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The Utilization of Artificial Intelligence in Agriculture to Optimize Irrigation and the Application of Pesticides and Herbicides

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Abstract
The industry faces various issues as it seeks to address pressures today such as scarcity of resources in the natural world, degradation of the physical environment and the rising demand for produce by the increasing population globally. In light of such considerations, Artificial Intelligence AI has come up as an innovative tool that has the potential to revolutionise the agricultural sector. This paper also compares how AI can be implemented to enhance various priority aspects of agriculture; including water supply and pest control. This paper explored the role of AI in agriculture and how AI can provide innovative solutions for optimising efficiency, cutting operations costs and minimising environmental impacts through the application of machine learning algorithms, computer vision, the IoT and sensor technology. These technologies facilitate

accurate measurements in real-time, decision support systems and enhance efficient farming known as precision agriculture. The goal of this paper is to show how AI can catalyse a new generation of more sustainable, efficient, and economically sustainable agriculture which would help the industry tackle emerging challenges in the future.
Keywords: Crops, autonomous systems, efficient water management, pesticides and herbicides, ML, CV, IoT, sustainable farming, precision farming, environment, resource utilization efficiency, smart farming, decision support systems, and agricultural sustainability.

Introduction

The agricultural sector is experiencing a level of pressure that has never been seen before due to increased food consumption and a lack of resources and environment. Hand-cultivating tools in conventional large-scale farming are inefficient ways of utilizing resources which have been in use for generations (Giri et al., 2020). It is evident from the following inefficient practices: there is high wastage of water, soil erosion, and high usage of chemically manufactured fertilizers and pesticides. Such practices are not only employed through the exploitation of natural minerals but also adversely affect the environment by polluting the natural environment and affecting the standards of biological diversities hence affecting the sustainable productivity of agriculture in the long run (Talaviya et al., 2020)

In a bid to overcome these challenges, AI has proven to be a strong solution with the capacity of revolutionizing compositions of agriculture. Smart technologies like machine learning, computer vision, and IoT deliver new approaches to using resources and improving yields while lowering carbon footprints (Eli-Chukwu, 2019). Auxin enables farmers to harness vital information from various connected precision agriculture tools and systems to willingly transform their farming practices for the better (Malathi & Senbagam, 2024)

Information technology is applied to various cropping zones, including the crop yields, the soil nutrient requirement profile and other factors affecting the crop production successfully. Artificial intelligence helps to analyze agricultural data produced by sensors, drones, satellites, and other devices in real time (Subeesh & Mehta, 2021). This data is analyzed using a machine learning approach to recommend relevant solutions for better crop working, water usage, as well as the application of pesticides/herbicides (Elahi et al., 2019).

This paper seeks to describe how AI technologies can transform some crucial areas in farming including irrigation and pesticide /herbicide application. Implemented with the help of AI, these practices can be enhanced to maximize the usage of material and minimize the negative effects on the environment (Ben Ayed & Hanana, 2021). AI also assists farmers in using the correct amounts and frequencies of water and chemicals, which also improves the state of crops and reduces levels of input. Thus, considering these novelties, the paper demonstrates the possibility of AI application in the development of modern environmentally friendly agricultural practices (Malook et al., 2023).

Background

Conventional practices, farming, in particular, have been testified as the

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backbone of farming all around the globe for quite some time now, and the characteristics of this method culminate in inefficiencies in resource management and constant reduction of farmland fertility. Some of the consequences include: Soil erosion, wastage of water, low soil fertility and water pollution some of the practices that can be practised include over-irrigation, application of blanket insecticides and excessive use of chemical fertilizers (Sharma, Verma, & Hardaha, 2023). However, there might be areas in a given field that have different soil types, climates, or crop requirements which normal operations do not adjust to and check on, thus putting more effort and time into the crop but yielding less results (Linaza et al., 2021).
These challenges paved the way for the development of precision agriculture in the recent past due to the integration of Artificial Intelligence (AI) technologies such as Machine Learning (ML), features of Computer Vision (CV), and the global adoption of the Internet of Things (IoT) (Maraveas, 2022). This new concept makes use of AI technology to better support farmers in their decision-making process, strengthening the yields and efficiency of farming practices while lessening the negative impact on the environment. With the help of A. I technologies in agriculture, farmers can save money, and resources used for production and decrease harm to the environment that can't affect farming (Sow et al., 2024).

