P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating: 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 6; June 2025; Page No. 662-668

Received: 11-03-2025
Accepted: 13-04-2025

Indexed Journal
Peer Reviewed Journal

Artificial intelligence in seed science

[1]Vinayak Savalagi and [2]Sumayya Mullal

[1]Department of Agricultural Extension Education, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad, Karnataka, India

[2]Department of Seed Science and Technology College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad, Karnataka, India

DOI: https://www.doi.org/10.33545/26180723.2025.v8.i6i.2092

Corresponding Author: Vinayak Savalagi

Abstract

In the context of a rapidly growing global population, the demand for food grains is anticipated to surge and agriculture remains the primary means of meeting the growing food demands of our expanding global population. Agriculture continues to grapple with challenges spanning from land preparation to marketing. The presence of designated diseases, physical impurities and genetic anomalies further compounds the problem, resulting in reduced yields and even crop failures, particularly when dealing with low seedling vigour and subpar seed quality. To tackle these pressing issues, there's a compelling need for a cutting-edge solution from the new generation of technologies. This solution should be characterized by speed, precision, accuracy, and indispensability, qualities that can be effectively harnessed through the application of Artificial Intelligence (AI). Artificial Intelligence (AI) can be used in various aspects of seed science, including seed production, certification, processing, quality control, seed storage, and marketing. Presently, AI has been exploited in the field of quality control. Seed image analyzers can be used to control seed quality by characterizing and identifying seed varieties, sorting and grading seeds, conducting physiological assessments, such as evaluating seed vigour, viability, and germination percentage, and detecting signs of mechanical damage, insect infestations, and diseases in seeds. AI can also be used for precision farming, crop monitoring, data-driven decisions, crop sorting and grading, labour efficiency, disease detection, soil health assessment, and climate adaptation.

Keywords: Agriculture, Artificial Intelligence (AI) & Seed science

Introduction

In the context of the global landscape, the United Nations Food and Agriculture Organization (UNFAO) has projected a population increase of 2 billion by the year 2050, accompanied by a corresponding expansion of agricultural land by approximately 4 per cent. Given that food is a fundamental necessity, agriculture remains the primary means of meeting the growing food demands of our expanding global population. According to estimates provided by ICAR, the demand for food grains is anticipated to surge from 192 million metric tons in 2000 to 345 million metric tons by the year 2030.

Bearing in mind situation of Indian agriculture, the 1960s saw the initiation of the Green Revolution, a transformative effort spearheaded by M. S. Swaminathan. During this period, High Yielding Varieties (HYV) were introduced in 1966, accompanied by intensive ploughing and increased use of chemical fertilizers and pesticides, which significantly boosted crop yields. However, like many advancements, this era brought forth its set of challenges. The extensive application of chemicals and their residual effects led to soil pollution. Moreover, the heavy ploughing with large tractors had adverse effects, including reduced air volume in the soil, decreased nutrient absorption, impaired water drainage, and depletion of essential soil nutrients. These combined factors eventually resulted in a significant drop in crop yields.

Agriculture continues to grapple with challenges spanning from land preparation to marketing, and one particularly significant issue revolves around plant protection, given that diseases alone account for a 40 per cent crop loss. Identifying these diseases presents a formidable challenge due to the scarcity of essential expertise and infrastructure. The presence of designated diseases, physical impurities, and genetic anomalies further compounds the problem, resulting in reduced yields and even crop failures, particularly when dealing with low seedling vigour and subpar seed quality. To tackle these pressing issues, there's a compelling need for a cutting-edge solution from the new generation of technologies. This solution should be characterized by speed, precision, accuracy, and indispensability, qualities that can be effectively harnessed through the application of Artificial Intelligence (AI).

