NOURISHING THE FUTURE

HARNESSING AI SOLUTIONS FOR SUSTAINABLE FOOD PRODUCTION AND SECURITY

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FOOD security is an ever-present issue and an eternal challenge for humanity. The Food and Agriculture Organization (FAO) estimates that almost 924 million people or 11.7 percent of the world's population have experienced extreme food insecurity. Inflation has skyrocketed in the post-COVID-19 economy, the Russo-Ukrainian conflict has disrupted supply networks, and unexpected weather patterns brought on by climate change are placing strain on the world's agriculture industry, causing food losses and shortages. The world needs to figure out how to adapt to the realities of climate change in light of the current food system crisis, and more significantly, how to do so while simultaneously producing more food more efficiently.

The issue of sustainable farming has risen to the forefront of debate in the current atmosphere of heightened social, economic, and environmental challenges. The population is expanding quickly, and this is a serious concern since it poses a number of difficulties that might endanger humankind's future. Food insecurity is mostly driven by economic factors. It is a condition characterized by inadequate and inconsistent access to a sufficient quantity of food to sustain an active and healthy lifestyle. In essence, a considerable number of individuals around the globe experience a scarcity of sustenance, rendering them uncertain about their ability to have food in the immediate or subsequent periods. Low-income families may experience the impact of several interconnected challenges. These include restricted access to arable land, instances of land-grabbing, conflicts, occurrences of natural disasters, the impact of climate change, as well as economic hardships such as unemployment, low-income, and price inflation.

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Source: Guliver Image

An AI-powered drone monitoring and spraying crops

A different tale is playing out in the world of entrepreneurs than that of politics, where delaying and deflection are often used to avoid responsibility. These forward-thinking businesses don't waste any time and are aggressively addressing urgent concerns related to food production and security. Modern agricultural technology has completely changed the way farming is conducted, providing a variety of innovative solutions that improve production, efficiency, and safety. These technical advancements, including but not limited to precision agriculture, automation, genetics, biotechnology, and resource management have made it possible to engage in agricultural methods that are more smart and environmentally friendly.

Nevertheless, in order to maximize resource allocation and minimize waste and losses, farmers and businesses should be able to use modern techniques to improve farming sustainability; and that technique is revolving around the use of "data." Nowadays, efficient farming relies on collecting accurate data on soil conditions, crop health, and weather patterns by using drones, satellite photos, sensors, and other

cutting-edge technologies that help farmers understand the crops and environment. With the use of vast amounts of data and knowledge, they can decide on many processes of farming such as irrigation, the fertilization process, and pest management with increased confidence that they can maximize resource allocation and minimize environmental harms. The good news is that many farmers and businesses from east to west are using these techniques, but others are still lagging behind. Labor-intensive jobs like planting, harvesting, and sorting have made farmers in rural areas more physically stressed and their time is almost entirely consumed by these operations, opening the possibility of crop failures and losses.

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But one innovation that has changed the agricultural landscape is artificial intelligence (AI) and machine learning (ML) algorithms, which can highly contribute to improved global food production and security.

Feeding the Farmers with Data

In today's rapidly evolving agricultural landscape, the importance of data cannot be overstated. Many countries depend on agriculture for economic growth, and this sector employs around 60 percent of the Indian workforce and accounts for roughly 18 percent of India's GDP. However, there is a significant loss in agriculture resulting from a lack of knowledge and usage of new technology and techniques. Crop damage and failure are caused by the over-dependence on conventional farming techniques, lack of resources and expertise in rural areas. But an increasing number of farmers and agriculture-related businesses in these countries alike are recognizing the value that data holds in enhancing the efficiency of agricultural practices to achieve resource maximization and profitability. By harnessing the power of data, they are able to make informed decisions and optimize their approach to farming.

