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ARTIFICIAL INTELLIGENCE TOOL FOR AGRICULTURAL EMPOWERMENT: MACHINE LEARNING

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ABSTRACT

India has the second-largest agricultural land area in the world, with almost 60% of rural Indian households relying on agriculture for their livelihood. We are mostly dependent on farmers to support us, and half of India's workforce works in agriculture. Changes in agriculture are becoming increasingly required in the contemporary environment due to a number of factors, including population growth, climate change, and increased food demand. If nothing changes, the agricultural sector may not be able to feed the world's growing population due to its severe issues. Precision farming, data analytics, and machine learning are examples of contemporary technology that can revolutionise agriculture by increasing productivity and decreasing waste. The productivity, sustainability, and profitability of farming might all be increased by machine learning, which has the potential to fundamentally alter how farmers treat their crops and cattle.

INTRODUCTION

Agriculture, a sector essential to human existence, has evolved dramatically over time. According to the World Bank, over 80 per cent of the world's poor live in rural areas and many of them depend on agriculture as their main source of income. According to the FAO, chronic undernourishment affects over 820 million people globally, and the COVID-19 pandemic has made the situation worse. Agriculture is a significant source of income for many people, particularly in poor countries. In low-income nations, it makes up roughly 25% of GDP, whereas in middle-income nations, it makes up around 10%. Empowering agriculture is crucial for preserving food security, reducing poverty, and promoting economic growth since it increases their output and income. According to the International Fund for Agricultural Development (IFAD), small-scale agriculture investments might lead to a 4.5% reduction in poverty for every 1% increase in agricultural production.

Among the many environmental issues that agriculture greatly contributes to are deforestation, soil erosion, and water pollution. Environmental sustainability may be advanced by promoting the use of sustainable practices such as conservation agriculture, agroforestry, and organic farming. The FAO claims that using sustainable farming practices may increase crop yields by up to 79%, reduce greenhouse gas emissions, and enhance soil health. Modernising agriculture is becoming increasingly important for a number of reasons, including population growth, climate change, and increased food demand. If nothing changes, the agricultural sector may not be able to feed the world's growing population due to its severe issues. One of the main factors causing the need for change is population growth. According to UN estimates,

the world's population will reach 9.7 billion by 2050. Food production will need to increase by as much as 70% in order to meet the demand. However, current agricultural practices such as soil degradation, water scarcity, and deforestation are already having a negative impact on the environment. All of these elements are causing productivity and yields to decline. Another aspect influencing the need for agricultural transformation is climate change. Agricultural production is being impacted by rising temperatures, shifting weather patterns, and an increase in the frequency of extreme weather events. The World Bank estimates that agricultural yields might drop by as much as 25% in some areas due to climate change, resulting in food shortages and price increases. The need for food is rising globally along with the middle class. By 2030, the global middle class is expected to have doubled, mostly due to rising nations, according to the Organisation for Economic Cooperation and Development (OECD).

In order to address these issues, agriculture needs to change. One strategy to boost output and cut waste might be to use contemporary technology like precision agriculture, data analytics, and machine learning. To protect the ecosystem and boost climate change resistance, it can also entail moving to more environmentally friendly farming methods including agroforestry, conservation agriculture, and organic farming. Technology has revolutionised agricultural production and management, increasing farming's productivity and efficiency. Machine learning is among the most important technical developments in agriculture.

Machine learning (ML), a subfield of artificial intelligence (AI), is concerned with creating computer systems that can identify patterns, learn from data, and make decisions without the need for explicit programming. Machine learning has gained prominence in recent years because to its applicability in a wide range of industries, including marketing, finance, healthcare, and transportation. Through the management of crops and animals, machine learning has the potential to revolutionise agriculture by increasing farmer productivity, sustainability, and profitability. The potential of machine learning to increase crop yields and decrease waste is one of its primary advantages in agriculture. Farmers may improve irrigation, fertilisation, and pest control by using machine learning algorithms to analyse data on soil moisture, temperature, weather patterns, and other factors. Machine learning has the potential to cut fertiliser consumption by up to 50% and boost crop yields by up to 70%.