We are in the era of robotics and use of robotics in agriculture can be game changer in agriculture sector. Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think like humans, act and mimic their actions. This term may also be applied to any machine that exhibits traits associated with a human mind such as learning and problem-solving. John McCarthy in the year 1956 coined the term Artificial Intelligence. AI is a wide-ranging branch of computer science concerned with building smart machines, capable of performing tasks that typically require human intelligence. It can solve real-world problems very easily and with accuracy. It can create personal virtual assistant, such as Cortana, Google Assistant and Siri, etc. We can build such Robots which can work in an environment where survival of humans can be at risk. AI opens a path for other new technologies, new devices and new opportunities.

AI is being intensely used in healthcare, automobiles, business, banking, e-commerce, entertainment, education, gaming, insurance, marketing and finance, manufacturing industries, social media, surveillance, space exploration and various other fields. Some best examples of AI include TESLA AI based self-driving car, first humanoid robot Sophia and first South Indian Robo Power TV news anchor Soundarya. AI is also explored in agriculture field but much of research and exploration work is yet to be done in seed science and technology.

Characteristics of AI

Big data: big data is simply a collection of unstructured information; AI has ability to reason and draw inference based to the situation using big data. It has Context driven awareness of the system *i.e.,* being aware and making decisions based on the specific background or situation on the way. It involves understanding the current environment, circumstances and appropriate factors before taking action or making decisions. Learning: AI has ability to learn based on historical pattern, expert input and feedback loop. Reasoning: it is capable of processing massive amounts of structured and unstructured data which can change constantly. Problem solving: it can analyze data and solve complex problems.

Understanding the Mechanics of Artificial Intelligence

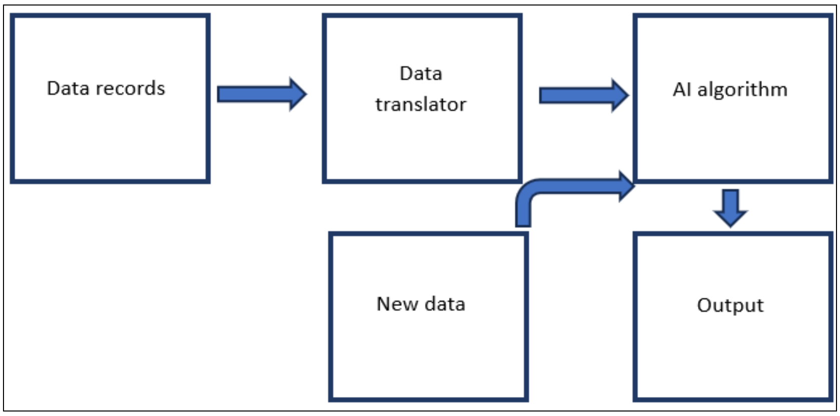


Fig 1: Inner Workings of Artificial Intelligence, design by author

The most important step in AI is algorithm. For example, whenever a nonprofessional cook wants to bake a cake, he follows sets of instructions provided in baking manual. Similarly, an algorithm is like a step-by-step recipe that tells you how to do something. It's a set of clear instructions that one can follow to solve a problem or complete a task. Just like a recipe helps you bake a cake by telling you what ingredients to use and what steps to take, an algorithm guides a computer or a person through a series of actions to achieve a specific goal. To create algorithm, set of data records are fed, this data is first converted into the machine language. Algorithms are constructed based on data, leading to the generation of outcomes (Fig.1).

Domains of AI

The domain of AI machine learning is the discipline of empowering machines to tackle real-world challenges through data interpretation and analysis. Real-world challenges include climate change, health, food insecurity etc. Machine learning comprises two fundamental categories: 1) Supervised Learning - "Train me". This technique involves instructing or educating the machine by providing it with meticulously labeled data 2) Unsupervised Learning - "I am self-sufficient in learning". It is a paradigm of training where models independently extract patterns and discern differences from unlabeled data, without receiving explicit instruction through labeled data.

