

Use of Ethical AI in Agriculture

Pooja Karkhile¹, Vaishnavi Kavade², Pranjali Bahalkar³

^{1,2}Student, Artificial Intelligence and Data Science, D.Y. Patil College of Engineering, Akurdi

³Professor, Artificial Intelligence and Data Science, D.Y. Patil College of Engineering, Akurdi

Abstract

We know that AI has been revolutionizing each and every industry. The use of AI in agriculture can ensure the revolution in farming practices, increased efficiency, more effectiveness, increased productivity and solution to the global food problem. Ethical use of AI in agriculture should ensure social accountability, ecological relevance, long-term viability, resource efficiency. AI's integration in the agriculture will be transformational. But we should make sure that the use is ethical. The users are bounded to the morals and the principals and to make sure that use is not going to harm the other people. With the help of in depth analysis of existing literature this gives the comprehensive report of the risks involved in the use of AI in agriculture. Furthermore, it gives the methods to avoid these risks and encouraging ethical use of AI in agriculture. It explores the application of AI in crop management, precision in pesticides, livestock management. The main purpose behind this paper is to consider the power of AI in transforming the field of Agriculture with ethical guidelines and principals.

Keywords: Artificial Intelligence, Agriculture, Smart Farming, Ethical Guidelines, Internet of Things(IOT)

Introduction

The use of AI in agriculture can do magic and revolutionize the whole industry. The global population is predicted to be 10 billion by 2050. So, there is a need for the production of food to feed the people. We need good quality food for the nutrition of such huge number of people. The process should be optimized in order to make the most efficient use of the resources and to the mass production. AI can help us to make the process smooth and efficient but there are some ethical concerns about it. The ethical concerns should be well thought and considered before the implementation. There are a lot of challenges and concerns associated with it. The issues are biases, privacy, transparency, robustness etc.

Practical applications of AI in agriculture-

1. Crop and Soil Monitoring
2. Insect and Plant Disease Detection
3. Livestock Health Monitoring
4. Intelligent Spraying
5. Automatic Weeding
6. Aerial Survey and Imaging
7. Produce grading and Sorting