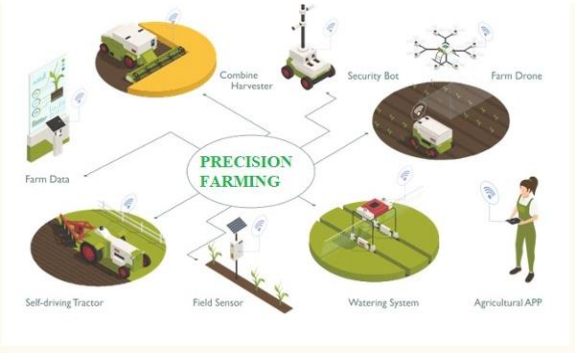
Machine learning may also help ease the sector's labour shortage by automating tasks like planting, harvesting, and sorting agricultural products. According to a USDA study, labour shortages have a significant influence on the agriculture industry, with many farmers struggling to recruit enough employees to meet their needs. By using robotics and machine intelligence, farmers may increase their output and efficiency while reducing their need on manual labour.

Applications of Machine Learning in Agriculture

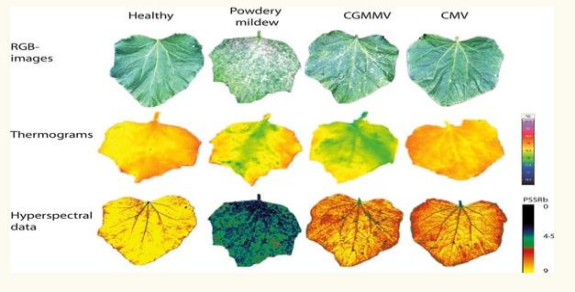
Machine learning has the potential to change farming practices and spark a new agricultural revolution. Because technology allows farmers to quickly analyse large amounts of data to maximise their operations and make educated decisions, it has become more important in the agricultural industry. Machine learning may help farmers understand soil conditions, crop yields, and other factors that affect their crops. This information might then be

used to create more effective and productive farming practices. Additionally, machine learning algorithms may be used to automate some tasks, like as irrigation and pest control. Farmers are able to reduce their environmental effect and increase their revenues by utilising machine learning. The general agricultural domains where machine learning is essential are as follows.

a) Precision farming: Technologies for optimising the use of resources, including water, fertiliser, and pesticides, are used in precision farming. Precision agriculture benefits greatly from machine learning, which enables farmers to make better decisions regarding crop planting, fertilisation, watering, and harvesting. By accessing data from a range of sources, such as weather patterns, soil moisture levels, and crop health, machine learning algorithms may assist farmers in streamlining their operations to increase yields and decrease waste. A research conducted in the United States found that utilising machine learning algorithms to improve irrigation plans can result in a 30% boost in crop yields and a 50% reduction in water usage. In contrast to traditional methods, machine learning can improve agricultural production forecast accuracy by as much as 80%, per another Chinese study. ML and AI may analyse sensor and other data to determine the precise amount of resources needed for each crop. This might lead to significant financial savings for farmers and more sustainable farming practices.



b) Disease and pest detection: Artificial intelligence and machine learning have demonstrated significant potential in the identification and control of agricultural diseases and pests. These technologies can accurately detect and diagnose the presence of illnesses and pests by evaluating vast volumes of data, enabling more focused and effective management techniques. According to a Brazilian study, citrus greening disease might be identified with an accuracy of more than 90% by analysing hyperspectral imaging data of citrus plants using machine learning algorithms. With an accuracy rate of more than 85%, researchers have also shown how well machine learning works for detecting and forecasting the severity of rice sheath blight illness. AI and machine learning may also be applied to the control and detection of pests. Machine learning algorithms have been used to forecast the presence and dispersion of an invasive insect pest, the brown marmorated stink bug, in apple orchards.

