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Utilisation of Artificial Intelligence for Improving Farmers' Income

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Artificial Intelligence (AI) is revolutionizing the agriculture industry, maximizing the efficacy of resource utilization, lowering the operational costs and leading to an increase of farmers' income drastically. In precision agriculture, farmers get to take advantage of AI tools, which not only assist them with weather predictions but also allow them to keep tabs on soil quality and satellite-detect pests. With that information, farmers can make a better use of the resources they apply to the soil in terms of water, fertilizers and insecticides. Furthermore, AI allows farmers to foresee changing trends in the market, thus breaking the traditional supply chain of agricultural products. The application of AI technologies in agriculture reduces farmers' risk of climate change, thus enabling farming to be fully data-driven process.

Keywords: Artificial Intelligence (AI), Machine Learning (MST), Internet of Things (IoT), Precision Agriculture, Smart Farming, Predictive Analytics

Introduction

Agriculture will remain the chief means of earning a living for many farmers living in rural locations because agriculture serves as the basis of a rural economy, which is also true for agrarian policy that must address several obstacles. These include erratic climatic conditions, decreasing soil fertility, diseases in crops and livestock, high input costs, shortage of labor, and changes in prices in the market. All these issues may seriously undermine farmers' profitability, even having achieved a high level of crop production. In this respect, the use of Artificial Intelligence (AI) creates an opportunity to enhance productivity, efficiency and profitability in agriculture. AI is the term used to describe the technologies that utilize computer programs which learn from data while discovering correlations and predicting outcomes. In agriculture, AI can utilize weather data from weather stations, satellites, drones, soil sensing devices, farm equipment, market databases, and historical crop data to deliver useful information to farmers, which is instrumental in making educated decisions on time. The goal of using AI in agriculture should not only be to enhance production. However, its greater significance should be seen in terms of raising net profits by increasing production

efficiency, limiting useless spending, minimizing losses, and allowing farmers to achieve more favorable prices for their produce.

AI in Precision Agriculture

Precision agriculture is an important area of use for artificial intelligence in agriculture. It was common to use the same volume of irrigation, fertilizer, or herbicide across the field, notwithstanding the fact that plants need different levels of these elements in different locations within the field. The specific technology in agriculture can utilize data from satellites, drones, GPS-based technology, and IoT sensors. This allows one to determine the unevenness of crops cultivation, moisture of soil, level of nutrition, and crop stress. The farmer can then apply the input according to the actual needs of the relevant area within the field. For instance, if the AI systems detect that the soil in one section of the field is sufficiently moist, irrigation should stop in this area. Usage of fertilizers will be done in an efficient manner if there is a demand from the soil for nutrients.

Weather and Climate Smart Agriculture

Weather has a considerable influence over agriculture. Unanticipated rains, droughts, heat waves, cold waves and storms cause great losses in the production of crops. AI and machine learning models can be used for analyzing the historical and present weather data in order to give a forecast about the risk associated with weather. Farmers will benefit immensely from AI-based forecasts if they want to know when to sow, irrigate and harvest their crops. If heavy rains are announced then farmers can postpone irrigation of crops or even harvest earlier when crops are already matured. If dry weather is known, then farmers can irrigate accordingly. AI also plays an important role in climate smart agriculture through the identification of the production techniques that will work the best under the new climatic circumstances.

Soil Quality and Effective Input Use

Soil quality is vital in sustainable agriculture. The excessive application of fertilizers raises operating costs and harms soil and the environment. Artificial intelligence allows for the establishment of targeted nutrient management strategies. Soil data on pH, organic carbon content, electrical conductivity, moisture, nitrogen, phosphorus, potassium, and other parameters can be processed using AI programs. On the basis of these data farmers get advice on the appropriate amount and timing of fertilizers. Likewise, AI irrigation systems can take advantage of the data on soil moisture and weather to determine when it is necessary to irrigate the field and approximately how much water is needed. Proper management of water and fertilizers will reduce input costs and increase the efficiency of resource use, which in turn allows reaching larger profits.

Early Detection of Pests and Diseases

Crop losses occur due to pests and diseases. Farmers usually perform visual inspections to identify the infection, so symptoms may be seen only after the occurrence of major damages. However, photo analysis can be performed by means of AI-based image processing techniques, which can process images made using smartphones and drones. Moreover, machine learning and deep learning models can identify characteristic signs of various pests and diseases. Timely detection allows farmers to undertake necessary measures. For instance, pesticides do not have to be applied to the entire field since measures can be properly targeted.