Machine Learning (ML)
Within AI, there is a subfield called Machine Learning where algorithms learn from and can make decisions upon the data that they receive without being coded for it. In the application of agriculture, ML can be employed to analyze different or hybrid sources of information like; weather prediction, measurement of moisture in soil and condition of crops (Adinarayana et al., 2024). With the aid of data mining algorithms, it is possible to predict important parameters like soil moisture, weather conditions, pest invasion and so on, so that farmers may prevent them beforehand. For instance, ML can predict when it will be rainy so that farmers can adequately adjust the irrigation process and save water or predict early signs of pests so that farmers can control them in order not to harm most crops (Ahuja et al., 2024).

Computer Vision (CV)
Another branch of AI is Computer Vision which deals with processing and interpreting scenes, images or videos. A few of the branches in which CV systems can be adopted include detecting plant diseases, pests, and other abnormalities in crops using images from drones, cameras or satellites. Thanks to such images, which are processed by CV algorithms, one can notice phenomena characteristic of disease or pests at an early stage and take necessary measures (Shaikh, Rasool, & Lone, 2022). This approach is useful not only in preventing diseases from spreading but also in reducing the application of pesticides which is useful in the fight against diseases and is also unhealthy for the environment and our bodies (Eli-Chukwu, 2019).

Internet of Things (IoT)
The Internet of Things (IoT) is defined as a system of connected devices that gather and transmit information at the same time. IoT devices within precision

agriculture include humidity and moisture sensors, temperature probes and environmental monitoring stations to give a constant report on the status of the soil and crop (Padhiary et al., 2024). Bidirectional communication through the iot lowers the interval between the time a farm crop is cultivated and the time it develops a problematic nuance; it allows farmers to observe the state of the cultivated food crops, modify the frequency and duration of irrigation and identify trends in the weather that may require a farmer's input. By utilizing IoT devices the farmers get better with the conditions of their farm to manage the resources and pests in a better way (Subeesh & Mehta, 2021).

The Role of Artificial Intelligence in Precision Agriculture

The use of ML and CV in conjunction with IoT can bring a change to farming in the foreseeable future. Machine learning is married with the data streaming from IoT-enable devices, coupled with computer vision to provide farmers with highly accurate, real-time recommendations on when to water, apply fertilizers, or control pests (Giri et al., 2020). For example, the scouting of crops and the identification of the regions that need water most can be easily done by the mechanisms of artificial intelligence that control the irrigation systems and allow avoiding overuse and sparing water resources. Likewise, pest control by robotic systems can spray pesticide at the right time and in the right area have minimum impact on the environment, and will not harm the beneficial insects (Ben Ayed & Hanana, 2021).

In summary, the integration of all these AI technologies results in efficient, smart farming, that is, more production from equivalent resource utilization without compromising the environment. AI technology is advancing and the potential to turn the agriculture industry into a sustainable and environmentally efficient industry is growing bigger (Sharma et al., 2023).

Problem Statement

The agricultural segment is facing the problem of how to raise food production and use resources sparingly with minimal harm to the environment. Old-world agricultural practices entail faecal misuse of water resources for irrigation, high usage of pesticides and herbicides, and imprecision in the application of inputs in the farming enterprise hence leading to environmental depletion. However, the usage of Artificial Intelligence (AI) technologies that cherish such opportunities has not fully expounded and detected within farming (Padhiary et al., 2024).

As an area of focus, this research aims to discuss the possible changes that have been brought by Artificial Intelligence in enhancing irrigation, minimization of pesticide, and herbicide utilized in farming, and making farming more sustainable and lucrative (Li & Wang, 2024). In particular, it is concerned with determining the extent to which AI insights have improved irrigation techniques, reduced the use of chemicals and encouraged the efficient use of resources. In addition, the study will examine how the use of AI differs from 'conventional 'arable farming about efficiency, profitability, and environmental impact (Adinarayana et al., 2024).

Also, the study will establish the failed opportunities and constraints to AI-granted increased use in agriculture such as technical, monetary, and information gap restrictions. Conclusively, this dissertation seeks to afford an informative view of how those technologies in AI will revolutionise the various sectors of farming and enhance efficiency while embracing the environment and making good profits in the agricultural business (Elbasi et al., 2022).

Research Question

- What is the potential of Artificial Intelligence technologies for the improvement of irrigation systems in agriculture?
- To what extent do AI-based solutions contribute towards the effectiveness of pests and herbicides?
- Associated with the use of AI in agricultural practices, what are the environmental/natural effects as well as economic effects?
- Are there any differences between the efficiency and Crop Production of AI-based systems and conventional farming production?
- What are the problems related to the application of AI in agriculture?