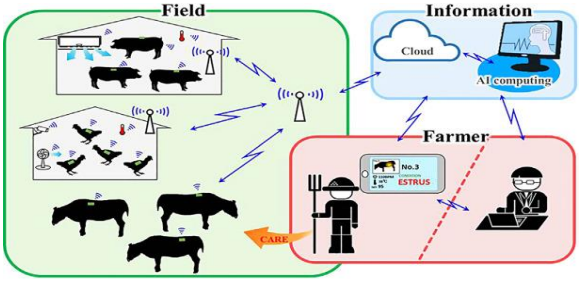


c) Crop monitoring and yield predictions: Machine learning and artificial intelligence are increasingly being used in precision agriculture to track crops and predict yield. ML and AI algorithms may be used to evaluate drone or satellite photographs of crops in order to identify any changes or abnormalities. Farmers may get the most recent information on the growth and condition of their crops thanks to these technologies. Algorithms that can predict agricultural yields based on historical data and current conditions may help farmers make better

decisions about when to plant, irrigate, and harvest their crops. In addition to improving agricultural monitoring and production prediction, AI and machine learning have the ability to maximise the use of fertiliser and irrigation. These technologies can assist farmers in figuring out the best time and quantity to apply water and fertiliser by evaluating data on crop development, weather patterns, and soil moisture levels. This can maximise agricultural yields while resulting in considerable input cost reductions. It was discovered that applying machine learning increased tomato output by 4.3% while reducing fertiliser consumption by 29%. In a similar vein, employing AI-based irrigation systems preserved or increased agricultural yields while reducing water consumption by 30%. Using soil and climatic data, researchers have also used machine learning to predict agricultural yields with up to 90% accuracy.

d) Robotic farming: Machine learning (ML) may automate a number of operations, including planting, monitoring, irrigating, and harvesting, which can boost productivity and cut expenses. In order to maximise agricultural output, machine learning algorithms have been employed to assess data from sensors installed on planting equipment and modify seed location. With this method, the amount of seed used was reduced by 10% while yield increased by up to 8%. An other example is the use of self-sufficient tractors that can plant, spray, and harvest crops. It has been demonstrated that autonomous tractors may save labour costs by up to 20%, increase crop yields by up to 5%, and use up to 20% less fuel.

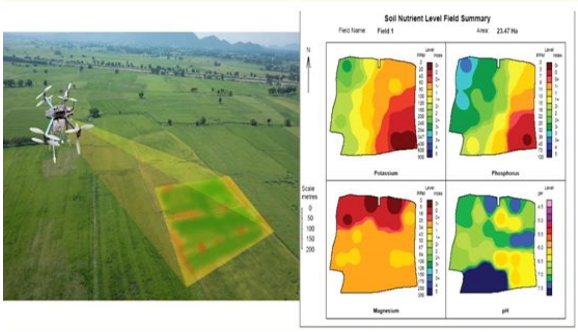
e) Livestock monitoring and management: Artificial intelligence and machine learning have also showed great promise in the monitoring and management of cattle. By evaluating data from sensors and devices, these technologies can give real-time information on the health and activity of individual animals, allowing for more targeted and effective management strategies. Machine learning (ML) and swarm intelligence (SI) systems were able to detect cow lameness with 90% accuracy by evaluating accelerometer data from leg-mounted sensors. Additionally, it has been demonstrated that machine learning can accurately anticipate, up to 93% of the time, when pigs will become ill based on behavioural changes. A Danish study that used machine learning to analyse pig growth and development data was able to identify specific factors that influence growth and predict the pigs' ultimate weight with up to 93% accuracy.



f) Climate risk management and weather forecasting: Machine learning (ML) significantly improves climate risk management and weather forecasting in agriculture by evaluating data from satellite photos, weather patterns, and historical

weather data. These technologies can provide more precise and timely weather forecasts, as well as assist farmers in managing climate change-related risks including drought, floods, and unexpected rains. In an Australian research, droughts were predicted up to four months ahead of time with an 82% accuracy rate using machine learning algorithms that analysed satellite data and other environmental factors. In contrast to traditional statistical models, which had an accuracy rate of about 60%, researchers discovered that the machine learning model performed better. A new weather forecasting model was able to predict rainfall with an accuracy rate of up to 80%.

