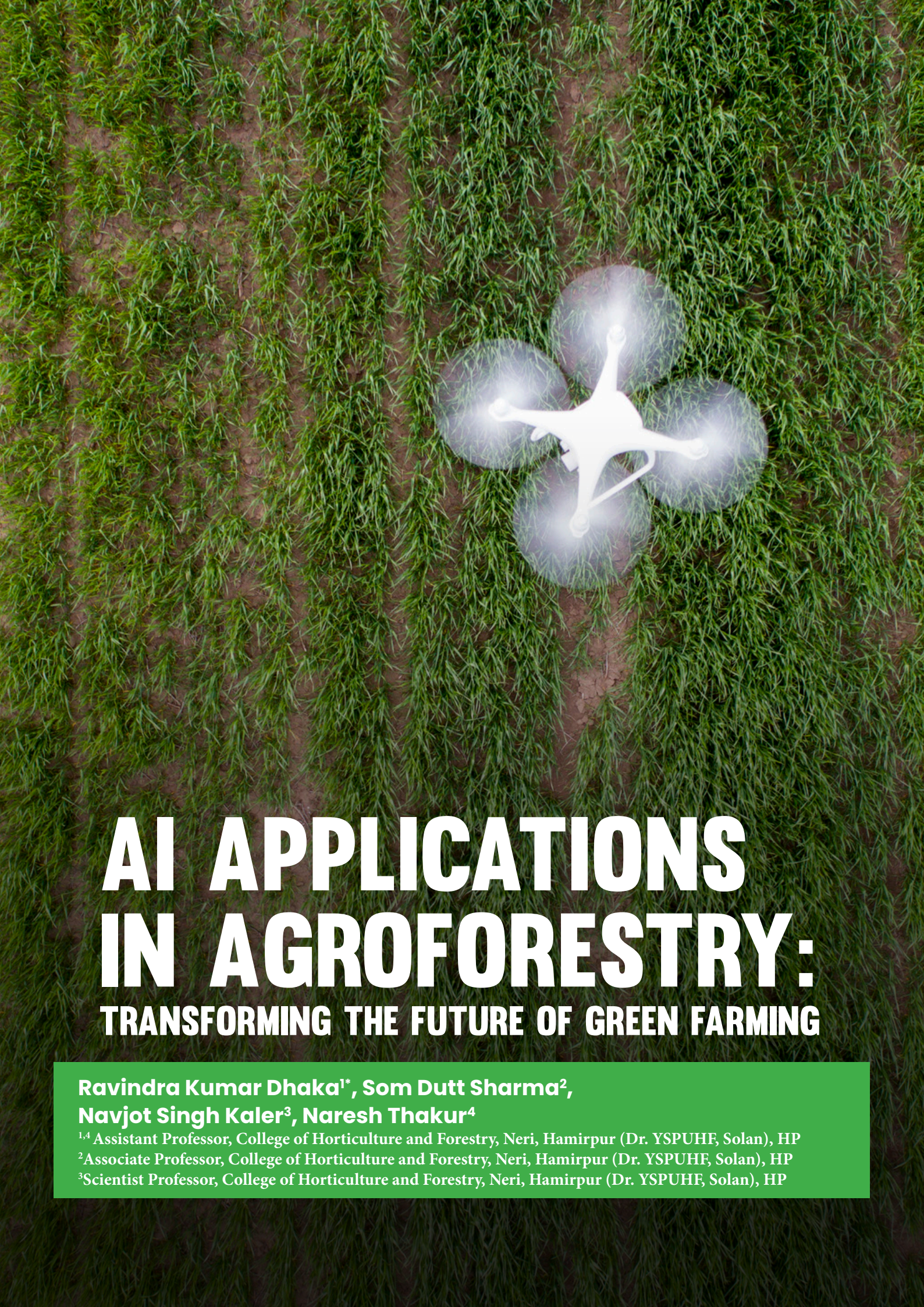

# AI APPLICATIONS IN AGROFORESTRY:

## TRANSFORMING THE FUTURE OF GREEN FARMING

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# INTRODUCTION

Agroforestry defined as an intensive and interactive land utilization system that optimizes the resources utilization patterns and mutual benefits from the interactions of biotic components such as deliberate use of trees and/or shrubs in combination with agricultural crops and/or livestock in temporal and spatial arrangements on the same piece of land. Agroforestry is the self-sustaining green technology to revolutionize future of Indian agriculture. Indian agriculture is backbone of the country's economy in which sixty percentage population is directly and indirectly depending on it for livelihood and income. Agroforestry is the fast-evolving science to address the issue of climate change and global warming along with carbon sequestration. For the modernization of agriculture, the uses of Artificial Intelligence (AI) have been started into various farming techniques from sowing to harvest. Now, there is a need of AI based technologies utilization in agroforestry to overcome the problems of labour, cost, time and accuracy or precision farming. The incorporation of AI- based tools and machine intelligence in the agroforestry farming is a paradigm shift from traditional old age farming practices. Artificial Intelligence has been rapidly emerged as a focal point in research point of view in computer science due to the swift of technological advancement as well as a wide-range of applications. AI-powered agroforestry plays a pivotal role in data collection, processing, evaluation, interpreting, acquiring knowledge and providing solutions to enhance the overall efficiency and productivity.