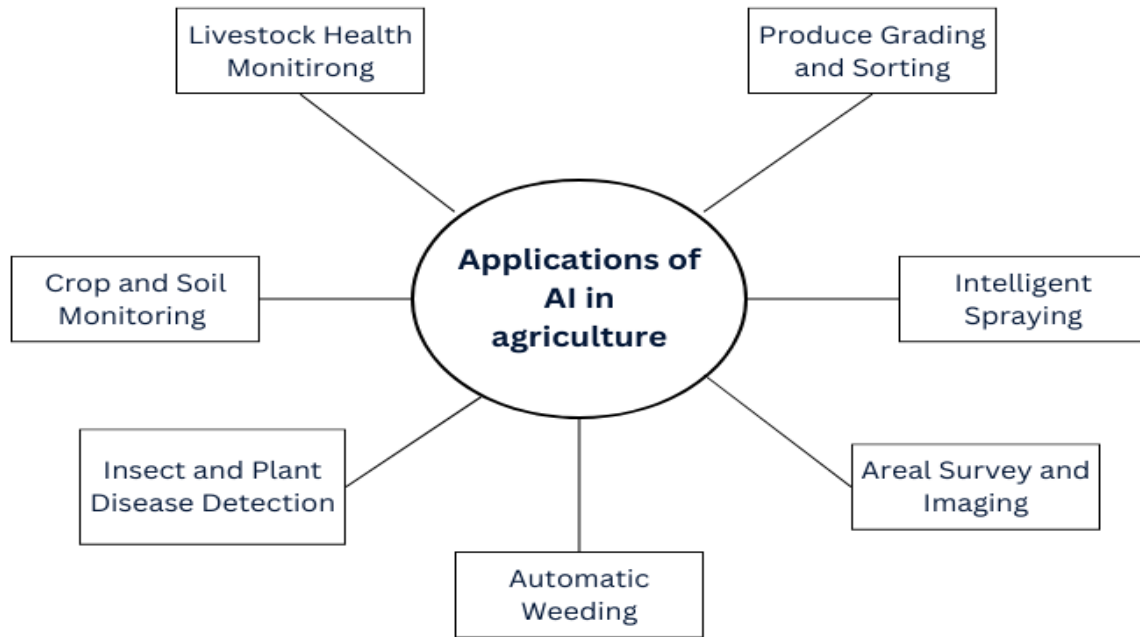


Figure 1:- Applications of AI in Agriculture

Let's see one by one how AI can be integrated into agriculture

1. **Crop and Soil Monitoring-** Drones having camera can click the images of the aerial view of the farms. It allows AI model to have a check on the condition of the soil, level of nutrition, and health of the crops. It helps in efficient use of resources and reduces the need of human manforce for farming. Which reduces the human capital cost involved in the farming procedure.
2. **Insect and Plant Disease Detection-** We can collect and analyze the plant samples which will help us to detect pests and diseases early. We can reduce the loss and damages that could have occurred. It gives us the alert before it reaches to uncontrollable level.
3. **Livestock Health Monitoring-** Animals have been important part in farming, Cow, Buffalo, goat, hen etc help the farmers with an another side income. As these animals are concerned it's very hard to have a check on their health regularly. Sometimes they get infected by the virus and get sick. Wearable sensor devices made with the integration of IOT and AI can be used to keep track of their health. This will help farmers to detect the diseases earlier and give early treatment to the animals.
4. **Intelligent Spraying-** sprayers are used for spraying the fertilizers and pesticides. If AI is integrated in the sprayers then we can efficiently use the sprayers. With studying the real time data we can get the idea about the quantity and number of times spraying should be done. So that, excessive pesticides spraying can be avoided. We can minimize the side effects that happen because of the excessive use of pesticides.
5. **Automatic weeding-** The robots can be used to remove weeds from the plants more efficiently. So, we will not require human intervention to remove the weeds. The cost of the labor will be reduced and the amount of herbicides that was used will be reduced as well. The harmful side effects of herbicides on the environment are reduced as well.

Literature Review

Known by its other name, precision agriculture or smart farming, this innovative approach to agricultural management makes use of cutting edge tools like robotics, drones, sensors and satellites to maximize farming efficiency. Although there are many advantages to smart farming in terms of output, effectiveness, and sustainability, there are also moral questions that need to be investigated and thoroughly examined. The purpose of this systematic literature review is to present a thorough overview of the ethical issues surrounding smart farming by highlighting major themes, obstacles, and implications found in the body of research to far.

One of the main reasons that caught our attention is the Potential Disruption of the Ecosystem.

The use of drones for monitoring purposes can disrupt natural ecosystems. The use of drones can change the behavior and habitat of species being observed.

We can see a rise in the requirement of Electronic devices which may create more E-waste.

Mitigation strategies for the environmental implications of AI

1. Development of energy-efficient AI algorithms
2. Renewable energy integration in the system: Giving power through wind energy, hydro-electric energy, biogas, and H₂ fuel cells, etc.
3. Using sustainable design principles: Implementing sustainability in the design of the data center to reduce heat, waste, etc.
4. Deployment of responsible AI systems: Considering all the potential threats to the environment before deploying the AI system and considering all the solution to the threats can make us prepared for the threats that may occur. It can reduce the harm that may be caused due to it.

The Role of Artificial Intelligence in Agriculture

The agricultural sector has witnessed significant advancements in recent years, with the integration of Artificial Intelligence (AI) playing a crucial role in enhancing productivity, efficiency, and sustainability. This literature review aims to provide an overview of the current state of AI applications in agriculture, highlighting the benefits, challenges, and future directions.