Whereas deep learning is leveraging neural networks for profound insights and problem solving in high-dimensional data. Deep learning represents an advanced domain within machine learning, tailored for tackling complex problems, its applications span across diverse areas, from fakebook's face verification algorithms to self-driving vehicles and virtual assistants such as google and Alexa. Deep Learning consists of Multi-Neural Network Architecture. This mainly includes networks like Artificial Neutral Network (ANN), Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN). In simple terms ANN is the neural network that stores data in the form of numbers. CNN is the neural network that secures data in the form of image. It is widely used in seed science *i.e.,* for image processing. And RNN is the neural network where data in the form of time and series. It is used in developing forecast model.

An expert system is a type of AI-powered computer system designed to mimic the decision-making skills of a human expert. These systems rely on if-then logic rules to solve intricate problems and don't follow the usual step-by-step programming. Expert systems find applications in fields like managing information, healthcare, and are even used in apps like Aarogya Setu. At the end of 1970's, the expert system started to be applied in agricultural domain (Table 1). An Expert System on Wheat Crop Management (Exowhem) has been developed by the Division of Computer Application, ICAR- Indian Agricultural Statistics Research Institute, New Delhi in collaboration with ICAR-IARI, New Delhi and ICAR- Indian Institute of Wheat and Barley Research, Karnal that helps in diagnosing the diseases and helps in its management. Here IF-THEN rules are employed to link symptoms with specific colors, as each disease manifests differently in the plant or its various parts (Islam *et al.*, 2018) [3].

Table 1: Expert systems in agriculture

Sl.No.	EXPERT SYSTEM	CROP
1	CALEX	Cotton (to diagnose the pest.)
2	PEKA-SEWIT	Oil-Palm (disease control diagnosis)
3	POMEE	Apple (to avoid infestation)
4	NAPER-WHEAT	Wheat (irrigation management)
5	TOMATEX	Tomato (disease control diagnosis)
6	MANAGE	Rice (diagnose pest and disease)
7	MAIZE/NAPRA	Maize (pest management strategies)
8	SEMAGI	Sunflower (weed infestations)
9	SOYBUG	Soybeans (insect pests)
10	CUPTEX	Cucumber (disease control diagnosis)

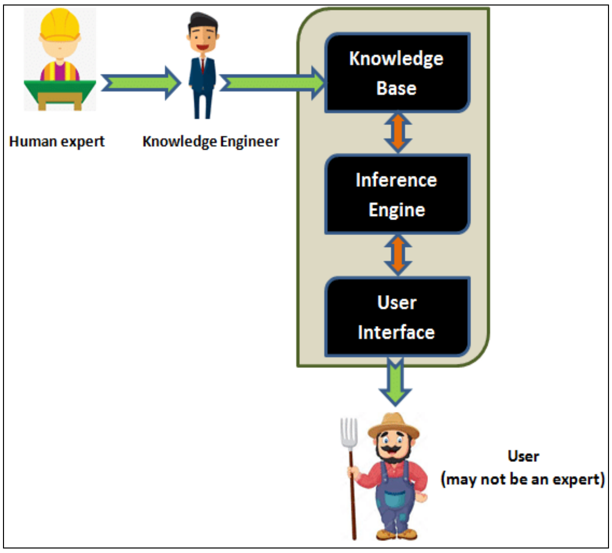


Fig 2: Main Components of an Expert System, (Mounir *at al.*, 2018) [6]

Fuzzy logic is a computing approach based on the principles of "degrees of truth" instead of the usual modern computer logic *i.e.,* Boolean in nature. Used in the medical fields to solve complex problems that involve decision making. Generally incorporated in automatic gearboxes, degree of disease (low to severe). Internet of things (IoT) describes the network of physical objects - "things" - that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. IoTs in an agricultural context refers to the use of sensors, cameras and other devices to turn every element and action involved in farming into data. Large data sets on Weather, moisture, plant health, mineral status, chemical applications, pest presence can be generated. Accordingly, via software algorithms store and transfer data for development of models. Natural language processing (NLP) is a field within computer science and artificial intelligence (AI) that focuses on enabling computers to comprehend and interpret written text and spoken language, aiming to replicate human-like language understanding capabilities.