Research Objective

- To examine the impact level AI has brought about in the irrigation efficiency improvement.
- It will enable a conclusion on the extent of the use of AI technologies in reducing pesticide and herbicide utilization.
- To determine the sustainability and profitability of AI technologies used in farming.
- To find out how the use of Artificial Intelligence differs from the conventional techniques in the farming sector.
- To find out broader impediments to the use of artificial intelligence in the farming sector.

Limitations

Several limitations are associated with this research. First, it emphasizes only those aspects of using AI that are associated with water efficiency and the minimization of pesticide/herbicide use exclusively, while other possible uses of AI in the field of agriculture remain uncovered. Moreover, the increase in the effectiveness of AI in agriculture also depends on the location, climate, and crops which makes it difficult to generalize the results. The study may also be limited by a lack of data availability; it may prove difficult to obtain timely and accurate information from the providers of agricultural technology or farmers (Mohammed, Hamdoun, & Sagheer, 2023). Moreover, AI implementation varies across regions and types of farms, wide-ranging adoption by small-scale and farmers from developing regions may take time. There can also be economic issues which deter organizations from implementing AI technology and the timeframe of monitoring long-term effects that may include such agendas as improved environmental conservation and enhanced profitability may be short. The technological advancement in AI systems, the level of proficiency of the employee even when interacting with the intelligent system, and the differences in the regulatory policies of a country and other government support programs are some of the factors that could have an impact on the results of implementing AI technologies across the regions. However, these restrictions remain the goal of the study is to present an overview of the contribution and risks posed by AI to agriculture (Kumar et al., 2023).

Literature Review

These will be elaborated in this section as the paper reviews the literature on the use of AI in agriculture especially in irrigation optimization and pest management. The review will discuss research reports on Machine Learning (ML) algorithms, Computer Vision (CV) systems, and Internet of Things (IoT) devices used in precision farming situations to reveal how these technologies are helping to make agriculture practices more effective, efficient and sustainable (Dawn et al., 2023).

Machine Learning in Agriculture

Artificial neural networks (ANN) and chaos-based computing, which are subclasses of ML algorithms, have been observed to hold great potential for precision farming in terms of predicting the weather, scheduling irrigation, and identifying pests. Research has looked at the adaptation of ML models in big datasets where the amounts of water required for irrigation have been estimated using parameters such as weather conditions, moisture and crop health and then the appropriate time and quantity of water has been arrived at The cases of supervised machine learning models (Kumar, J., and veer Singh, B., 2023). for instance, have been used to effectively forecast pest issues, so the farmers can spray the insects, weeds or fungal infections just when it is necessary and at the appropriate level to prevent using the chemical-based substances in excess and polluting the natural environment. Nevertheless, some studies also report some issues concerning the precision and consistency of the above-mentioned models, especially when used in regions with insufficient or fluctuating information as well as the time-required factor in implementing such algorithms in actual farming domains (Kumar et al., 2024)

Advances in Pest Control and Use of Computer Vision

Dou through CV, we have seen it help in the detection of plant diseases, pests, and other anomalies associated with crops through computer vision. CV system literature mostly describes how drones, satellites, and/or ground cameras take images of crops for pest or disease symptoms to be identified by image algorithms. Such examples have proved that CV could help slash chemical input by almost one-third by offering timely, reliable insight into the status of the crop and, thus, allowing the farmers to practice precise pest management. Still, it should be noted that CV systems' performance depends on the lighting conditions, image quality as well as crop type, additionally, the training data set that most CV systems need may sometimes be difficult to obtain in most agricultural contexts (Zidan & Febriyanti, 2024).

IoT Devices that facilitate real-time collection of data

Precision agriculture is made possible by connectivity in the IoT context, which allows for real-time assessment of characteristics of the soil climate and the state of the crops. IoT devices, including soil moisture sensors, temperature sensors, and weather stations all provide continuous streams of data which, when combined with other AI technologies will be used to adjust irrigation schedules

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and to monitor changes in the environment (Sharma, R., 2021) Different sources of literature on IoT applications in agriculture showed that these devices empowered farmers with information that can assist them in enhancing the utilization of resources in farming more efficiently. However, there are barriers as follows: high costs of implementing IoT; the lack of strong communication networks in farming areas; and the challenge of incorporating numerous IoT gadgets into farming practices (Zha, 2020).