Crop Management and Monitoring:

AI has been successfully applied in crop management and monitoring, enabling farmers to make data-driven decisions. For instance, researchers have developed AI-powered systems that utilize machine learning algorithms to analyze satellite imagery and predict crop yields, allowing farmers to optimize their harvesting strategies. Additionally, AI-driven sensors have been integrated into precision agriculture systems to monitor soil moisture, temperature, and other environmental factors, enabling farmers to adjust their irrigation and fertilization practices accordingly.

Automation and Robotics:

The integration of AI with automation and robotics has transformed various agricultural tasks, such as seeding, weeding, and harvesting. Autonomous robots equipped with AI-driven sensors and algorithms can perform these tasks with greater precision and efficiency, reducing labor costs and environmental impact.

Pest and Disease Management:

AI has also been utilized in pest and disease management, with applications ranging from early detection to targeted treatment. AI-powered image recognition systems have been developed to identify and classify pests, enabling farmers to take timely action to prevent infestations. Furthermore, AI-driven predictive analytics have been used to forecast disease outbreaks, allowing farmers to implement preventive measures and reduce the use of chemical pesticides.

Challenges and Future Directions

Despite the promising results, the adoption of AI in agriculture is not without challenges. One of the primary concerns is the availability and quality of data required to train AI models effectively. Additionally, the integration of AI systems into existing agricultural practices and infrastructure can be complex and may require significant investments. Future research should focus on addressing these challenges and exploring new applications of AI in agriculture, such as the use of AI in livestock management and farm-to-table logistics.

In conclusion, the integration of AI in agriculture has the potential to revolutionize the sector, enhancing productivity, efficiency, and sustainability. As the technology continues to evolve, it is essential to address the challenges and limitations associated with its adoption, ensuring that AI is used to benefit both farmers and the environment.

Methodology

Using keywords like “smart farming”, “precision farming”, “ethical considerations” and similar topics, a systematic search of academic databases was carried out, including PubMed, Scopus, and Web of Science. Peer reviews, research papers, and review articles that were published between 2010 and 2023 were deemed relevant and chosen for the review. To find important ethical questions and topics pertaining to smart farming techniques, a thematic analysis of the literature was conducted.

The Role of Ethics in Smart Agriculture**1. Ownership and Privacy of Data:**

Studies (e.g., Aerni, 2019; Zimdahl et al., 2020) address issues about data ownership, control, and privacy in smart farming, highlighting the need for clear standards and legislation to safeguard farmers’ data rights. To meet privacy concerns, researchers stress the significance of informed permission, data anonymization, and openness in data collecting and sharing methods (e.g., Lowenberg-DeBoer et al., 2018; Tubex et al., 2021).

2. Effect on the Environment:

Studies examine how smart farming technology may affect biodiversity conservation, soil health, energy consumption, and resource efficiency (e.g., Schut et al., 2018; Dorward et al., 2020)

While tackling issues like reducing the use of pesticides and conserving water, academics emphasize how precision agricultural techniques in smart farming have the ability to ameliorate environmental deterioration (e.g., Wang et al., 2021; Wu et al., 2022).

3. Algorithmic Inequality and Openness:

Academics examine the potential hazards of algorithmic prejudice in intelligent agricultural systems, emphasizing the necessity of impartiality, responsibility, and openness in algorithm development and decision-making procedures (e.g., He et al., 2020; Klerkx et al., 2021).

Research highlights the significance of auditability, interpretability of models, and explainable AI in reducing algorithmic bias and fostering transparency in smart farming(e.g., Smith et al.,2019; Strickland et al.,2022)

4. Reliance on Technology:

The research examines the hazards and consequences of relying too much on technology in smart farming, encompassing concerns about accessibility, cost, shortage of skills, and susceptibility to outside influence (e.g.,Birner et al.,2017; Van Bommel et al.,2021). Scholars have underscored the significance of advancing resilience, variety, and inclusivity in the use of agricultural technology in order to minimize the dangers associated with dependence and provide fair access to technological solutions(Paudyal et al.,2019; Geist& Nicholson, 2022).

