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CONTENTS

Reimagining Agriculture: The Role of Digital Technologies

Agriculture has long been the backbone of India's economy, but it is increasingly confronted with growing challenges. Rising food demand, erratic climate patterns and labour shortages place immense pressure on an industry that must evolve to sustain future generations. As the world grapples with these issues, the solution is emerging in the form of innovation, particularly through the integration of digital technologies, lasers and automation. These technologies are not only reimagining how farming is done but also creating opportunities for sustainable, profitable and efficient agricultural systems. The future agriculture will be led by knowledge, technology innovation and skill.

Digital agriculture, the convergence of information technology and farming, is transforming traditional agricultural practices into data-driven, precision-based systems. The role of technologies such as Artificial Intelligence (AI), Internet of Things (IoT) and data analytics has become indispensable. These technologies help optimize farm operations, offering solutions for precision farming and predictive crop management. Digital tools like drones, IoT-based decision support systems and augmented reality (AR) labs are leading the way in efficient crop management and forecast-based farming.

Digital technologies can help bridge the rural-urban digital divide and offer better rural job opportunities in agriculture, the agri-food system and the broader rural economy. With the advanced tools such as precision farming, smart agriculture, big data analytics, artificial intelligence, robotics, the country is set to become a global leader in agricultural digitalization. These technologies offer numerous benefits, including increased yields, resource conservation, enhanced sustainability and better livelihood. To face the challenges like limited access to technology, high costs and regulatory barriers, there is a need to develop a strategic roadmap for implementing digital solutions in Indian agriculture.

This issue is mainly focussed on the digital agriculture with its diverse insights and success stories.

This issue is mainly focussed on the digital agriculture with its diverse insights and success stories. It contains articles on precision agriculture, digital farming solutions, AI-based disease and pest identification solution, lasers in agriculture, smart agriculture including aquaculture, digital image processing, mechanization and E-learning platforms.

It is believed that this issue of the magazine will be very much useful, informative and beneficial for the students and other stake holders. The editors express their gratitude to all the authors for developing and providing the articles. We sincerely thank Hon'ble Minister of Agriculture and Farmers' Welfare, Hon'ble Ministers of State of Agriculture and Farmers' Welfare, Govt. of India and Secretary, DARE and Director General, ICAR for their guidance and support in this activity. We are also thankful to the ICAR-Directorate of Knowledge Management in Agriculture, New Delhi for all support in printing this magazine.

(RC Agrawal)

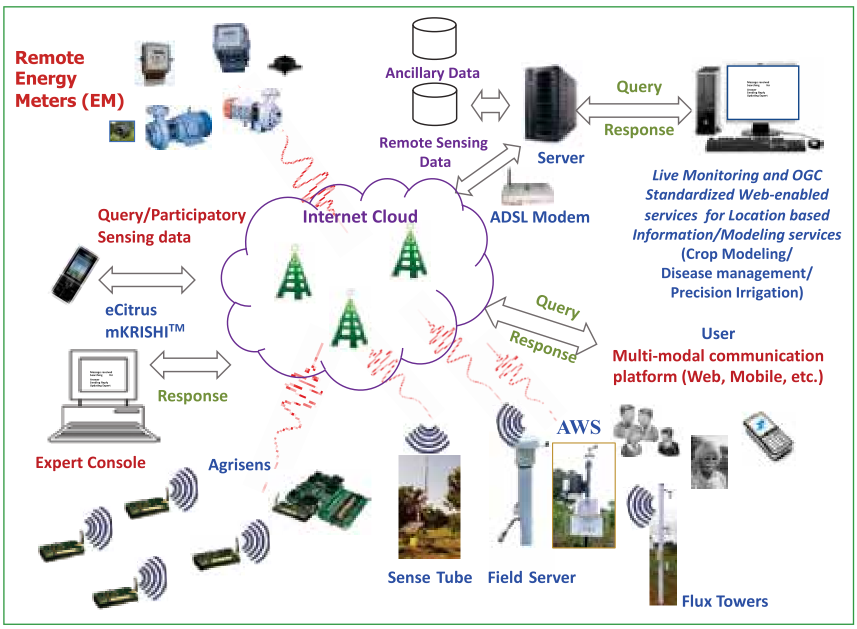
Adinarayana Jagarlapudi, Saurabh Suradhaniwar, Soumyashree Kar, Rohit Nandan and Rahul Raj

Disrupting Agriculture with Innovation: The Role of AIIA Model in Precision Agriculture

Precision Agriculture (PA) has revolutionized the way we approach farming by leveraging several advanced technologies that have either emerged or undergone major breakthroughs in the last decade, thereby providing farmers with real-time inputs to make informed decisions. The emergence of very high-resolution hyperspectral, multispectral, and microwave remote sensing data, coupled with innovations in plant phenotyping and genotypic variations, the evolution of industrial-grade unmanned aerial and ground vehicles, and the integration of physical and empirical crop models into deep learning models are among the core technologies that have significantly enhanced the capability to sense and analyze data in PA. Furthermore, advancements in edge and cloud computing paradigms, as well as the growth of interpretable deep learning at the edge, have further improved our ability to model plant-environment interactions with increased accuracy and efficiency while creating datasets for knowledge generation. By leveraging information and technology, farmers can gain a deeper understanding of the environment and its impact on agriculture. As we continue to face new challenges in agriculture, such as climate change and food security, the role of PA will only become more critical in ensuring a better future for our planet and its ecosystems.