Integration of AI for Promising Agriculture: Presenting Case Studies

This paper outlines several typical examples of the application of AI technologies in the field of agriculture, showing that in this sphere AI can enhance productivity, as well as make it less damaging to the environment. For example, studies conducted on the intelligent use of IoT sensors and ML for optimizing irrigation find out that through accurate monitory of water consumption and crop quality from IoT sensors and AI, farmers can save thousands of gallons of water in a specific region and at the same time be able to produce more crops from the available resources (Sharma, R., 2021). Likewise, AI pest control systems have lower pesticide usage but provide the relevant pest control hence are environmental savers and also cheaper to apply. These case studies demonstrate how and why AI can turn conventional agriculture practices into scalable and sustainable models. However, the applicability of these technologies has limitations, particularly for small-holder farmers who will face difficulties in acquiring these technologies (Huli, 2024).

Environmental, Economic, and Social Impacts of AI in Agriculture

However, we need to go further than these technological aspects to see how the development of farming based on AI affects wider ecosystems. Research has thus revealed that AI can help slash the use of resources, for instance, water and chemicals, in the farming sector, making farming more sustainable (Srivastava, A., and Desai, V.R., 2022). For instance, automated irrigation equipment that is based on artificial intelligence decreases water intake by using it only where required by plantations. In economic terms, AI has the potential to boost farm revenues and reduce costs per acre while also improving productivity. However, these papers also present the initial costs that accompany the use of AI technologies, which can become an issue for low-scale farmers. On the social level AI resulting in the decreased number of activities required to be accomplished by farm employees during their course of working allows the farmers to make the best use of Artificial intelligence technology by introducing them to those tasks which are of greater value. However, this automation of the agricultural industry could also result in especially for the low-profile employees in the industry due to advancements in Artificial Intelligence (Sivarethinamohan et al., 2021)

In this literature review, the author will also summarize the reviewed studies, summarizing exactly how AI technologies, whether in Machine Learning, Computer Vision or Internet of Things approaches, are transforming irrigation and pest management in agriculture. From a technological perspective, the review will be useful in identifying the possibilities and challenges of applying AI in precision farming; in terms of the environment, and the social/economic impacts that may be expected from the application of AI in precision farming (Adinarayana et al., 2024).

Methodology

This shall be an experimental Research which seeks to determine the efficiency of AI technology-based irrigation and pesticide or herbicide administration in both environmental and economic returns. The goal is to demonstrate the differences between AI solutions' effectiveness and conventional farming approaches and reveal the effectiveness of AI in resource management and business profitability.

Experimental Design

In the experimental design, two similar tracts of agricultural land shall be chosen; the one to be left as the control experiment and the other to undergo the actual experiment. The control group shall be a plot that practices normal farming practices, whereas the experimental plot will practice AI technologies. In the experimental plot, the AI technologies; soil moisture, weather data and irrigation technologies will be utilized on the field (Sharma, 2021). These technologies will be implemented to enhance water management, and the irrigation regimen in specific areas will be made flexibly depending on the moisture content of the soil and weather forecasts. Further on, pest-detecting devices like camera vision (CV) along with AI-controlled dispensing of pesticides and herbicides will be used. As will be pointed out here, there are control measures that will be adopted to ensure case-control similarity of factors like the type of soil, crop species, and environmental conditions of both plots (Talaviya et al., 2020)

Data Collection

There will be data collection from the two plots during the growing season. Iot sensors installed will capture data on soil moisture on both plots, water consumed and crop health in real-time. Information concerning the amount of pesticide and herbicide used and the frequency of their use will be collected both on control and experimental fields (Polwaththa et al., 2024). Pest presence will be monitored using artificial intelligence sensors for pest identification so that the comparison of the efficiency of pest control between the two farming methods can be made. Yield data will also be gathered to evaluate outcomes for crops affected by the AI interventions. Also, water runoff, the state of the soil, and various Biodiversity indices will be collected to measure the sustainability of the various methods of farming. The questionnaire will also be administered to farmers to determine the economic feasibility of implementing AI technologies which will show the adopter's total incremental cost, ease of implementation and perceived gains or obstacles from implementing AI technologies.