The investigation began with the inquiry, “What are the ethical issues in smart farming?”

In order to alleviate the problems faced by an expanding global population, farming is essential. The need for food is growing along with the global population, which underlines the importance of effective and sustainable agriculture methods. Furthermore, farmers are now able to increase the output, adjust to shifting environmental circumstances, and lessen the effects of climate change thanks to developments in agricultural technology and methods. Modern agriculture is being revolutionized by drones, sensors, satellites, and robotics because they provide creative answers to the many problems that farmers face. Drones with cameras and other sensors are used for precision agriculture, crop monitoring and aerial photography. By giving farmers access to up-to-date information on crop health, soil moisture content, and insect infestations, they boost resource efficiency and allow for focused interventions. Drones can also be used to spray crops, which use fewer chemicals and have a smaller environmental impact.

While the cutting- edge technologies has transformed farming methods there are a number of ethical concerns that must be resolved.

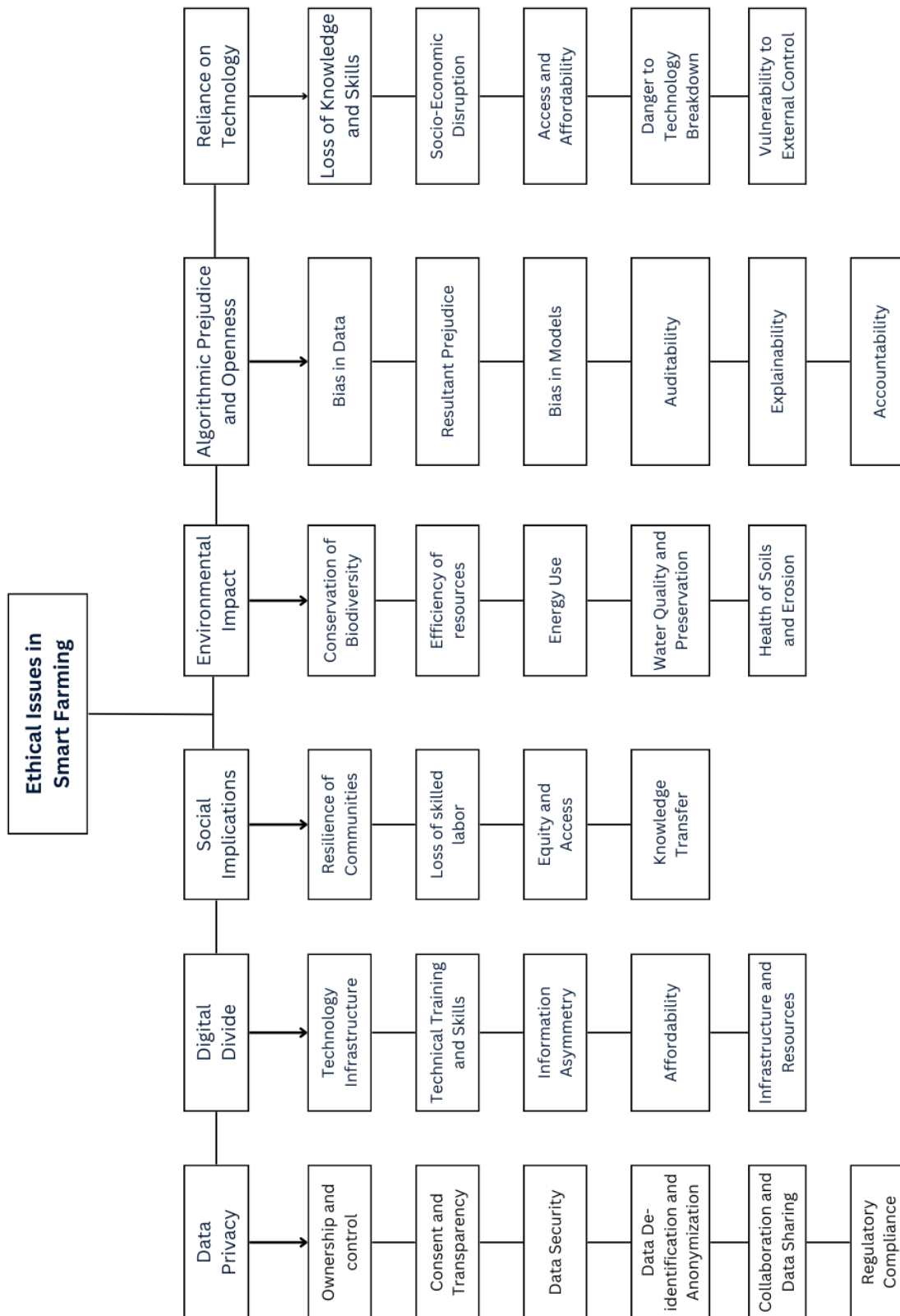


Figure 2:- Ethical Issues in Smart Farming

Data Privacy:

Large volumes of data about crop health, soil conditions, and farm operations are produced when sensors and drones are used in agricultural applications. Concerns occur about who owns and controls this data. Potential conflicts over data access, sharing, and privacy may arise from the competing interests of farmers, technology businesses, and other stakeholders regarding data ownership.

- 1. Ownership and control:** Deciding who owns and has control over agricultural data is a critical ethical question. Using sensors and other monitoring tools, farmers can create data about their crops, the state of the soil, and their agricultural methods. But when technology firms or service providers gather and handle this data, concerns about data ownership and control over its usage. Storage and distribution surface.
- 2. Consent and Transparency:** In order to adhere to ethical data practices, farmers must give their informed consent before any agricultural data is collected, used or shared. It is imperative that farmers process comprehensive knowledge regarding the categories of data being gathered, the intended use of data, and any possible hazards or consequences linked to the exchange of data. Transparent data practices enable farmers to make well-informed decisions about their data and foster confidence between farmers and technology suppliers.