By leveraging information and technology, farmers can gain a deeper understanding of the environment and its impact on agriculture.

Considering the ecological challenges, it is imperative to introduce innovative technologies and methods to augment existing agricultural practices. Disruptive innovation may hold the key to address the evolving demands and challenges of modern agriculture, leading to greater sustainability, eco-friendliness, and growth opportunities. One such innovation is the application of state-of-the-art Geo-ICDTs (Geographical Information, Communication, and Dissemination Technologies) in Agri-Food systems, which represent a framework that guides the process of innovation. Geo-ICDTs constitute a smart combination of technologies that have the potential to disrupt conventional notions of PA. It is important to note that while most of these technologies are well-established and widely accepted by the scientific community, they are often employed in isolation. A Geo-ICDT-derived framework helps in selecting the most suitable technologies and focuses on



A simple example of AIA Model

addressing the problem at hand rather than relying on existing solutions.

However, this article focuses on a higher level of abstraction and introduces two approaches toward the adaptation of Geo-ICDTs for PA. The first approach is centered on data collection, modeling, and dissemination and is abbreviated as the **AIA** (**Assimilate**, **Interpret**, and **Adapt**) model. This model relies on proximal and remote sensing platforms for data assimilation, computing infrastructure for interpretation or knowledge generation, and dissemination platforms to promote adaptability among stakeholders. It is widely recognized that the dimensionality of agricultural input is exceedingly high due to the vast number of parameters that impact crop growth and ensure sustainability. The highly non-linear and stochastic nature of these parameters presents a significant challenge in simulating future trends and scenarios under climate change and creating reliable forecasts for stakeholders. As a result, data from multiple sources is

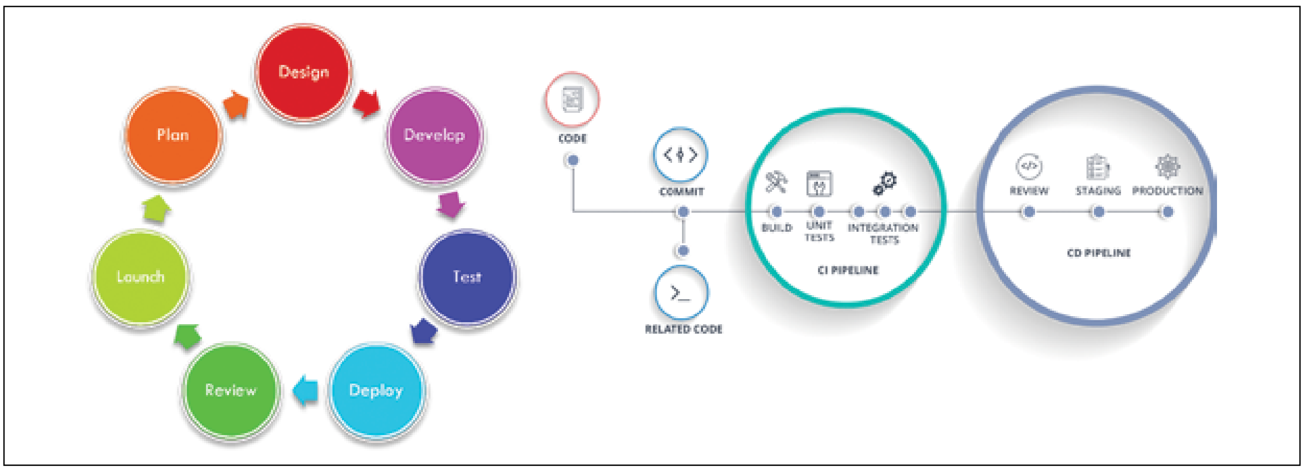
However, this article focuses on a higher level of abstraction and introduces two approaches toward the adaptation of Geo-ICDTs for PA. The first approach is centered on data collection, modeling, and dissemination and is abbreviated as the AIA (Assimilate, Interpret, and Adapt) model.

required, necessitating stream and complex event processing to track changes in parameters in real time.

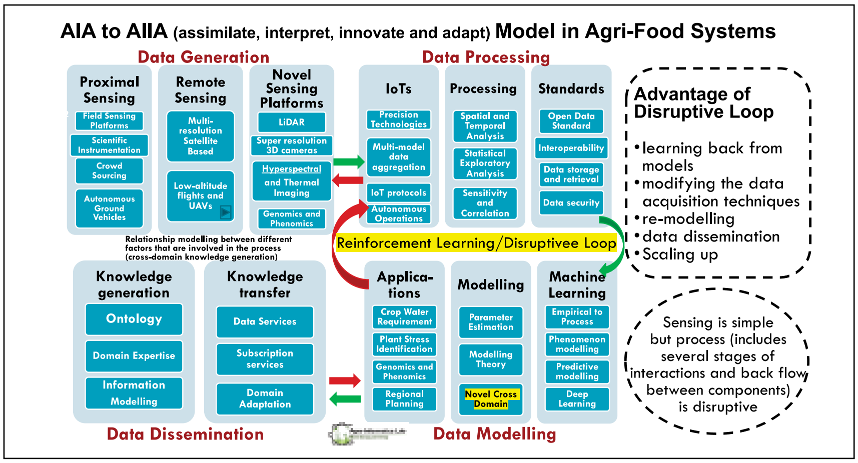
However, this approach introduces additional overhead during data interpretation and dissemination due to the abundance of information and the lack of a logical method to connect or model the dependencies between seemingly independent tasks. A simple Geo-ICDT infrastructure follows the AIA approach toward deployment, with a strong emphasis on data collection to aid the process of model generation. Nevertheless, this model lacks innovation, is difficult to scale, and employs a deprecated approach to PA.