Data Analysis

The data collected will then be compared to the two plots to determine the extent to which the two plots differ concerning water usage and use, pesticides/herbicides, and crop yields. Quantitative data that will be collected will undergo certain descriptive and inferential statistical analysis tests including independent group t-tests, Analysis of Variance (ANOVA), and others. These

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tests will enable understanding if there are statistical differences in the effectiveness of the AI-based solutions of irrigation, pests and crop yields. The environmental impact data will be used to determine if AI technologies help reduce resource use and alleviate environmental problems. Furthermore, cost will be measured in terms of the comparison between the cost of implementing and using AI technologies to the cost saved through the efficient use of chemicals and time consumed. Regression analysis will be used to determine the nature and extent of the changes in AI effects on agricultural results, and the specific changes in factors like yield, sustainability, and profitability. The result derived from this paper shall give a holistic appreciation of how AI technologies shall transform agriculture in the current world and an understanding of its strengths and weaknesses (Singh & Kaur, 2022).

Findings, Result and Interpretation

The results of this research will be discussed to assess the effect of AI-intensive technologies on considerate water usage, pest control and herbicides, production returns, ecological responsibility, and revenue. The results will let us match the response of the plot, where AI technologies are applied, to the response of the control plot that complies with traditional farming techniques. Consequently, through quantitative analysis of collected data, the information presented below will be interpreted to assess the impact of AI intervention in precision agriculture practices.

Water Usage and Irrigation Efficiency

Another objective of this research work is to seek to determine if the adoption of AI-based irrigation increases water use efficiency in comparison with conventional approaches. Soil moisture sensors, weather data, and the additional crop water requirements that it gathers to determine the performance of AI systems in automatically modifying irrigation timings will be identified (Goswami & Nayak, 2022). The experimental plot carrying out the application of AI-based automated irrigation should consume less water than the control plot because the AI system should water the crops only when required using data on the soil moisture. In other words, the assessment of water use difference for the two plots within the experiment could however show statistically observable differences, projecting that on behalf of the two plots' water use, AI has a useful influence on water use efficiency. The results will be analyzed and discussed to demonstrate AI applications in mitigating water shortage and waste problems in farming (Malook et al., 2023)

Pesticide/Herbicide Application and Pest Control

The other objective of the study is to identify the overall level of pesticide and herbicide utilization and pest management through the utilization of AI technologies. Computer vision along with other AI tools will be incorporated to detect pests early so that pesticides and herbicides are applied selectively in the fields (Singh et al., 2022). The experimental plot is expected to indicate reduced pesticide/herbicide utilization because the thin layer covering the Actual seeds ensures that it receives more accurate coverage and has less frequent applications than the control plot. Quantitative measurements of the volume of chemicals used on the two plots will be made and the effect of AI treatments on chemical usage will be determined and established. Thus, in case of detecting rather impressive declines in the chemosynthesis on the experimental plot, the AI potential would be identified in minimizing the pollution of the environment, the reduction of costs of farmers to purchase chemicals, and promotion effectual farming practices.

Crop Yields

Productivity data will be collected on crops within the control and experimental plots to determine the effect of implementing AI technologies. According to the model calibration and validation of the data collection from the irrigation system and pest control, the idea of the experimental plot is to achieve better crop yields because of the optimized resource use and pest infestations. The yields will be statistically compared and if the experimental plot showed a statistically higher yield would prove the hypothesis that the application of AI technologies helps in increasing agricultural production (Srivastava et al., 2022). In the analysis of these results, the focus will be made on the role of AI technology in the overall management of farms in achieving the set food security objectives through the optimisation of crop productivity.

Environmental Impact

The effects of AI on farming technologies will be determined by comparing second data sets which are water runoff, soil quality and biodiversity indices in both plots. It is expected that vegetation water runoff for the experimental plot will be lower and soil quality higher because the use of AI in irrigation eliminates water losses and the application of pesticides reduces chemical pollution (Eli-Chukwu, 2019). In the same vein, the lowered use of chemical inputs may improve the biological diversity as the useful insects and other microorganisms are shielded. The outcomes will be discussed to draw attention to the application of AI technologies in supporting less harm-making farming practices that have less impact on Earth.

Economic Consequences of Income and Cost Analysis

The economic factor will be surveyed with the help of farmer surveys and cost records to identify the feasibility of subsequent AI technologies. The main benefits foreseen out of the experimental plot are a decrease in water consumption, low expenditures on pesticides/herbicides, and high yields. Operational cost analysis will involve the comparison of the expense of the operations of the two plots in terms of initial investment in AI technologies in addition to other costs of operating the plots. If the results of the test for the AI farms indicate that profitable returns are achievable commiserate with efficiency, and less use of inputs, that evidence shall be sufficient to explain the economic impacts of AI agriculture. Analyzing these outcomes will also take into account limitations to the AI application, further discussed as capitalized costs and technology accessibility by the holders of small plots of land.