Applications in seed science

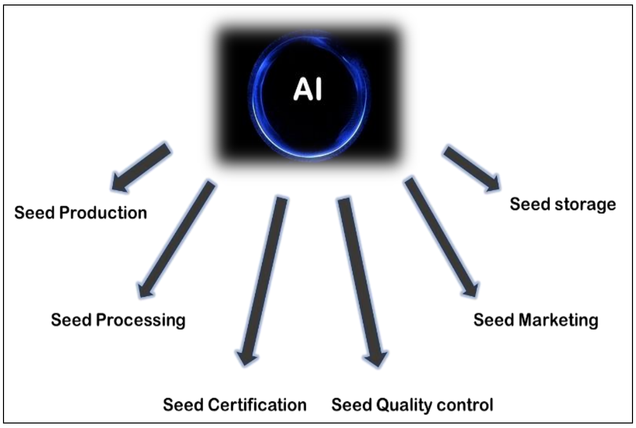


Fig 3: The figure shows the application of AI in various sectors of seed science, Design by author

AI can play role crucial role in seed production, seed certification, seed processing, seed quality, seed control, seed storage and seed marketing (Fig.3). There are numerous challenges and issues in the process of seed production. Seed production is a complex process marked by various factors that can introduce uncertainty and difficulties. These factors encompass fluctuating environmental conditions in the seed production plot, challenges in determining optimal sowing timing and methods, managing seed rates, handling nutrients and irrigation, controlling weeds, identifying off-types, managing soil moisture, fine-tuning inter and intra-row spacing, and addressing pest and disease issues. These factors collectively contribute to the potential production of lower-quality seeds. Artificial intelligence (AI) has practical applications in the management of seed production. The utilization of precise sowing techniques through AI is possible which ensures efficient seed placement, minimizes seed wastage, and allows for precise control of the seed rate (Fig.4). The AI can water plants the exact amount they need, so that crop does not suffer from drought or wastage of water (Fig.4).

Source: https://genesis.farm.bot/v1.6/extras/reference/seeds.html

Fig 4: Farmbot precisely planting seeds and irrigation.

Fig 5: Rice seed production plot, off type detection based on anthocyanin pigmentation.

AI-based farmbots have the capability to detect and eliminate weeds in their early stages within the seed production plot. This proactive weed control strategy helps preserve seed quality standards and prevents any adverse impact on the crop from weed management activities (Fig.4). Identifying off-types in seed production plants during their initial stages poses a considerable challenge, and the subsequent removal process demands skilled labour. These off-types can significantly reduce the genetic purity of crops. However, artificial intelligence (AI) has the potential to revolutionize this aspect. For instance, in a rice seed production plot, AI can effectively detect off-types by analysing the presence or absence of anthocyanin pigmentation. When AI-based robots identify off-type plants lacking pigmentation, they can systematically eliminate them, streamlining the process and preserving crop genetic purity (Fig.5).

Drones

Drones, officially known as unmanned aerial vehicles, represent flying robotic devices. When utilized in agriculture applications, they are commonly referred to as agricultural drones. The adoption of drones is rapidly expanding across various sectors of the economy, with the agricultural industry experiencing remarkable growth. According to reports, the agricultural drone market is projected to surge from a $1.2 billion (USD) industry in 2019 to a staggering $4.8 billion by 2024. Drones are poised to become increasingly prevalent on both large and small farms, serving a range of purposes from field scouting to security. These drones play a pivotal role in what's commonly known as 'precision agriculture,' where data collected from these aerial devices aids farmers in making well-informed agronomic decisions. In fact, drone technology has already become indispensable in many large-scale precision farming operations. The insights gleaned from drone surveys of fields empower farmers to meticulously plan their planting and treatments, optimizing crop yields. It's worth noting that precision farming systems have been reported to potentially boost yields by up to 5 per cent, a significant enhancement in an industry often characterized by narrow profit margins. In this article, we will delve into the existing applications of drone technology in farming, explore emerging agricultural drone technologies, and touch upon the steps and challenges associated with the widespread integration of drones in agriculture.