The second approach toward adapting Geo-ICDTs focuses on collecting data from multiple sources, data analysis and interpretation, innovation through a connected data approach, and application-oriented dissemination to end-users. This integrated approach is known as the **AIIA** (**Assimilate**, **Interpret**, **Innovate**, and **Adapt**) model. The AIIA model inherits its features from the AIA model but introduces several important improvements. The AIIA model emphasizes a closed-loop feedback system, where innovation is achieved through continuous improvement using a simple Agile Approach. This approach helps in disintegrating complex problems into logical partitions, where recurring components can be reused in new solutions.

For example, a project that focuses on monitoring crop stress through UAVs could serve as an input to another project that focuses on crop disease spread and impact mapping—the emphasis should be on creating reusable datasets and transitioning from customization to generalization.



Agile model and Continuous Integration and Continuous Development (CI/CD) framework



AIIA Framework with Disruptive Loop

An essential aspect of any assimilation infrastructure is the provision of a tightly integrated system between data processing and data modeling pipelines. In the context of AIIA, this integration is accomplished through the "Interpret" and "Innovate" substages. The tasks of data processing and data modeling are interdependent and continuously linked through feedback, creating a disruptive loop.

This loop focuses on:

- Linked data (understanding hidden interdependencies between data from different platforms or IoTs),
- Vanilla processing (e.g., EDA, spatial and temporal analysis),
- Industrial standardization (proprietary and open-source protocol stacks), and
- Learning from previous models through transfer and federated learning.

The loop also involves re-modeling and re-using through transfer learning, cross-domain applications, and, ultimately, dissemination. The fundamental concept here is that:

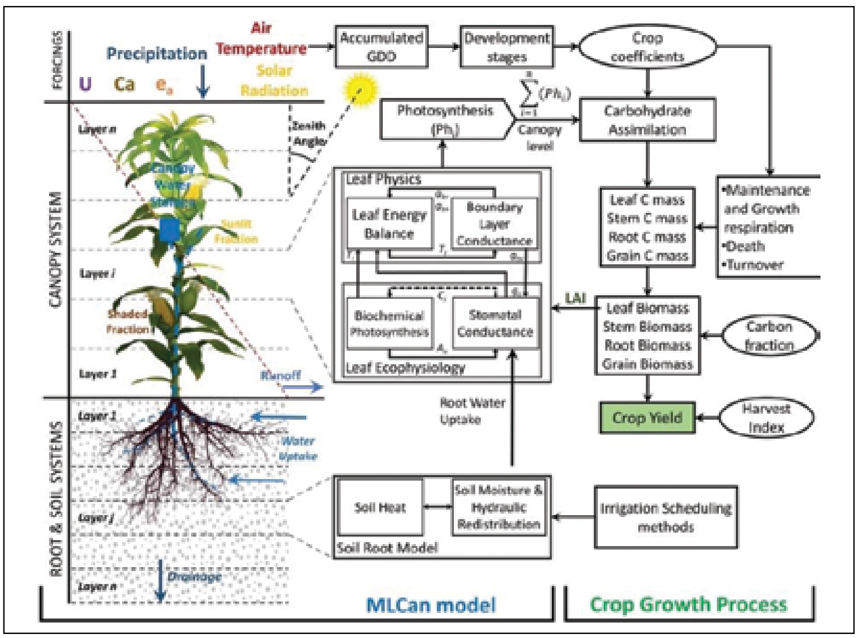
One of the R&D projects, carried out under the Indo-Japan collaboration, involves the application of high-end integrated information and agricultural sciences to support high-performance and sustainable agriculture.

'Sensing is simple; SMART (Scientific, Marketable, Affordable, Reliable, and Timesaving) sensing is difficult, and continuous sensing is a nightmare'.