- 3. Data Security:** To guard against illegal access, data breaches, and cyberattacks, it is crucial to ensure the security of agricultural data. The use of cloud storage, data processing platforms, and network connectivity in smart agricultural technology raises the possibility of data security flaws. Security sensitive agricultural data from potential threats requires the use of strong data encryption, access controls, and cybersecurity measures.
- 4. Data De-identification and Anonymization:** Methods like data de-identification and anonymization can be used to exclude personally identifiable information from datasets in order to reduce privacy hazards related to agricultural data. De-identified data preserves personal privacy while enabling insightful analysis and deductions from agricultural data.
- 5. Collaboration and Data Sharing:** Although sharing data amongst farmers, academics and other agricultural stakeholders can provide insightful and beneficial outcomes, it also brings up moral questions about data privacy. Farmers may be reluctant to divulge their farming data because they fear for their competitive edge, privacy, and confidentiality. Establishing precise rules, agreements, and procedures to guarantee data anonymization, aggregation, and safe sharing while defending individual privacy rights are all part of ethical data-sharing practices.
- 6. Regulatory Compliance:** In smart farming, ethical data practices should be compliant with applicable data protection laws and guidelines, such as the California Consumer Privacy Act (CCPA) in the US and the General Data Protection Regulation (GDPR) in the EU. Adherence to regulatory mandates guarantees that agricultural information is gathered, handled, and disseminated in a way that upholds personal privacy rights and fulfills legal responsibilities for data security and privacy.

Digital Divide:-

When discussing smart farming, the term “digital divide” describes the difference between farmers who can effectively use and have access to cutting-edge agricultural technologies and those who cannot or are unable to do so. There are several aspects of the digital divide that apply to agriculture.