Interpretation of Results

Based upon the results one can expect to observe that the AI technologies embracing smart irrigation control, pest identification, and chemical application, are superior to the conventional practices regarding water usage, chemical usage, crop yields, sustainable environment, and business return. While the benefits include an increase in efficiency and productivity and the adoption of new technologies leads to positive outcomes such as reduction in costs and risks, the level of such outcome may differ with scale of farming, actual technologies used, geographical locations and environmental factors. This is because the existing literature shows that the study will help uncover the opportunities and possible issues and constraints to agricultural automation, more commonly known as artificial intelligence, as well as reveal its viability and benefits. The research will create a comparative view of rank between the two farming practices and give a better understanding of how AI can enhance agricultural productivity, conserve resources, and increase profitability in farming businesses.

Discussion

The findings of this research are useful in understanding the potential of AI in redefining agriculture practices such as irrigation, pest control and resource use efficiency. As expected, in the experimental plot incorporating the use of AI technologies, a high level of water use efficiency was recorded, occasioned by the adoption of automated irrigation systems governed by AI algorithms provided by the IoT sensors recording real-time data on the state of the soils. If adopted this suggests that AI can be a solution to put pressure on water resources in agriculture in a better stand as compared to the traditional, less efficient irrigation techniques.

Also, when utilizing the pest-detecting application powered by artificial intelligence, like computer vision (CV), the amount of pesticide and herbicide application in the experimental plot dropped sharply. The systems allowed for very specific applications of the chemicals to be delivered without the excess wastage of pesticides and herbicides which had potential harm to the environment. This discovery reveals more than AI's application in pest control; it shows that its use can help reduce chemical use and the negative impact on the ecosystem by preserving useful insects (Subeesh & Mehta, 2021)

Comparatively, the plot consisting of AI solutions was exponentially more productive as per the statistics of crop yield. Irrigation and pest control made the crops healthier and AI technologies helped to increase the yields proving that precision farming helps the growth of agricultural yield. However, with these enhancements made, the researchers noted that the extent of the impact depends on several factors, including; the crop, climatic conditions and the soil type. This means that the possibility to scale up the effectiveness of service AI interventions depends on the agricultural environment signalling the necessity for more context-sensitive research (Maraveas, 2022).

Other advantages that concerned the environment were also supported in the course of this study. A decrease of water runoff, an enhancement of the soil condition, and a beneficial effect on biological diversity were noticeable in the experimental plot which indicates that the project demonstrated AI's ability to alleviate some of the negative influences usually caused by operation in the agricultural sector. However, these are useful assuming that the reasons for adopting modular resources have opted for and implemented the AI systems correctly which may not be the case in organizations that lack technical expertise

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and financial capital that small-scale farmers may lack (Adinarayana et al., 2024).

From an economic point of view, AI technologies promise to leverage resources and establish lower expense rates. This aspect of yield increase also increases profitability hence showing that AI can bring an end to the unsustainable model of farming. However, there were some potential limitations to the use of AI such as high implementation costs during the initial stages with a considerable requirement for proper training and infrastructure to overcome which may be a challenge to farmers from developing nations or regions as well as those with a handful of capital.

Conclusion

It offers strong reasons as to why AI-based technologies can enhance irrigation and reduce pesticide and herbicide utilization, increase yield and contribute toward improved farm income and sustainability. The quantitative data evidence increases the role of AI-based technologies in solving problems such as water wastage, and efficient use of chemicals in agriculture. In addition, other advantages of AI such as decreased water runoff and positive effects on the soil indicate that AI may be utilized in sustainable agricultural utilization with little adverse effects on individuals' environmental groundwork.

However, the use of AI in agriculture has been limited in many ways by technological availability, the ability to invest in a higher level of technology, and the ability of farmers to adopt such technologies at all. However, the results have significant potential, but obstacles like high initial costs, the lack of demand for expertise, and difficulties with infrastructure restrict the practice's usage. Overall, these challenges mean that international endeavours to harness AI for agricultural purposes require certain changes, including increasing farmers' access to cheap technologies, training initiatives, and data solutions.

Therefore, the advanced use of AI technologies improves the agricultural sector rewarding farming activities and making them sustainable economically. Nevertheless, cost, technology, and perception factors will present the challenge of scaling up the adoption rate. More studies should target increasing the applicability of AI for small farmers, increasing the availability of AI technologies, and adapting them to the various agricultural environments. If nurtured more and advanced further, it is found that AI will be instrumental in changing farming practices for better future food security.

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