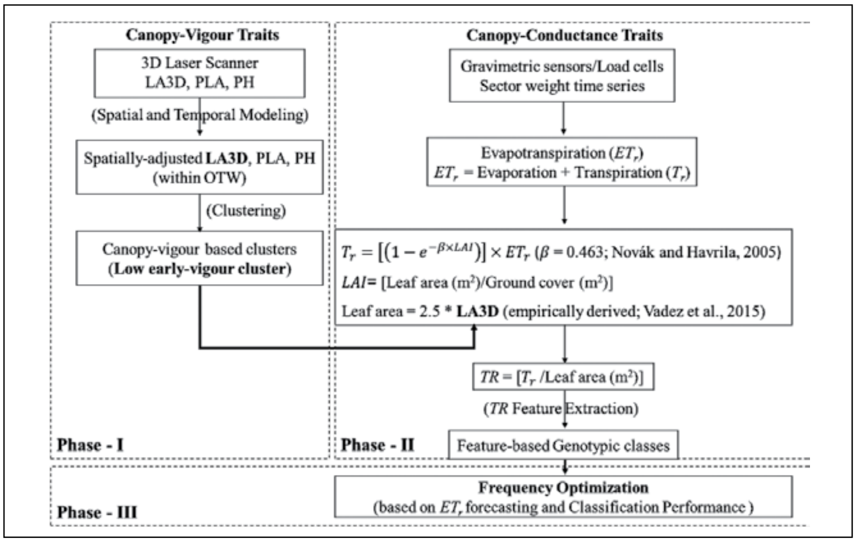
The rest of the article highlights interdisciplinary research conducted at the Agro-Informatics Lab of CSRE, IIT Bombay, as part of consortium-based projects. The focus of this research is on integrating the AIIA modeling ideology into the project pipeline. One of the R&D projects, carried out under the Indo-Japan collaboration, involves the application of high-end integrated information and agricultural sciences to support high-performance and sustainable agriculture. The project has resulted in the development of new methods, models, analytical pipelines, and an IoT platform for optimal crop management and high-performance plant breeding.

These data science-based smart agriculture solutions (Fig. 4-7) include:

Drone-based RGB and



Schematic diagram for the coupling of MLCan with crop growth processes (MLCan-Ag) that has multilayer canopy and soil representation to capture vertical distribution of the fluxes
Source: Nandan, et al., 2021



Research framework for precise identification of drought-prone genotypes based on canopy growth and conductance traits analysis pipelines and optimal frequency for canopy-conductance trait assessment using high-throughput data
Source: Kar, 2021

hyperspectral data analysis for on-farm crop stress dynamics and management.

Model 'MLCan-Ag', which incorporates agricultural solutions into an eco-hydrological modeling framework for irrigation and nitrogen management.

SpaTemHTP, an R package for high-throughput and integrated spatial and temporal analysis of canopy growth traits.

EZTr, an R pipeline for automated and high-throughput analysis of dynamic plant functional traits by deriving trait-specific proxy-phenotypes that cannot be directly imaged or measured.

A serverless computing platform that integrates Edge, Fog, and Cloud computing resources for real-time data assimilation and edge analytics.

This article outlines the significance of Geo-ICDTs and emphasizes the necessity of selecting the most optimal technologies when designing solutions for Precision Agriculture (PA). These technologies should be chosen through a framework that prioritizes modularity, generalization, recurrence, disruption, and ultimately, innovation.

The AIIA model (Assimilate, Interpret, Innovate, Adapt) serves as a straightforward guideline for integrating innovation into the development process and creating sustainable solutions. It is important to note that the AIIA model provides a framework for logical containerization of solutions, while the disruptive loop handles innovation. However, this disruption is often conditional on the problem at hand, and the AIIA framework may not be applicable in certain practical scenarios.

Nonetheless, it serves as a standard guideline for creating innovative solutions that have the potential to transform the agricultural industry and the way we perceive it.

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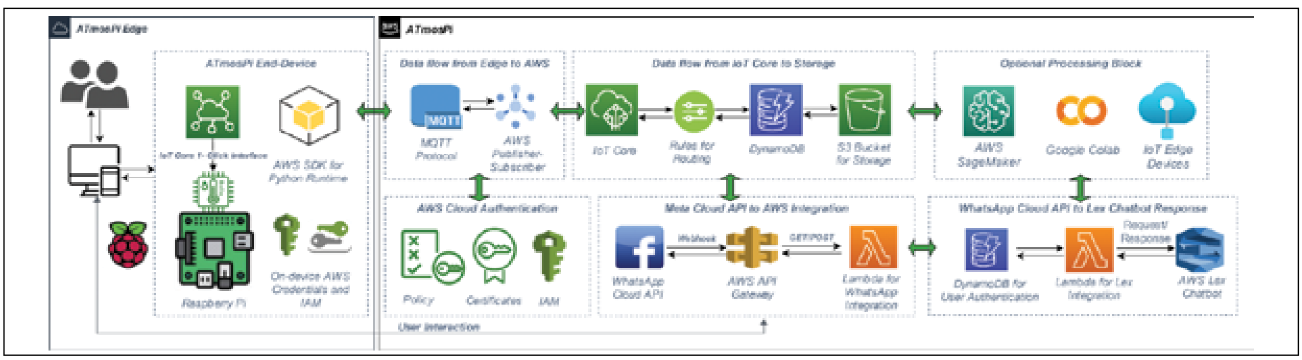


A serverless computing approach towards data using edge devices and fog capable hardware (Raspberry Pi) and Amazon Web Services for cloud resources. The proposed architecture supports data dissimilation over WhatsApp Web API and natural language interaction through AWS Lex services
Source: Suradhaniwar et., al. 2021

Prof. Indra Mani

Digital Technology in Agricultural Machinery: Industry Perspective

India's food production has grown in tandem with advancements in agricultural mechanization during the post-independence era. Food production leaped from 50 million tonnes per year in 1950 to over 323 million tonnes today. Similarly, the mechanization revolution has seen the country move from zero tractors in 1950 and 880 tractors in 1961 to producing over 1 million tractors per year currently, transforming tractor-implement production, usage, and exports.