Spraying drones: The use of drone technology for applying spray treatments is already well-established in South-East Asia, where South Korea, for instance, employs drones for approximately 30 per cent of their agricultural spraying needs. These drone sprayers exhibit the ability to access challenging terrain, including steep tea fields at high altitudes. Importantly, they enhance worker safety by eliminating the need for manual field navigation with backpack sprayers, which can pose health risks. Furthermore, drone sprayers excel at delivering precise, fine spray applications, allowing for targeted treatment of specific areas, thereby maximizing efficiency and reducing chemical costs. However, it's important to note that regulations surrounding drone sprayers vary significantly between countries. For example, in Canada, their use is currently not legal due to the need for further testing to assess the impact of spray drift. Some regulatory proposals advocate for the restriction of flying spray drones to trained professionals, mirroring Yamaha's approach. Yamaha, a manufacturer of spray drones, does not sell them directly but offers spray drone services complete with licensed operators. Utilizing drones for precise chemical application ensures that the correct dosages are used, leading to both the prevention of soil pollution and significant reductions in time and labour.

Crop monitoring drone: The field of drone security is rapidly expanding, offering valuable benefits not only outside agriculture but also in farm management. Drones play a pivotal role in efficiently monitoring vast farm areas, saving valuable time, and enabling more frequent oversight of hard-to-reach locations. Equipped with cameras, these drones provide continuous surveillance of farm operations, ensuring smooth running and facilitating the tracking of equipment usage. In the realm of security, drones are a cost-effective alternative to traditional security personnel for monitoring fences and perimeters, especially for high-value crops like cannabis. Additionally, drone cameras are being leveraged in innovative ways to enhance the protection of farm animals. They aid in locating missing or injured herd animals in remote grazing areas, a task that once required hours of manual searching but can now be accomplished within minutes with drones. This technology is revolutionizing the monitoring of remote areas, making farm management more efficient and effective (Fig.6).

Source: https://www.croptracker.com/blog/drone-technology-in-agriculture.html

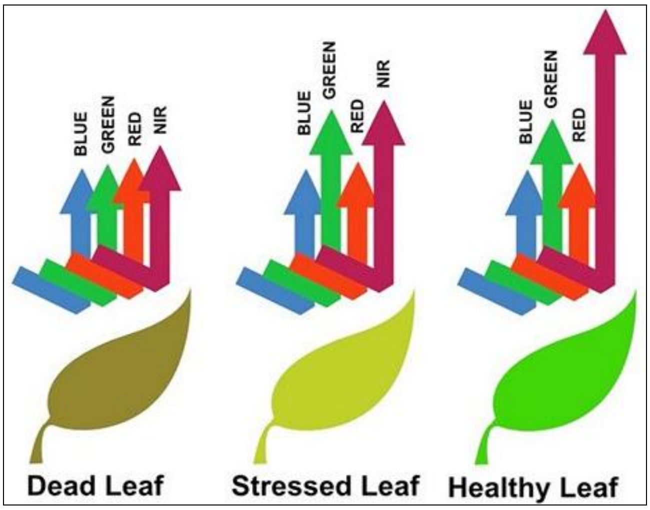
Fig 6: Spraying drones and crop monitoring drone.

Irrigation drones: Recent research from Australia is opening up promising avenues for the application of drones in agriculture. In light of the escalating impact of climate change on drought conditions, the development of more efficient irrigation solutions is of paramount importance. Drones equipped with microwave sensing technology can obtain precise soil health data, including moisture levels, without interference from plant growth. This breakthrough allows for the optimal distribution of water across fields, promoting resource conservation and enhancing overall efficiency in irrigation practices (Fig.8).