It is very essential to understand the complexity of agroforestry system, cropping patterns, succession, stratification, productivity and biodiversity on the land. However, a larger workforce is required to increase the farm productivity which also enables with employment opportunity and smart work in a reconnection with nature. Thus, AI and robotics in agriculture will not only observe a paradigm shift in agricultural

production but also provide additional employment opportunities. Thus, the integration of AI, robotics, machine and ancestral wisdom is the way of a transformative technological era to regenerate agriculture and agroforestry across the globe through encompassing diverse crops and livestock animals. This transformation will have a profound influence on mitigation of climate change effect, biodiversity conservation, global food security, soil health and nutritional health of humans by envisioning the future. The harmonious alliance between agriculture and forest trees will be crucial for a sustainable and long-lasting future. In connection to this, agroforestry enabled with AI-powered advanced technologies will provide more efficient food production, diverse ecosystem and restoration ecology which enhancing the resilience and adaptability of agricultural landscapes across the globe.

# ARTIFICIAL INTELLIGENCE (AI) AND MACHINE LEARNING (ML)

Artificial intelligence is powerful technology that encompasses computers and machines to simulate the intelligence of human to solve specific problem on the basis of logical reasoning and fast experiences. As a field of computer science, AI enables machine learning and deep learning. These two disciplines involve to develop AI algorithms, then models after the decision-making processes of the human brain or intellectual which is 'learn' from existing data and make progressively very high accurate simulations, classifications or predictions over time. Digital assistants, autonomous vehicles, GPS guidance and generative AI tools such as Chat GPT, Open AI are some examples of Artificial Intelligence in our daily lives and the daily news.

# TYPES OF AI: WEAK AI AND STRONG AI

1. **Weak AI:** This AI is trained and very much focused to accomplish a specific task. It is also known as artificial narrow intelligence (ANI) or narrow AI.
2. **Strong AI:** It is a theoretical form of Artificial Intelligence where a machine would have an intelligence equal to a human such as self-awareness with a consciousness that would have the ability to solve problems, learn, understand and plan with a solution for the prediction of future. It is made up of artificial general intelligence (AGI) and artificial super intelligence (ASI). ASI is also known as super intelligence would surpass the intelligence, consciousness and ability of the human brain.

# DEEP LEARNING AND MACHINE LEARNING

Both machine learning and deep learning are sub-disciplines of Artificial Intelligence. Deep learning is a sub-discipline of machine learning. These learning algorithms are mainly used the neural networks to 'learn' from huge amounts of existing data to programme structure of model after the decision-making processes of the human brain. They consist different layers of interconnected nodes at each level that extract features and specifications from the existing data and make predictions of future on the basis of simulations.

# APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN AGROFORESTRY

In Indian economy, Agriculture is the backbone of the country where sixty percentage of Indian population are mainly depended on agriculture whether directly or indirectly. Agroforestry system has the potential capacity to achieve big goals such as social, economic, and environmental goals through optimizing and improving the land productivity. In recent time, advances have been made in green faming such as Smart Agriculture, Robotic Agriculture, Precision farming, Regenerative Agriculture, Satellite based Agriculture, Artificial Intelligence enabled Agriculture etc. to meet out the productivity and sustainability challenges.

The large information available on internet which is generated by soil water content sensor, ph sensor, soil moisture content sensor, weed seeker sensor, soil electrical conductivity sensor, temperature sensor, and wind speed sensor. Internet of Things (IoTs) adopts various enabling techniques viz., wireless sensor networks, big data analysis, cloud computing, security protocols, embedded systems, communication protocols, architectures and web services. Additionally, AI enables automated agricultural operations and systems requiring minimum supervision

and control with drones or ground based autonomous vehicles and use of robotics in agriculture and agroforestry. The various applications of AI in agroforestry have been describing in following ways:

1. **Weather Forecasting System:** AI-enabled weather forecasting system is analysed fast year data and present weather conditions to predict the future rainfall, temperature, humidity etc. On the basis of forecasted weather, farmer can choose the suitable suggested agricultural crop, forest crops and livestock, and also the optimal time of seed sowing. AI technologies also empower Indian farmers to take well-suggested decisions based on real-time weather data.