- 1. Technology Infrastructure:** Having access to high-speed internet connectivity is crucial for using digital tools and services in smart farming, and it is one facet of the digital divide. Farmers' capacity

to use online platforms, cloud-based services, and data-intensive applications for precision agriculture is limited in rural locations due to the frequent absence of dependable internet connectivity and infrastructure.

2. **Technical Training and Skills:** Digital literacy and technical training are necessary for the efficient application of smart farming technologies. To operate, maintain, and understand data from sensors, drones, and other digital instruments, farmers require assistance and training. Lack of access to technical support, training programs, and educational materials that might enable farmers to successfully integrate technology into their farming operations exacerbates the digital divide.
3. **Information Asymmetry:** The digital divide is exacerbated by differences in the availability of information and expertise regarding smart farming technologies. Big commercial farms and agribusiness might have better access to market intelligence, research results, and industry knowledge which would help them adopt and use cutting-edge technologies more successfully. On the other hand, the adoption of smart agricultural solutions may be impeded for small-scale farmers and rural communities due to their limited access to pertinent information, best practices, and support systems.
4. **Affordability:** The high cost of sophisticated agricultural technologies poses a major obstacle to their adoption. Small-scale and resource-constrained farmers may face financial difficulties due to the high upfront costs associated with purchasing gear such as drones, sensors, and robotics as well as continuing expenditures for software licenses, maintenance, and technical support. The degree to which farmers can implement and reap the benefits of smart agricultural techniques is determined by the cost-effectiveness of technological solutions.
5. **Infrastructure and Resources:** The use of smart farming technology may be hindered by infrastructure limitations such as unstable electrical supplies or insufficient storage facilities. Drones and sensors, for instance, need power sources to function and transmit data; these sources can be difficult to get in off-grid or isolated agricultural areas. Farmers' inability to maintain and troubleshoot technological solutions is an additional factor contributing to the digital divide, as is the lack of technical support services and repair facilities.

Social Implications:-

Artificial intelligence and robotics are automating farming operations, which poses ethical questions about labor displacement and rural lives. The socioeconomic fabric of rural communities and employment prospects may be impacted by farms becoming more automated and mechanized. Ensuring fair distribution of the advantages of technical breakthroughs and promoting the welfare of rural communities and agricultural workers are examples of ethical considerations.

1. **Resilience of Communities and Rural Economy:** The adoption of technology in agriculture can lead to significant changes in agricultural practices, which can have a significant impact on the resilience of communities and the rural economy. While increased automation and efficiency could benefit some farmers in terms of production and profitability, it might also lead to farm consolidation and a decline in the number of small, family farms. The agricultural environment, local companies and services, and the possibility of increased social and economic divides between rural and urban areas are all potential effects of this consolidation on rural communities.
2. **Loss of skilled labor and the skills gap:** Mechanization, robotics, and artificial intelligence used to automate farming chores may cause worker displacement in rural agricultural areas. The need for traditional farm labor may decline as farms become more automated and dependent on technology, which

might lead to employment losses and changes in the rural labor market. Moreover, there can be a widening skills gap since smart farming instruments require farmers to have new abilities in data analysis, digital literacy, and technology operation.

3. **Extension services and knowledge Transfer:** For farmers to properly use smart agricultural technologies, they need to receive continual education, training, and assistance. Knowledge transfer initiatives, agricultural consultants, and extension services are essential in giving farmers the knowledge, skills, and support they need to accept and use new technologies. Supporting farmers in implementing smart agricultural methods requires making extension services available and easily accessible, especially in rural and isolated locations.
4. **Equity and Access:** Not every farming community may have equal access to digital resources and cutting-edge agricultural technologies. In comparison to small-scale or subsistence farmers with limited resources, large-scale commercial farms with higher financial resources and access to finance may have a competitive edge in adopting and implementing smart farming solutions. It is imperative to tackle inequalities in technology and digital infrastructure accessibility to foster fairness and guarantee that every farmer can capitalize on the prospects presented by intelligent farming.