Digital Agriculture refers to the integration of ICT (Information and Communication Technology) and data ecosystems to support the development and delivery of timely, targeted information and services, making farming more profitable and sustainable.

In India, the agriculture sector is of paramount importance and is listed among the top six priority areas, alongside defense, education, health, climate change, and cyber security. The future of agriculture will be driven by knowledge, technological innovation, and skill development. Digital technologies can help bridge the rural-urban digital divide and provide better job opportunities in agriculture, the food system, and the broader rural economy.

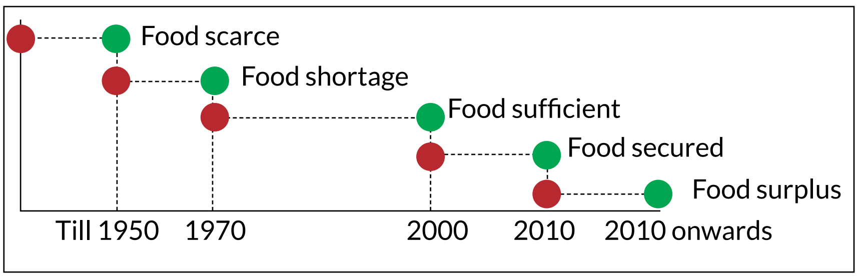
Digital Agriculture refers to the integration of ICT (Information and Communication Technology) and data ecosystems to support the development and delivery of timely, targeted information and services, making farming more profitable and sustainable. Current digital agriculture tools include advanced technologies such as sensors, controllers, and computational decision-making tools. Field-based activities are increasingly enabled by geo-location communication systems (cellular, broadband, etc.), geographical information systems (GIS), artificial intelligence, yield monitors, precision soil sampling, proximal and remote sensing, unmanned aerial vehicles (UAVs), variable rate technologies, and robotics.

Specific livestock technologies include radio-frequency identification (RFID), automatic milking systems, and electronic feeding systems, among others. Digital tools such as drones and satellites, equipped with aerial imagery and sensors, can provide farmers with timely warnings about pests and plant diseases, significantly improving risk management and efficiency.

Challenges in Indian Agriculture

Indian agriculture is currently facing numerous challenges:

- ***Land Degradation***: Continuous degradation due to intensive cultivation, outdated agricultural practices, and excessive use of agrochemicals, fertilizers, pesticides, and herbicides.



Transformation of India from food scarce to food surplus nation

- ***Water Stress***: India's water resources are under severe strain, with the country using significantly more water than other major agricultural nations to produce the same output.
- ***Climate Change***: Unpredictable weather patterns are affecting cropping cycles and increasing the risks of crop damage.
- ***High Costs***: Productivity increases are often accompanied by higher average production costs, necessitating higher output prices to ensure profitability.

There is an urgent need to shift from a focus on 'growth' to 'efficient growth,' ensuring that productivity improvements are coupled with reductions in average production costs. Automation and digital technologies hold the key to addressing these challenges. The focus should be on producing more with fewer inputs, emphasizing efficiency and cost-effectiveness. Digitalization not only helps farmers enhance productivity and quality but also ensures faster market access for crops.

To achieve this transformation, there is a need to train future agricultural scientists and engineers in basic sciences integrated with modern technologies like automation and digitalization.

From the moment a seed is sown, countless factors can impact its ability to reach its full genetic potential. To mitigate these risks, farmers need to make numerous real-time decisions, which often

Many start-ups, industries, State Agricultural Universities (SAUs), and research institutions have begun exploring the potential of drones in agriculture, including for soil and crop nutrient spraying.

exceed human cognitive capacity. However, computers, data science, and advanced machinery can collaboratively address these challenges, unlocking unprecedented opportunities to revolutionize agriculture.

Thousands of data points related to temperature, soil conditions, water usage, weather patterns, and more are collected daily through sensors, drones, smart cameras, and aerial surveys. Using artificial intelligence (AI) and machine learning (ML) models, this data is processed in real-time to generate actionable insights, enabling smarter and more efficient farming practices.

Drone: A New-Age Technology

Drones have the potential to revolutionize the farming industry through need-based, precise, and variable input applications. This technology enables input savings, timeliness of operations, reduced cultivation costs, and ensures farmers' safety by minimizing direct exposure to chemicals. Drones are widely used for targeted input applications, timely diagnosis of nutrient deficiencies, crop health monitoring, and rapid assessment of crop yield and losses.

Flying at low heights (1–3 meters) above the crop canopy, drones are highly effective for spraying crop protection chemicals and nutrients. This approach is more adaptable compared to traditional aerial spraying. Unlike ground-based spraying methods, drones can operate in field conditions that restrict the movement of wheeled vehicles, ensuring timely spray treatments without causing soil compaction.