Planting & Seeding drones: A relatively newer and less common application of drones in agriculture revolves around seed planting. Currently, automated drone seeders find primary usage in the forestry sector, but the potential for broader adoption is increasingly promising. The use of drones for planting offers several advantages, particularly in reforesting challenging and remote areas, without putting human workers at risk. Additionally, the efficiency gains are substantial, as a team of just two operators working with ten drones can plant an impressive 400,000 trees in a single day. This technology holds the promise of transforming the way we approach large-scale planting operations.

Field monitoring conditions drones: drones are increasingly employed for comprehensive field monitoring, enabling the assessment of soil health and overall field conditions. These aerial devices offer precise field mapping, including elevation data, which empowers growers to identify any anomalies within the field. Elevation information proves valuable in determining drainage patterns and pinpointing wet or dry areas, thereby enhancing the efficiency of irrigation practices. Furthermore, certain agricultural drone retailers and service providers offer advanced sensors that can monitor nitrogen levels in the soil. This capability facilitates the precise application of fertilizers, eliminating underperforming areas and promoting long-term soil health improvements. In essence, drones are becoming invaluable tools for maintaining optimal field conditions and maximizing agricultural productivity (Fig.6).

Plant health monitoring drones: drones are proving to be highly effective tools for scouting and monitoring the health of plants. Equipped with specialized imaging technology like the Normalized Difference Vegetation Index (NDVI), they use detailed colour information to provide real-time insights into plant health. This empowers farmers to closely track crop development, enabling swift responses to any emerging issues, ultimately saving the plants from potential harm. In addition to NDVI-equipped drones, standard camera-equipped drones are also utilized for crop health monitoring. While some farmers already rely on satellite imagery for assessing crop growth, density, and coloration, accessing satellite data can be expensive and less effective in certain situations compared to the closer-range drone imaging. Drones flying in proximity to fields are less impacted by cloud cover and poor lighting conditions. While satellite imaging may offer accuracy to the meter, drone imaging provides precise image location down to the millimetre. This level of precision allows for the early detection of issues such as stand gaps after planting, enabling timely replanting as needed, and the prompt identification and treatment of diseases or pest infestations (Fig.7).



Source: https://www.croptracker.com/blog/drone-technology-in-agriculture.html

Fig7: Normalized Difference Vegetation Index (NDVI).

Drone pollination: Emerging applications of drones in agriculture, although still in the experimental and developmental phases, hold significant promise. One of the widely discussed and sometimes sensationalized applications is the use of drones for pollination. Researchers in the Netherlands and Japan are actively working on the development of compact drones designed for pollinating plants in a non-invasive manner. The future objective is to create autonomous pollination drones capable of independently carrying out pollination tasks and monitoring crop health without the need for continuous operator intervention (Fig.8).

Source: https://www.croptracker.com/blog/drone-technology-in-agriculture.html

Fig 8: Irrigation drones and drone pollination

Several mobile applications have been developed to detect plant diseases in their early stages, and one noteworthy example is the Plantix app. The Plantix app offers coverage for 30 major crops and boasts the capability to identify over 400 plant diseases. It's available in 18 languages and has been downloaded more than 10 million times, establishing itself as the leading agricultural app worldwide for early damage detection, pest and disease management, and enhancing crop yields for farmers. Plantix is developed through a collaborative effort involving Progressive Environmental and Agricultural Technologies, in partnership with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Professor Jayashankar Telangana State Agricultural University (PJTSAU), the

Government of Andhra Pradesh, and on-site collaboration with Food and Agriculture Organization (FAO), Centre for Agriculture and Bioscience International (CABI), International Maize and Wheat Improvement Centre (CIMMYT) and ICRISAT.