Environmental Impact:

Although the goal of smart farming technology is to increase agricultural sustainability and productivity, there are worries over the environmental effects of these innovations. For instance, using robotic equipment or drones to spray pesticides may raise concerns about the use of chemicals, the health of the soil, and the preservation of biodiversity. Minimizing environmental harm, encouraging sustainable activities, and guaranteeing responsible stewardship of natural resources are all ethical considerations.

1. **Conservation of Biodiversity:** Using smart agricultural techniques can affect biodiversity in both positive and negative ways. Precision farming methods have the potential to mitigate habitat loss and lessen the adverse effects of agricultural growth on natural ecosystems. However, by lowering habitat diversity and endangering non-target organisms, the use of pesticides and monoculture agricultural systems associated with current farming methods can have a negative impact on biodiversity. To reduce adverse and encourage biodiversity conservation, it is crucial to properly evaluate and manage the implications of smart farming for biodiversity.
2. **Efficiency of resources:** More economical use of resources like water, fertilizer, and pesticides is made possible by smart farming technologies including satellite-guided planting, sensor-based nutrient management, and precision irrigation systems. Smart farming techniques can decrease environmental degradation caused by the overuse of chemicals of reduce resource waste by only applying inputs where and when they are needed.
3. **Energy Use:** Drones, sensors, and robotic equipment are examples of smart agricultural technology that require energy to operate, which can have an impact on the environment and increase greenhouse gas emissions. However, the environmental impact of agricultural energy use can be lessened by the effective use of resources made possible by smart farming techniques, such as decreased fuel consumption through precision planting and improved machinery performance. To further lessen the environmental impact of agricultural activities, smart farming systems can be powered by renewable energy sources like solar electricity.
4. **Health of Soils and Erosion:** By supporting conservation efforts and precise soil management, smart agricultural technologies can enhance soil health and lower erosion. Farmers can implement targeted

treatments like variable-rate fertilization and erosion control measures by using soil and mapping technologies, which offer comprehensive information on soil conditions. Smart farming helps to preserve soil fertility and lessen soil erosion by optimizing soil management techniques. These two factors are critical for sustaining agricultural productivity and ecosystem resilience.

- 5. Water Quality and Preservation:** Because they provide precision irrigation systems, soil moisture monitoring, and the enhancement of water use efficiency, smart farming technologies are essential to water management. Smart agricultural methods can help enhance water quality and reduce environmental pollution by using water resources more effectively and avoiding runoff and pesticide and fertilizer leaching. Furthermore, smart farming helps conserve water and build resilience against water scarcity brought on by climate change by supporting sustainable water management techniques like conservation tillage and cover crops.

Algorithmic Prejudice and Openness:

Smart agricultural technology may result in unjust judgments or outcomes due to biases in the algorithms driving them. For instance, biases in training data may be unintentionally perpetuated by machine learning algorithms used for pest identification or crop yield prediction, leading to discrepancies in resource allocation or decision-making. To solve these ethical issues, algorithmic justice, accountability, and openness are crucial.

Algorithmic Prejudice:

- 1. Bias in Data:** Algorithms trained on agricultural data may produce biased results because data may present past prejudices or inequality. Algorithms trained on historical crop production data, for instance, might not adequately reflect the requirements and experiences of smaller, resource-constrained farms if the majority of the data originates from larger, more automated farms.
- 2. Resultant Prejudice:** Decisions made by algorithms may be skewed in a way that favors or disadvantages particular farmers or community groups disproportionately. For instance, a predictive model for crop insurance eligibility may perpetuate existing disparities in access to financial resources and support if it favors farms with particular features (e.g., greater landholdings or higher yields).
- 3. Bias in Models:** Based on the characteristics and variables utilized throughout the model training process, machine learning models may display biases. The model's structure, the weighting of some features over others, or the choice of input variables can all lead to biases.