The adoption of drone-based applications in agricultural production systems also results in significant input cost savings and environmental benefits. Due to these advantages, the use of drones in agriculture has risen sharply in recent years across the globe. They are now employed for soil and field analysis, mapping and animal detection, irrigation, crop spraying, and planting. Drone technology not only reduces the quantity of inputs like pesticides and nutrients but also minimizes environmental harm and shields farmers from hazardous exposure. This technology is particularly useful for spraying inputs in hilly regions where conventional farm equipment cannot easily operate.

Many start-ups, industries, State Agricultural Universities (SAUs), and research institutions have begun exploring the potential of drones in agriculture, including for soil and crop nutrient spraying. With the availability of DGCA guidelines, numerous companies have registered their products on the Digital Sky Platform, including agriculture drones.

Standard Guidelines for Drone Use

The lack of standard guidelines for the use of drones in agriculture has been a bottleneck in popularizing drone-based technologies in India. As drones are increasingly utilized for various agricultural operations, it has become imperative to develop Standard Operating Procedures (SOPs) that facilitate the application of different types of soil and crop nutrients using drones, plant health management, and the adoption of successful soil and crop nutrient spraying techniques, including pesticide application.

The Ministry of Agriculture and Farmers Welfare, Government of India, formed several committees to establish standard guidelines for drone applications in agriculture. The first committee, focusing on the development of guidelines for drone pesticide application, was chaired by Dr K Alagusundaram, DDG (Engg.), ICAR, New Delhi, with Dr Indra Mani as the convener. Subsequently, a committee under the chairmanship of Dr Indra Mani was formed to draft SOPs for spraying soil and crop nutrients using drones. Another committee, led by Dr Ravi Prakash, addressed SOPs for applying pesticides for crop protection with drones.

The committee chaired by Dr Indra Mani recommended generic SOPs for drone applications in crop protection, covering agricultural, forestry, and non-cropped areas. This comprehensive SOP addresses statutory provisions, flying permissions, area distance restrictions, weight classifications, restrictions in crowded areas, drone registration, safety insurance, piloting certification, operational plans, air flight zones, weather conditions, and SOPs for pre-, post-, and during operations. These SOPs were released by the Ministry of Agriculture and Farmers Welfare (MoA&FW, GoI) in December 2021.

Furthermore, crop-specific SOPs for the application of pesticides with drones were released in April 2023. These SOPs, recommended by the Committee for Drafting Crop-Specific SOPs for Application of Various Forms of Soil and Plant Nutrients with Drones under the chairmanship of Dr Indra Mani, Vice-Chancellor, VNMKV Parbhani, provide guidance on technical, operational, and safety requirements during pesticide spraying in crops such as paddy, maize, cotton, groundnut, pigeon pea, safflower, sesame, soybean, sugarcane, and wheat. These SOPs offer guidance to stakeholders involved in ensuring the safe and effective control of pests and diseases through drone-based applications. They are valuable for the effective, efficient, and safe operation of drones under different agro-climatic conditions in the country.

National Policy on Drone use in Agriculture – SoP guidelines resealed by the auspicious hands of honorable Central Union Minister (Agri. & Farmers Welfare) Shri Narendra Singh Tomar, Minister of State (Agri. & Farmers Welfare) Shri Kailash Choudhary and others

Farm Industries in India and Start-ups in Drone Technology: Farm industries in India, along with many start-ups, have begun manufacturing/assembling drones and providing drone technology/services to farmers. The industry and start-ups are collaborating with research institutions, farmer producer organizations, and NGOs to popularize drone technology. ICAR, through ATARIs, has provided 300 drones, along with funding, to demonstrate the technology over large

Demonstration on insecticides spraying by drone on farmers fields by VNMKV, Parbhani

Release of Crop specific SoP for the application of pesticides with drones

areas, to KVKs and SAUs. This is a significant initiative in popularizing this new-age technology. Farm machinery industries are also developing manufacturing infrastructure for drones and accessories.

AI and Robotics in Farming: The use of AI, such as drones, in agriculture is also emerging, especially in three major categories: agricultural robotics, soil and crop monitoring, and predictive analytics. In many developed countries, farmers are using AI technologies for sowing seeds with drones, soil mapping, and commodity pricing. AI helps reduce operational costs on farms by decreasing dependence on manual labour and allowing agronomic expertise to make data-driven decisions.

In India, work on the use of AI and robotics for agriculture is at an early stage and needs extensive field evaluation to fully reap the benefits of advanced technology. Blockchain technology will be a major focus in the coming days. It is possible to have real-time monitoring of the supply chain by leveraging blockchain, which will bring more transparency to agricultural transactions. This is vital for both farmers and consumers, as it allows farmers to negotiate better prices throughout the supply chain while enabling consumers to confidently know precisely where the produce they buy comes from.

This transparency is essential, especially in light of the growing lack of trust in the sourcing of produce sold in markets. As our population continues to grow, our agricultural methods must evolve accordingly. It is time to take advantage of the technology at our disposal to feed the growing population and provide relief to our farmers.