2. **Monitoring of Soil Health:** AI-driven technologies can detect the nutrient status, deficiency of nutrients and provide information regarding to use the fertilizer in which quantity.

3. **Monitoring and Control of Crop Health:** AI-enabled techniques used to detect and control insect-pest attack and its management using drones or autonomous tractors (Fig.2). AI systems utilize satellite imageries, fast historical data and employing algorithms to detect and control insect pest attack. Farmers can receive real-time alerts and pest control measures on their smartphones.

**Fig. 2: AI-enabled crop health monitoring**

4. **Optimizing Automated Irrigation Systems:** AI based irrigation system used sensor data i.e., monitor soil moisture levels and weather conditions and algorithms can decide and prove in real-time solution how much water is required for irrigation in the crop. Therefore, an automated crop irrigation system has been designed to conserve soil water and provide irritation in real time

.

5. **Yield Mapping and Predictive Analytics:** Yield mapping of crop uses ML algorithms to analyse large datasets in real time and this is used to understand the patterns and yield of the crops which allowing a farmer for better planning and management. By combining different techniques such as 3D mapping, data from various sensors, drones, automated machines and robots predict the crop yield for a specific crop. Data is collected on multiple drone flights in the field, enabling increasingly the levels of precise analysis with the use of various algorithms to predict very precise yield.

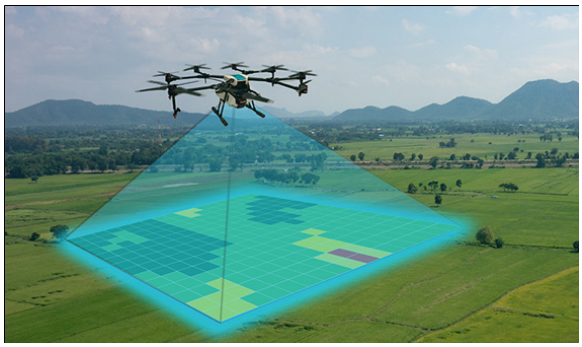

**Fig.3: Crop yield mapping using drone technology**

6. **Automated Weeding:** When AI combined with machine learning, the computer software analyses all the data regarding to the size, shape, and color of leaves to distinguish weeds and invasive plant species from crops and provide the solutions which can be used to program a robot that carry out the robotic process automation (RPA) tasks which is also called as automatic weeding.

7. **Automatic Harvesting:** Similar to the AI-enabled technologies used for detect insect-pests and diseases, weeds etc. can also be used to detect and harvest the crop. In fact, the crop harvesting robot has already been used effectively in developed countries. As these AI-driven technologies become more accessible for harvesting of the crops in real time.

8. **Smart Grading of Harvested Produce:** AI-enabled technologies are not only useful for identifying and detecting potential problems with crops while they are growing to sort and grade the harvested produce more accurately.

9. **Agricultural Marketplace:** Recently, Smart Agricultural Marketplace which is enabled with AI-technologies such as blockchain to optimize and regulate the supply and demand of agricultural products. This innovative solution can also be integrating with agricultural products, e-marketplace services and blockchain to collect information and data at various stages of the supply chain which enhancing transparency and efficiency.

10. **Surveillance and Security of the Farm:** Security is very important part of the farm management. Farms are common targets for animals and birds and even humans which is hard for farmers to monitor their fields all around the clock. When AI combined with video surveillance systems, mobile, computer software and ML can quickly identify security breaks and issue the alert. Where some automated security systems are even well-advanced enough to distinguish regular employees from unauthorized persons.

# THE FUTURE OF AI IN AGROFORESTRY TRANSFORMATION

AI is definitely playing an increasingly huge role in agriculture as well as agroforestry and food security with sustainability over the upcoming years. AI-enabled technologies have always been at the forefront of agriculture and agroforestry such as from primitive tools and implementations to irrigation to tractors to drones to robots to AI. This is also called as Smart Farming. Every development of technology and its advancement has increased efficiency with accuracy while reducing the challenges of green farming all around the world. AI has the modern tools to address various challenges posed by climate change, global warming, environmental issues, and an increasing demand for food and nutrition. It will revolutionize modern agriculture and agroforestry by improving efficiency with accuracy, sustainability, management, resource allocation on top of real-time monitoring and predictions for healthier and higher-quality food produce.

**Fig. 4: Robots enabled with AI in Agroforestry**

# CONCLUSION

The AI-enabled technologies are very useful from the growing of a crop, its risk management, crop management, crop protection, crop advise, soil and crop health analysis and management, crop feeding, automated irrigation, automatic crop harvesting and finally crop grading and even marketing. Thus, these various applications can be utilized in agroforestry. It will revolutionize modern agroforestry practices by increasing efficiency with accuracy in real-time monitoring and predictions for higher yield of food produce.