Transparency:

- 1. Auditability:** Algorithmic systems should be auditable, which allows independent third parties to examine and validate the underlying data and decision-making procedures. Algorithmic decision-making biases, mistakes, and unintended consequences can be found and fixed with the aid of auditing algorithms.
- 2. Explainability:** Algorithms ought to be created with the intention of giving concise, intelligible justifications or explanations for their choices. To promote informed decision-making and accountability, farmers and other stakeholders should be able to comprehend the reasoning behind each recommendation or choice that an algorithm makes.
- 3. Accountability:** In smart farming systems, there should be distinct accountability chains for algorithmic decision-making process. This entails designating accountable persons for the creation, testing,

implementation, and oversight of algorithms as well as procedures for handling grievances, objections, or inconsistencies arising from algorithmic choices.

Reliance on Technology:

Concerns concerning vulnerability and dependency are raised by farming's growing reliance on technology. For decision-making and farm management, farmers may grow reliant on intricate technological systems, which raises concerns about resilience, autonomy, and the capacity to adjust to unanticipated shocks or breakdowns in the technology infrastructure.

- 1. Loss of Traditional Knowledge and Skills:** An overreliance on technology could result in the generational transmission of traditional farming knowledge, skills, and practices disappearing. Farmers run the risk of losing or undervaluing traditional knowledge and skills about the local agroecological conditions, biodiversity protection, and sustainable farming methods as they depend more and more on technology for decision-making, monitoring, and management duties. It is imperative to maintain and use traditional knowledge alongside contemporary technologies in order to foster agricultural sustainability and resilience.
- 2. Danger to Technology Breakdown:** Farmers that rely heavily on technology in their operations run the danger of technological faults, failures, or disruptions. Critical farming activities can be disrupted by hardware malfunctions, software bugs, or communication problems, which can result in lower yields, financial losses, and a diminished standard of living for farmers. Excessive reliance on technology in the absence of backup plans or other techniques might make a system more susceptible to unplanned outages and breakdowns.
- 3. Vulnerability to External Control:** Farmers that rely too much on digital platforms and proprietary technological systems may be more susceptible to outside manipulation by tech companies, agricultural giants, or governmental organizations. Farmers may grow reliant on tech companies to provide them with technical support, data storage, and access to basic services, which raises questions regarding data control, privacy, and ownership. Farmer's power and autonomy to make decisions may be restricted by centralized control over agricultural data and technology platforms, raising questions about data exploitation, manipulation, and spying.
- 4. Access and Affordability:** Technology dependence may make access and cost gaps worse, especially for small-scale and resource-constrained farmers. For farmers with limited resources, high upfront expenditures for technological hardware and software purchases combined with recurring costs for maintenance, updates, and technical support, can be a financial barrier to adoption. Disparities in technology uptake and utilization are made worse by unequal access to technology infrastructure, such as dependable internet connectivity and electricity.
- 5. Socio-Economic Disruption:** Agriculture's reliance on technology can cause socioeconomic upheavals in rural areas, especially for farmers whose jobs are directly related to customary farming methods. Farm labor displacement brought about by automation, changes in work options, and adjustments to local economies can have an effect on community resilience, social cohesiveness, and cultural identity. In order to mitigate the socio-economic effects of technology dependence, comprehensive plans that promote inclusive growth, skill development, and diversification are needed in rural regions.

References

1. Ryan, M. (2022). The social and ethical impacts of artificial intelligence in agriculture: mapping the agricultural AI literature. *AI and Society*, 1–13. doi: 10.1007/s00146-021-01377-9
2. Rozita Dara, Seyed Mehdi, Hazrati Fard, Jasmin Kaur, “Recommendations for ethical and responsible use of artificial intelligence in digital agriculture”.
3. Tanha Talaviya, Dhara Shah, Nivedita Patel, Hiteshri Yagnik, “Implementation of artificial intelligence in agriculture for optimization”.