Numerous challenges exist in the realm of seed quality control, including: Identifying and categorizing seeds based on attributes like size, shape, and colour. Assessing physical purity by identifying weed seeds, other crop seeds (OCS), and inert matter. Evaluating seed quality through germination, vigour, viability, and health assessments. These issues are compounded by the time-consuming nature of these processes and their reliance on manual labour. These issues can be solved using AI. Seed Image analyser can be used to control seed quality. Image analysis refers to the process of deriving valuable insights from images. This encompasses a range of tasks, including identifying shapes, detecting edges, eliminating distortions, tallying objects and computing statistical data for tasks like texture analysis or assessing image quality. Seed image analyzer serve various purposes, including: characterizing and identifying seed varieties, sorting and grading seeds, conducting physiological assessments, such as evaluating seed vigour, viability, and germination percentage. Detecting signs of mechanical damage, insect infestations, and diseases in seeds. Seed image analyzer has been successfully used to evaluate rice germination by using digital image processing and an artificial neural networks technique. Artificial neural network (ANN):18 features: 3 colour features, 7 morphological features (change in morphological features such as seed size, seed shape, seed area, seed perimeter, seed length, seed width, seed radicle length and roundness factor), and 8 textural features were considered to evaluate germination of rice seeds (Lurstwut *et al.*, 2017) [4].

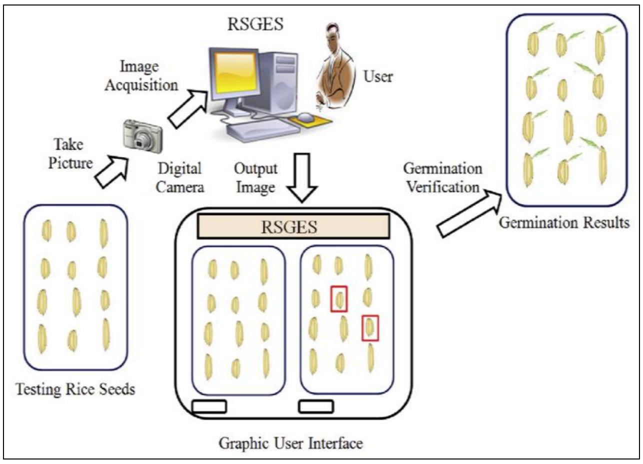


Fig 9: Rice Seed Germination Evaluation System (RSGES) conceptual diagram, (Lurstwut *et al.,* 2017) [4].

Problems in seed marketing: Insufficient storage infrastructure, including concerns related to temperature, relative humidity, and moisture in storage facilities. The difficulty of accurately estimating seed demand. Issues related to the timely availability of seeds. Challenges with price determination, promotional activities, and sales strategies. A novel perspective on spring onion seed demand forecasting and hybrid Holt-Winters and Support Vector Machine (SVM) forecasting model was proposed by Zhu *et al.* (2019) [5]. This study provides a promising spring onion seed demand forecasting model that helps understand the seed demand and the model could potentially be applied to demand forecasting of other crop seeds to reduce total operational costs.

The advantages of AI: Precision Farming: AI enables precise monitoring and management of crops, optimizing resource utilization such as water, fertilizer, and pesticides. This leads to increased crop yields and cost savings. Crop Monitoring: AI-powered drones and satellite imagery can monitor crop health, detect diseases, and assess nutrient levels, allowing for timely intervention and improved crop management. Data-Driven Decisions: AI processes vast amounts of data from sensors, weather forecasts, and historical information to provide farmers with data-driven insights for better decision-making. Predictive Analytics: AI algorithms can predict crop yields, disease outbreaks, and weather patterns, enabling farmers to plan and adapt their strategies accordingly. Weed and Pest Control: AI-driven robots and drones can identify and eliminate weeds and pests with precision, reducing the need for chemical interventions and minimizing environmental impact. Livestock Management: AI can monitor the health and behavior of livestock, helping farmers detect diseases early and improve overall animal welfare. Supply Chain Optimization: AI can optimize the logistics and supply chain for agricultural products, reducing wastage and ensuring timely delivery to markets. Crop Sorting and Grading: AI-powered machines can sort and grade harvested crops based on quality, size, and other attributes, improving product quality and market value. Labor Efficiency: Automation through AI reduces the need for manual labour, making agriculture more efficient and reducing labour costs. Disease Detection: AI can quickly identify and diagnose plant diseases and recommend appropriate treatments, reducing crop losses. Soil Health Assessment: AI can analyse soil data to assess soil health and recommend soil management practices to improve fertility. Climate Adaptation: AI helps farmers adapt to changing climate conditions by providing real-time weather forecasts and suggesting suitable crop varieties and planting times. Financial Management: AI-based tools can assist farmers in financial planning, budgeting, and risk management, improving overall farm profitability. Remote Monitoring: Farmers can remotely monitor their farms and equipment through AI-powered mobile apps, ensuring timely responses to issues. Research and Development: AI accelerates agricultural research by analysing large datasets and assisting in the development of new crop varieties and farming techniques. These advantages of AI in agriculture contribute to increased productivity, sustainability, and profitability while minimizing environmental impact and addressing the challenges of feeding a growing global population.