Robots and Artificial Intelligence in Agriculture: Robots and artificial intelligence represent the pinnacle of technological progress. Their unmatched contributions in overcoming human challenges are undeniable. Robots have taken repetitive and boring tasks out of human hands, leaving us to focus on creative work. In any industry, robots perform similar functions—handling repetitive and time-consuming tasks that would otherwise require a lot of manpower. This could include anything from spraying to removing weeds from hundreds of acres of crops, tasks that would have been seemingly impossible for humans to complete.

Some start-ups are currently developing laser and camera-guided robots that not only identify specific types of weeds in a crop but also remove them without human intervention. This development could be revolutionary, as it could eliminate the need for chemicals previously used to remove weeds, thus reducing the cost of the operation and making crops healthier and more organic.

Another application of

Release of SoP for use of drone with pesticides for crop protection and for spraying soil and crop nutrients in agricultural, forestry, non-cropped areas, etc.

robots is in vegetable and fruit farms, where the monotonous task of fruit picking requires a lot of time and labour. More and more companies are introducing robotic solutions for this process to make it easier, cheaper, and faster than it currently is. Some robots, still in the testing phase, are being designed to perform delicate tasks such as nut harvesting.

Initiative at VNMKV, Parbhani for Digital Agriculture

The Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani, has taken the initiative to promote the digitalization of agriculture. The Centre of Excellence for Digital Farming Solutions for Enhancing Productivity by Robots, Drones, and AGVs (DFSRDA) under the Centre for Advanced Agricultural Science and Technology (CAAST) was established under the World Bank-sponsored National Agricultural Higher Education Project (NAHEP) of the Indian Council of Agricultural Research (ICAR), New Delhi, Government of India, since 2019. The main objective of the center is to train postgraduate (PG) and PhD students, as well as faculty, about advances in digital technologies, i.e., new-age technologies useful for the agriculture sector. Overall, the project aims to establish an advanced basic engineering hardware and software setup, including Mechatronics, CAD/CAM/CAE, 3D printers, and instrumentation laboratories for Agribots, Agri-drones, and Agri-AGVs, so that a holistic model can be developed to raise the standard of the current agricultural education system, which provides more jobs and entrepreneurship development among youth and aligns with global agricultural education standards.

The Centre of Excellence creates advanced digital laboratories for students, faculty, and entrepreneurs to obtain a chain of knowledge for farming productivity solutions using Agri-bots, Agro-drones, and Agri-AGV devices. These solutions are organized into four portfolios: Climate-based Digital Knowledge Support (CDKS), Centre for Seed/Seedling Processing & Nursery (SSPN), Centre for Smart Portable Machines (SPM), and Centre for Food Processing Automation (FPA). With the help of these four functional areas, essential digital equipment for farmers is being developed under NAHEP. Undergraduate, postgraduate, and PhD students, as well as researchers, are being assisted in their research work through this project. Various activities are being implemented under this project, involving students, scientists, and farmers

> **The Centre of Excellence creates advanced digital laboratories for students, faculty, and entrepreneurs to obtain a chain of knowledge for farming productivity solutions using Agri-bots, Agro-drones, and Agri-AGV devices.**

with the help of CAD/CAM, advanced instrumentation, modern workshops, robots, drones, and mechatronics. More than 30 training sessions have been conducted to familiarize students and faculty with digital technology. Scientists and professors from different countries have guided these training sessions. Memorandums of Understanding (MoUs) have

Korean Vegetable Grafting Robots at VNMKV, Parbhani

Japanese Vegetable Grafting Robots at VNMKV, Parbhani

been signed for collaborative efforts regarding digital agriculture with many reputed national and international institutes, including US universities and IIT-Kharagpur and IIT-Mumbai.

Other Key AI Solutions for Indian Agriculture

Crop and Soil Monitoring: Micro and macronutrients in the soil are critical factors for crop health and the quantity and quality of yield. Traditionally, soil quality and crop health were determined by human observation and judgment or with the help of soil testing labs. These methods are less accurate and not based on real-time data. Instead, we can now use drones (UAVs) to capture aerial image data and process it for intelligent monitoring of crop and soil conditions.

Visual sensing AI can analyze and interpret this data to:

- Characterize soil texture and soil organic matter
- Track crop health
- Make accurate yield predictions
- Detect crop malnutrition

AI models can inform farmers of specific problem areas so that they can take immediate action.

Observing Crop Maturity: Manual observation of crop growth stages is labour-intensive and inaccurate. Visual data points can be processed using AI to accurately identify crop growth stages and guide farmers on the best time to harvest crops, fruits, and vegetables, bringing ease to farming and improving productivity.

Insect and Plant Disease Detection and Control: Using image recognition technology based on deep learning, we can now automate the detection of plant diseases and pests. This works using image classification, detection, and image segmentation methods to build models that can monitor plant health.

- UAVs (drones) equipped with computer vision AI make it possible to automate the spraying of pesticides or fertilizer uniformly across a field.
- With real-time recognition of target spraying areas, UAV sprayers are able to operate with high precision, both in terms of the area and the amount to be sprayed. This significantly reduces the risk of contaminating crops, humans, animals, and water resources.
- A camera mounted on the sprayer records the geo-location of weeds and analyzes the size, shape, and colour of each pesky plant to deliver precise amounts of herbicide with pinpoint accuracy.
- Many technology companies have developed robots that use computer vision and artificial

Drone assisted crop monitoring

intelligence to monitor and precisely spray weeds. These robots can reduce chemical consumption by 80% and lower herbicide expenditures by up to 90%. These intelligent AI sprayers can drastically reduce the number of chemicals used in the fields, thus improving the quality of agricultural produce and bringing in cost efficiency.