In recent years, the agricultural sector has faced numerous obstacles such as unpredictable weather patterns, pest infestations, and resource management issues. AI and ML algorithms provide the capability to analyze extensive quantities of data supplied from diverse origins and subsequently enhance decisionmaking processes in domains facing difficulties. The solutions provided by AI have revolutionized agriculture practices in numerous ways according to recent literature and practices such as crop monitoring, pest detection, predictive analytics, food safety, and many others.

One of the most important aspects of precision agriculture that AI solutions provide is crop growth prediction, which is crucial for yield mapping and management to improve productivity. For example, ML has been used to analyze various commodities such as coffee crop yields in the tree branches. ML model divides coffee crops into three groups: coffee crops that have been harvested, those that have not been harvested, and those that are still maturing. The weight and ripening rate of coffee crops are also estimated using ML. The goal of using ML systems in coffee production was to teach farmers how to maximize financial rewards and organize their agricultural outputs. Cherry crop is another example where studies and practices have been applied within the realm of ML. Cherry-picking and vibration during harvesting was used during growth prediction in a machine vision sensor system. Even when sight can be hazy for farmers to identify which cherries are fully matured, ML vision sensor makes leaf-covered cherry in the tree branches visible. Another example of an early harvest mapping system is made to identify immature green citrus on citrus farms under specific environmental conditions. These maps provide farmers with the knowledge they need to estimate crop needs more accurately, enabling them to record crop performance, which in turn helps them make better management decisions. The major objective of using this ML technique was to cut down the amount of time and labor needed for hand harvesting and processing. Numerous other studies on a range of different crops, including rice, wheat, tomatoes, grass, and other crops, have shown the promise of AI solutions in agricultural domains.

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Pests and diseases that affect crops are another concern for farmers and businesses in the agriculture sector. One of the most widely used and common practices in pest and disease control is uniform spraying of pesticides over the crop area. This practice, although effective, is considered to have a high financial cost and significant environmental impact. Environmental impact can come down to pesticide residues in crop products, which then also have side effects on soil pollution, groundwater, impact on wildlife and ecosystems, etc.

But ML offers some solutions to address this problem, as ML and sensing are used to target diseased crops in terms of time and space. In one such example, a tool for detecting and distinguishing diseases and fungus during vegetative growth was presented. A new method based on image processing procedures has also been developed for the classification of parasites and automatic detection of a wide range of crops like strawberries and rice. The discovery of infected plants led to an increase in yields and a reduction in time spent relative to examination with the naked eye. And when the devices detect certain diseases, the sensor machines spray pesticides at the right place and time instead of using invasive spraying tools, which may cause many side effects to the environment in general.

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The detection and treatment of weeds is another concern with huge side effects on agriculture crops, where weeds are one of the biggest threats to crops that affect their productivity. Simply said, weeds are plants that flourish in areas where farmers do not intend for them to flourish. They are persistent, dangerous plants that prevent the development of crops and have a detrimental effect on agricultural output. Unwanted weeds usually grow next to the good ones. Accurate detection of weeds is of great importance for sustainable agriculture because it is difficult to detect weeds and distinguish them from crops. Thus, the role of ML systems with sensors for accurate detection and discrimination of weeds comes at a low cost and without environmental problems and side effects. ML sensors can accurately distinguish these species to preserve crops, which contributes to reducing economic and environmental losses.

By applying AI to sensor data, crop management systems have evolved into real artificial intelligence systems, providing richer recommendations and insights for decisions and actions related to improving production. It is expected that the use of ML methods in agriculture will be more widespread than today, which will allow the possibility of having integrated and applicable tools for farmers and businesses.

Within the domain of supply chain management, agriculture is widely acknowledged as a very intricate supply chain characterized by its multifaceted nature, including its complex stages of production, distribution, and consumption. In the realm of food production, AI has the ability to enable the optimization of production processes by monitoring crop health, predicting weather patterns, and optimizing irrigation and fertilization schedules across various aspects of crop cultivation. These AI-powered tools are instrumental in providing knowledge and guidance on crucial tasks such as crop rotation planning, determining optimal planting times, managing water and nutrient levels, implementing effective pest management strategies, controlling diseases, ensuring optimal harvesting practices, and even aiding in food marketing, product distribution, and food safety measures throughout the entire food supply chain.