Every new technology brings with it certain drawbacks or disadvantages. As a result, some of the disadvantages include: High Initial Costs: Implementing AI technology in agriculture can be expensive, making it less accessible to small-scale farmers and developing regions. Data Privacy Concerns: The collection and sharing of extensive agricultural data for AI analysis raise concerns about data privacy and security. Lack of Skills and Training: Farmers may require training and education to effectively use AI systems, which can be a barrier in regions with limited access to technology education. Dependency on Technology: Overreliance on AI technology may reduce farmers' traditional farming skills and knowledge. Maintenance and Upkeep: AI systems require regular maintenance and updates, which can be challenging in remote areas with limited technical support. Complexity: AI systems can be complex, and farmers may find it challenging to understand and operate them effectively. Job Displacement: Automation through AI could potentially lead to job displacement in agriculture, particularly in manual labour roles. Environmental Impact: While AI can optimize resource use, it may also contribute to increased energy consumption if not designed with energy efficiency in mind. Ethical Concerns: There are ethical concerns related to AI in agriculture, including issues of transparency, bias in algorithms, and responsible AI use. Dependency on Data: AI systems heavily rely on data, and the accuracy of predictions and recommendations depends on the quality of input data. Regulatory Challenges: The regulatory framework for AI in agriculture is still evolving, which can create uncertainty and compliance challenges for farmers and technology providers. Unintended Consequences: AI decisions can have unintended consequences, and errors or biases in algorithms can lead to undesirable outcomes. Long-Term Sustainability: The long-term sustainability of AI in agriculture, including its environmental impact and economic viability, remains uncertain. It's important to recognize and address these disadvantages while leveraging the benefits of AI to ensure responsible and sustainable adoption in agriculture.

Conclusion

The combination of advanced computational techniques with traditional agricultural practices will unlock new opportunities for sustainable and efficient crop production.

Future aspects

The Artificial Intelligence (AI) in seed science can be used in seed production, certification, processing, quality control, seed storage and marketing. Presently AI has been exploited in the field of quality control. No research has been done in the aspects of certification, processing as well as storage.

References

1. https://genesis.farm.bot/v1.6/extras/reference/seeds.html
2. https://www.croptracker.com/blog/drone-technology-in-agriculture.html
3. Islam S, Sharma AK, Sharma K, Farooqi MS, Chaturvedi KK. Diagnosing wheat disease using expert system. Indian Soc Agric Stat. 2018;72(3):255-9.
4. Lurstwut B, Pornpanomchai C. Image analysis based on color, shape and texture for rice seed (*Oryza sativa* L.) germination evaluation. Agric Nat Resour. 2017;51(5):383-9.
5. Zhu Y, Zhao Y, Zhang J, Geng N, Huang D. Spring onion seed demand forecasting using a hybrid Holt-Winters and support vector machine model. PLoS One. 2019;14(7):1-18.
6. Mounir M, Abu-Naser S. Rule based system for diagnosing and treating potatoes problems. Int J Acad Eng Res. 2018;2(8):1-9.