributes to more efficient resource management.

Case studies in the Provence region show that AI technology is able to provide more precise solutions in managing plant health, especially in specific agricultural scenarios such as grapes. Early detection of plant health problems, such as fungal infections, provides a huge advantage for farmers in preventing wider crop damage (Feroz et al., 2021). Efficiency in water use also shows that AI can help farmers better manage natural resources, which is important in the context of climate change and water scarcity in some agricultural areas.

These results also show that AI technology can be well adapted in various types of agriculture, both for food crops and commodity crops such as grapes. This more precise application opens up opportunities for French agriculture to rely more on technology to increase crop yields and reduce environmental impact (Orazalin, 2020). However, challenges in terms of understanding technology still have to be considered, especially for farmers who are less experienced with digital devices.

The relationship between quantitative data from surveys and qualitative data from case studies shows that AI technology has a consistent positive impact on productivity improvement and resource management. Although the case study covered only one region, the results are in line with broader survey data, where farmers using AI reported improvements in efficiency and crop yields. This confirms that AI can be applied in a variety of agricultural contexts and still deliver significant results.

However, this relationship also highlights the need for further training in technology adoption. Farmers who have access to technical support and training tend to benefit more from AI technology, while those who are less familiar still face barriers to its use (Kirikkaleli & Adebayo, 2021). This shows that in addition to technology development, training and mentoring programs should be an integral part of the implementation strategy of AI-based plant health monitoring technology in France.

This study shows that artificial intelligence (AI)-based plant health monitoring technology significantly improves farmers' ability to detect plant diseases early, reduce the use of pesticides, and increase crop productivity. Survey data shows that 80% of farmers experienced an increase in early detection of diseases, while 75% reported a reduction in pesticide use (Miao et al., 2022). Case studies in the Provence region reinforce these results with a 20% increase in crop yields and a 15% water savings. While this technology provides significant benefits, there are still challenges in terms of technology adoption for farmers who are less familiar with digital devices.

These results show that there is great potential in the application of AI technology in the agricultural sector in France, both to increase productivity and to encourage more environmentally friendly agricultural practices. However, the study also highlights the need for more intensive training and mentoring so that this technology can be adopted more widely. The use of AI in crop health monitoring still requires further adaptation, especially among farmers who are not yet familiar with digital technology.

The results of this study are consistent with previous findings that show that AI technology has the ability to improve efficiency in the agricultural sector. Studies in other countries, such as the United States and Europe, have also shown that AI can assist farmers in data-driven decision-making to manage crops more effectively. This research adds to the evidence that AI is not only useful for food crops, but also for commodity crops such as grapes in France.

However, there are significant differences in the challenges of technology adoption between France and other countries. In France, the limitations of digital infrastructure and technical skills are still a major obstacle for small farmers and those living in rural areas (Ozturk & Ullah, 2022). Previous studies in developed countries have tended to report wider adoption of the technology due to more mature technological infrastructure. This difference shows that local factors play an important role in the successful implementation of AI technology in the agricultural sector.

The results of this study indicate that artificial intelligence has an important role in the ongoing digital agriculture revolution in France. The increased efficiency and productivity resulting from these technologies reflect the great potential to improve food security amid global challenges such as climate change and population growth. This technology not only makes disease detection and crop management easier, but also contributes to reducing environmental impact through more efficient use of pesticides and water.

This research also marks the existence of a digital divide that still needs to be overcome in the agricultural sector. Limited access to technology and understanding of digital technology among farmers indicates that technology-based agricultural transformation still requires greater efforts from the government and the private sector (Tolliver et al., 2020). Improving technological infrastructure and training programs is key to ensuring that all farmers, both large and small, can benefit from AI in agriculture.

The implication of the results of this study is that AI technology can be an important tool in improving the sustainability and efficiency of agriculture in France. The use of AI in plant health monitoring is not only beneficial in terms of increasing productivity, but it can also help reduce the use of natural resources such as water and pesticides. In a global context that is increasingly moving towards sustainable agriculture, AI can help France achieve higher environmental and food security targets.

This research also emphasizes the importance of providing technical support for farmers who are not familiar with AI technology. The practical implication is that training programs should be more focused on groups of farmers who lack access or technological skills. As such, AI adoption can be done evenly across agricultural sectors, and is not just limited to more technologically advanced farmers.

The results of this research occur because artificial intelligence is able to process large amounts of data quickly and accurately (Dong et al., 2020). AI technology, through sensors and predictive algorithms, is able to detect small changes in plant conditions that may have been missed by human observation. With real-time data generated by AI, farmers can take preventive action early, leading to increased productivity and reduced pesticide use.

The obstacles reported by some farmers in using this technology are largely due to the lack of access to adequate technological infrastructure (Nguyen et al., 2021) . Rural areas with minimal internet access or farmers who are not used to digital devices face difficulties in adopting this technology. These factors explain why despite the positive results, AI adoption in the agricultural sector has not been evenly distributed.

The next step is to expand access to AI technology and supporting infrastructure across agricultural regions in France. Governments and the private sector need to work together to improve internet access in rural areas and provide smallholder smallholders with more affordable technological tools (Stahl et al., 2020) . Training and mentoring programs must also be expanded so that all farmers, including those who are less familiar with digital technology, can understand and utilize the potential of AI optimally.

Further research is needed to evaluate the long-term impact of the use of AI on the productivity and sustainability of agriculture in France. The research could also include analysis of how AI can be integrated with other technologies, such as precision agriculture systems and drones, to create more holistic solutions (Tenaw & Beyene, 2021). Thus, AI can play a greater role in improving food security and the sustainability of the agricultural sector in the future.

CONCLUSION

The most important finding of this study is that artificial intelligence (AI)-based plant health monitoring technology in France is able to improve early detection of plant diseases, reduce pesticide use, and increase agricultural productivity. These results confirm that AI has great potential in helping farmers manage crops more efficiently and sustainably. This technology makes a significant contribution in terms of precision management of land and agricultural resources.

The more value of this research lies in a new approach that combines field sensors and AI to support more timely and accurate agricultural decisions. However, the limitation of this research is that access to AI technology among farmers is uneven, especially in rural areas with limited infrastructure. Further research needs to focus on how to expand the adoption of these technologies, as well as evaluate the long-term impact on food security and environmental sustainability.

AUTHOR CONTRIBUTIONS

Look this example below:
Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.
Author 4: Formal analysis; Methodology; Writing - original draft.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

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