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While the potential of these technologies to enhance global food security and address environmental and climate change issues is recognized, there are significant challenges in terms of establishing a conducive business ecosystem, engaging stakeholders to form strategies, supporting research and development (R&D) efforts, promoting awareness and education in countries where such reforms and support are most needed.

Overwhelming Obstacles Despite Meaningful Solutions

It is an inescapable challenge to enable AI for traditional farming producers and those who lack expertise in rural areas, especially in developing nations. There are many challenges that are faced in this domain. The first challenge is the cost of investing in the AI solutions. While AI may provide many benefits, it is important to acknowledge that the initial investment and expenditure might be rather substantial. The current financial challenges faced by several farms and agribusinesses make the implementation of AI unattainable, particularly for small-scale farmers and those operating in developing nations. However, the expense associated with the integration of AI is anticipated to decrease with time due to the availability of advanced technologies offered by agritech businesses. Moreover, there are other financial opportunities that contribute to cost reduction, including government grants and/or private investment.

The second challenge is resistance to change. People in general are reluctant to adapt to new technologies, which is another challenging aspect of implementing AI into agriculture. The impediment to the advancement

of agricultural practices and overall profitability of the sector stems from a reluctance to embrace innovation in agriculture. It is essential for farmers and enterprises to understand that AI represents a heightened iteration of previous technological advancements in data analysis and processing. Once they do, public-private partnership at both the local and regional levels will be of great importance to effectively address this issue, which can serve to promote the utilization of AI, while also facilitating the provision of necessary resources, training, and incentives. Collaborations with regional agricultural universities, research institutes, and non-governmental organizations (NGOs) are essential to advancing the knowledge and abilities of those working in the agricultural industry. These collaborations may be very helpful in developing thorough training programs that cater to the various requirements of farmers, researchers, and other stakeholders. Agricultural institutions may be partnered with to get important academic resources and knowledge in a variety of agricultural fields, including crop science, animal management, and sustainable farming techniques.

The third challenge is that AI solutions are not specifically targeted to the special requirements of areas and regions. Both low and-high income countries have different challenges and often face formidable obstacles when trying to acquire and use this cutting-edge technology. There is an increasing need to create AI solutions that are specifically tailored to the special requirements and resources of these nations in order to overcome this discrepancy. Localized AI solutions should be intended to solve the particular issues that regions confront. The provision of these particular solutions may successfully facilitate the utilization of AI, hence leading to favorable results while considering the constraints of limited resources, infrastructure, and knowledge prevalent across many continents. Affordability, user-friendliness, and compatibility with current agricultural practices are important considerations when looking for solutions in the agricultural sector. To guarantee broad acceptance and effective execution, it is critical to identify solutions that satisfy these special climatic, and environmental requirements.

The fourth challenge is the lack of infrastructure. For AI technologies to be successfully implemented, infrastructure and data access are essential. It is critical to have quick, simple access to the infrastructure and data required to fully realize the promise of AI. In order to train AI models and algorithms, data is essential; the ability of an AI system to learn and provide precise predictions or choices increases with the amount and quality of the data available. For many firms, getting relevant and trustworthy data can be a challenge. There can be restrictions on the kind of data sources that are available, accessible, or compatible. Thus, in order to support various sectors and advance development, it is essential to ensure dependable internet connectivity, access to agricultural databases, and the development of sensor networks for data collection. To improve access to data, it is important to establish data-sharing agreements, promote open data initiatives, and ensure data privacy. These factors significantly contribute to encouraging development and innovation across many sectors. Reliable internet and data access is one of the most important features of contemporary life. It has developed into a necessary tool for people, organizations, and communities to acquire information, efficiently interact, and take part in numerous online activities. The internet has changed how we live and work in a variety of ways, including education and healthcare as well as commerce and entertainment. Therefore, in order to close the digital divide and guarantee equitable possibilities for everyone, it is crucial to offer dependable internet and data access to all locations, especially rural and distant ones.