AI-Based Crop Yield Prediction

The accuracy of estimating the yield of the crop is of great importance for farmers when it comes to preparing their activities and marketing. The artificial intelligence algorithms utilized for yield forecasting are able to process the historical yield data with the climate, soil, crops, date of planting, methods of irrigation, fertilization, and other methods of government management. The possible algorithms that can be used for forecasting the yield using

machine learning are regression models, different types of decision trees, support vector machines, random forests, and neural networks. It is known that a good estimation of the yield helps the farmer in scheduling the harvesting process, storage and transportation of the produced products, hiring the necessary workers, and selling the food products in stores.



Market Intelligence and Better Price Realisation

Even when farmers achieve a high yield from their crops, it doesn't always mean making a profit. However, AI makes it possible to find a solution to this problem through market analysis based on such information as past performance, arrival of goods, demand patterns, trending periods etc. Predictive analytics enables getting predictions about future prices and aids in choice of the best time and the best place to sell harvest. In case storage capacity allows it and the prices will keep on increasing in the near future, growers may wait for selling their harvest. AI-based digital platforms can link farmers with customers, processors, retailers, wholesalers, and end consumers. The provision of better market information leads to increased transparency and diminished information imbalance between growers and buyers.

Reduction in Labour and Operational Costs

Agriculture labor shortages and work expenses are a growing issue. Time-saving technologies such as artificial intelligence (AI)-enabled automation and smart machines can do or assist with things such as crop surveillance, precision spraying, weed identification, and harvesting, along with field mapping. Machines with autonomous or semi-autonomous systems can use sensors, cameras, Global Positioning System (GPS), and AI algorithms to perform many operations with increased accuracy. Although the initial capital investment might be big, right agricultural mechanization could significantly lower ongoing labor costs and improve operational efficiency. For smallholder farmers and marginal farmers, shared machinery services, custom hire centers, farmer producer organizations, and cooperative models could enhance the access to AI-powered technologies without the requirement of possessing them.

Improving Farmers' Income Through Integrated AI

The integration of different types of agricultural data has the most promise. AI can combine the data about weather, soil, crops, pests, inputs, harvests, and markets into one effective decision-making tool. This tool can help farmers make the right decisions in crop production from the selection and sowing of seeds through the management of inputs to harvesting and selling crops.

The net income can be calculated based on the following simple formula:

$$\text{Net income} = \text{Revenue} - \text{Total cost}$$

AI can impact these two indicators positively and increase profits. It can lead to increased revenue levels due to enhanced crop yields and quality of produce as well as improved price strategies used. And it can help reduce costs as well thanks to the optimization of usage of water, fertilizers, pesticides, labour, energy, etc.

Table: Major Applications of AI in Agriculture and their benefits

AI application	Key Data Used	Core Function	Marginal Benefit
Accurate Weather forecasting	Temperature, precipitation, humidity	Weather-risk Assessment	Reduce Crop loss
Soil Testing	Moisture Level, pH, NPK	Nutrient management	Reduced cost of Cultivation
Crop tracking	Satellite/drone imagery	Assessment of crop growth	Early stress detection
Pest and disease tracking	Crop images, sensor data	Early identification	Less crop damage
Yield estimation	Weather, soil, and crop info	Yield prediction	Improved farm planning
Smart irrigation	Soil moisture, weather	Watering plan	Water and energy saving
Market forecasting	Price, demand, and supply	Price prediction	Increased profit
Precision spraying	Images, GPS, sensors	Targeted spraying	Reduced pesticide cost

Obstacles in Adoption

Despite the potential benefits, there are many challenges faced by AI technologies before farmers can be able to adopted in their farms. These challenges include initial costs needed to set up the systems, issues with digital literacy and internet infrastructure in some rural areas, scarcity of local datasets, and concerns about how complicated advice and recommendations from AI systems can be understood. Farmers may need inexpensive solutions given that they are specifically small producers. Therefore, the systems should be designed in such a way that information is easily understandable and can be used for local conditions. Data security issues must also be considered.

Future Prospects

There are several signs for indicating a promising future of AI in agriculture closely connected with the introduction of various techniques such as IoT, remote sensing, drones, robotics, cloud computing, mobile apps and up-to-date machine learning models. Agricultural advisory systems powered by AI can give more personalized advice based on a particular farm. The development of affordable technologies will be important for small and marginal farmers. AI applications that work in local languages will allow sowing agricultural information more effectively and bridging the digital gap. Thus, AI should be seen not as a substitute for farmers' knowledge but a tool to empower farmers in their decision making.

Conclusion

The incorporation of Artificial Intelligence (AI) technology will usher in the period of positive moments for agriculture. With AI, farmers will enjoy the possibility to make improved decisions concerning weather conditions, to handle soils and inputs effectively, to detect pests and diseases on time, to predict yield more precisely, and to run their businesses more economically. However, for the successful application of technology, the most critical aspect is the cost and reliability of technology; it should include minimal risks, if there are any. However, the main aim is to achieve higher productivity, reduced expenses, and an environmentally friendly way of sustainable resource utilization and higher income for farmers.