g) Soil analysis: This method is very useful in soil analysis since it provides accurate and current information on soil fertility, nutrient levels, and quality. With this knowledge, farmers may make better decisions about their farming operations, such as which crops to grow, how much fertiliser to use, and how to sustainably maintain their land with correlation values of 0.65 and 0.75, respectively, it has been shown that machine learning algorithms that analyse soil data and predict nutrient levels are accurate in predicting phosphorus and nitrogen levels. Furthermore, it can identify areas of deteriorated soil by analysing satellite photos. Additionally, a model with an overall accuracy of 85.6% was developed that could effectively forecast deteriorated regions.



Challenges of Implementing ML & AI on Farms

Although machine learning (ML) and artificial intelligence (AI) have shown great promise in transforming agriculture, a number of challenges must be addressed before their full potential can be reached.

a) Data collection and management: For ML and AI systems to provide accurate predictions and judgements, large amounts of data are required. However, collecting and arranging data in agriculture may be difficult due to the significant variations in crop growth, weather patterns, and other factors. Furthermore, there is a lack of standardisation in data collection methods, which makes it challenging to compare data from different farms and regions.

b) Technical Expertise: ML and AI to be developed and function, certain technological know-how is needed. It's possible that farmers lack the skills necessary to create and deploy ML and AI systems. To put these technologies into practice, they might have to collaborate with technological partners or recruit data scientists.

c) Infrastructure and technology adoption: Significant investments in infrastructure and technology, including sensors, drones, and computer power, are needed to use ML and AI on farms. Small and medium-sized farms may find this to be a hurdle since they lack the funding or technical know-how to use these technologies.

d) Integration with existing systems: ML and AI to be effective, they must be combined with

current farm management procedures and systems. Because agricultural systems are complicated and algorithms must be tailored to certain crops and geographical areas, this may be difficult.

e) Lack of trust and knowledge: Some farmers could be reluctant to use ML and AI technology because they don't trust them or don't comprehend how they operate. Programs for education and training that assist farmers in comprehending the advantages and constraints of these technologies can help solve this.

f) Data privacy and security: As more information is collected and shared among farmers, service providers, and other stakeholders, the likelihood of data breaches and privacy infractions increases. Farmers must ensure that they retain ownership of their data and that it is secure.

Farmers, tech firms, and lawmakers must collaborate to get beyond these barriers and create an atmosphere that promotes the application of ML and AI in agriculture.

CONCLUSION

Agriculture is undergoing a transformation because to data-driven accuracy brought about by machine learning (ML) and artificial intelligence (AI). With the use of these technologies, farmers may effectively examine vast databases in order to maximise farming decisions. By identifying the best ways to utilise water, fertiliser, and pesticides, machine learning (ML) helps precision farmers increase crop output and resource efficiency. Research shows that ML based irrigation scheduling may save up to 50% of water and enhance production by up to 30%. AI systems help identify pests and illnesses early, allowing for prompt action to minimise agricultural losses. For example, hyperspectral imaging can identify citrus greening with an accuracy of above 90%. Based on past and current data, machine learning models can project yield with an accuracy of up to 90%. Applications for robotic farming increase yields by 5–8% and reduce labour costs by 20% by automating planting, watering, and harvesting. By accurately forecasting disease risks and tracking animal health, machine learning also enhances livestock management. AI also improves climate risk management and weather forecasting, which helps farmers lessen the effects of floods and drought. ML based soil analysis detects degraded areas for reclamation and provides information on the best way to apply fertiliser. However, there are obstacles to ML and AI implementation, including a lack of technical knowledge among farmers, a lack of data standardisation, and expensive infrastructure. Adoption is further hampered by issues with data protection and integration with current agricultural systems. To overcome these, politicians, technology developers, and academics must work together, engage in farmer training, and create supporting regulations. All things considered, ML and AI hold the potential to improve food security issues while increasing agricultural productivity, profitability, and sustainability.

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