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The fifth challenge is economic in nature. Interest rate remains very high in most countries as a means for central banks to combat price inflation. An increase in interest rates can result in a decrease in anticipated profits due to the heightened expenses associated with borrowing and the manufacturing process. The agriculture sector has been affected by such policies worldwide. Thus, the government and non-government institutions may offer grants, subsidies, and low-interest loans to agriculture businesses and farmers. A funding initiative that aims to enable the use of AI in agriculture can be received from various sources, including governments, international organizations, and private sector entities. Entities may encourage innovation and create a setting that supports the deployment of AI technology by funding R&D. Those initiatives may result in higher production and sustainability of the food security. However, funding AI activities in agriculture is a major responsibility of international institutions such as the FAO and other similar organizations, which have already begun deploying projects and initiatives worldwide.

SOLUTIONS IN COLLABORATION?

It is more urgent than ever for governments, NGOs, academic institutions, and private businesses to collaborate in order to tackle complex issues and realize shared objectives. Collaborations have become a potent instrument for encouraging resource

sharing, skill exchange, and information sharing among these groups. They may use these assets and pool their resources to address urgent problems like reducing poverty, combating climate change, and public health crises by cooperating in partnerships. The complexity of AI technology necessitates a team effort, where specialists from different fields collaborate to share resources and information. The strength of cooperation resides in its capacity to unite various viewpoints and skillsets.

One of the other major challenges that agriculture sectors in many countries face is the lack of favorable and conductive economic ecosystem. It is essential to develop rules and regulations that provide a supporting environment in order to encourage the broad use of AI in the agriculture sector. These actions will motivate farmers and other interested parties to adopt AI technology and use it to improve agricultural practices. To overcome any possible obstacles or worries that would prevent the use of these technologies in agriculture, it is crucial to build supporting legislation and regulations. Furthermore, in the context of today's quickly changing technological scene, it is important to address issues like fostering an environment that encourages innovation, defending intellectual property rights, and guaranteeing data privacy and security. These elements significantly contribute to encouraging growth and development across diverse sectors. Creating an atmosphere that promotes experimentation and risk-taking is one of the essential components in encouraging creativity. This entails developing laws and rules that encourage entrepreneurship, opening up financial resources, and encouraging cooperation among many parties. Notably, countries such as the United Arab Emirates, Singapore, Japan, South Korea, and Israel have taken a leading role in this endeavor. By removing market barriers and, more significantly, facilitating the advancement of agricultural practices, countries can enhance their resource allocation and pave the way for the future of farming.

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Innovations within the AI and tech industry have the ability to transform agricultural practices and meet the challenges posed by a rising global population, climate change, and limited resources. AI can optimize agricultural output, decrease waste, improve supply chain management, and improve nutritional outcomes by using the power of ML, predictive analytics, and data-driven decisionmaking. Investing in AI in agriculture offers many solutions to increase food production such as accurate crop monitoring and management, resulting in greater yields and resource efficiency. AI-powered drones, sensors, and satellite imaging provide real-time monitoring and allow for the early diagnosis of illnesses, pests, and water stress. This also enables the analysis of massive volumes of data and provides farmers with actionable insights, allowing them to make smart choices and maximize agricultural output as well as improve the efficiency of the food supply chain, from production to consumption. AI tools can forecast market demand, optimize distribution routes, and eliminate post-harvest losses. This allows for better resource coordination and distribution, ensuring that food reaches those who need it the most.

Although AI has enormous potential for boosting food security by increasing agricultural sustainability and resilience, stakeholder engagement, research, and policy activities are critical to maximizing the advantages of AI while resolving the accompanying problems. The same applies to agriculture-related issues and constructing more efficient and equitable food systems that satisfy the requirements of present and future generations.