Multi-spectral cameras on drones use special filters to capture reflected light from selected regions of the electromagnetic spectrum. Stressed plants typically display a 'spectral signature' that distinguishes them from healthy plants.

Livestock Health Monitoring: Livestock are a major component of our agricultural systems, and they tend to need more tracking than plants. In developed countries, cattle can be tracked and monitored remotely and in real-time so that farmers can be notified as soon as a problem is observed. This can help in counting animals, detecting diseases, identifying changes in behaviour, tracking the health of animals, and more.

Livestock Specific Technologies: Livestock-specific technologies include radio frequency identification, automatic milking systems, and electronic feeding systems, among many others. There is an immediate need for the agricultural sector to adopt cutting-edge digital and precision agriculture technologies to improve input use efficiency and enhance farmers' profitability by increasing productivity, reducing the cost of cultivation, and adding value to farm produce.

Produce Grading and Sorting

- Imaging algorithms can also be used to sort good produce from defective or unsightly ones.
- By inspecting fruits and vegetables for size, shape, colour, and volume, computer vision can automate the sorting and grading process with accuracy and speed much higher than even a trained professional.

Predicting the Best Time to Sow: The difference between a profitable year and a failed harvest often comes down to timely information about the best time to sow seeds. To address this, analytics tools can be used to determine the precise date for sowing seeds to maximize yield.

Crop Yield Predictions and Price Forecasts: For farmers, a significant concern is the fluctuation in crop prices. Due to unstable prices, farmers can never plan a definite production pattern. This problem is particularly prevalent in perishable crops with very limited shelf life. Satellite imagery and weather data can be used to assess the acreage and monitor crop health on a real-time basis. With the help of technologies like Big Data, AI, and Machine Learning, companies can estimate the output and yield and forecast prices. They can guide farmers and governments on future price trends, demand levels, the type of crop to sow for maximum benefit, pesticide usage, and more.

Thus, AI allows for the efficient growth of agriculture, solves the scarcity of resources and labour to a large extent, and minimizes the use of inorganic chemicals. It is a powerful tool that can help farmers cope with the increasing complexity of modern agriculture. To make this a reality, it is time to reimagine agriculture and agricultural education in India. There is an urgent need to restructure the curriculum in

Drone flying with cameras to monitor soil and crop

Automatic Weather Station at VNMKV, Parbhani

agricultural sciences. Students need a thorough understanding of emerging technologies that can be leveraged for agriculture. Colleges should offer elective courses in areas such as AI, Machine Learning, Image Recognition, Automation, UAV use, robotics, and more. The modern technologies that can revolutionize agriculture are here. It is time to adopt them quickly and possibly kickstart the Green Revolution 2.0.

Mechanization and Automation: *Attracting Youth to Agriculture*

Mechanization and automation are among the top 20 inventions of the 20th century, and India has made monumental progress in this area. With the combined efforts of research institutions, a vibrant industry, and conducive government policies, agriculture—particularly mechanization—has grown exponentially in the country. Today, India holds first or second positions globally in the production of many agricultural and allied commodities and ranks as the world's leading producer of tractors.

A significant challenge for agriculture today is attracting educated youth to the sector. Mechanization has brought about social engineering changes in agricultural entrepreneurship by improving social status, removing drudgery, saving time, enhancing precision and efficiency, and increasing farmers' incomes. Digital tools for mechanization and automation of agricultural operations have the potential to attract young, talented individuals, including CEOs of startups and professionals engaged in NGOs and FPOs. These efforts will pave the way toward achieving India's vision for agriculture by 2047.

The Potential of Digital Agricultural Technology

Digital agricultural technology holds immense potential to revolutionize agriculture by improving efficiency, ensuring environmental sustainability, and boosting productivity in crop and livestock production. The driving forces behind digital agriculture include not only major global input industries but also emerging players such as software companies and startups. These entities cater to a wide range of farmers, from large-scale operators to smallholders. However, concerns remain regarding the potential for digital agriculture to amplify the market influence of large agribusiness enterprises.

In developing countries, public initiatives have the power to transform private-sector digital agriculture innovations into thriving industries, benefiting a broader spectrum of farmers and consumers. Potential interventions include:

- Implementing policies to foster a conducive business environment.
- Building knowledge and skills.
- Developing communication infrastructure.
- Financing applied research to support digital technologies.

Public action is essential not only to harness the opportunities of digital agriculture but also to address risks, such as the increased concentration of market power among agribusinesses. A collaborative approach that combines private-sector efforts with strategic public interventions is critical to ensure that digital agriculture leads to an agricultural revolution benefitting farmers, laborers, consumers, and the global environment.

Way Forward: *Triple Helix or AIG Approach*

Economic growth and national welfare depend on foundational innovations. The objective of innovation policy is to envision a desirable future and facilitate its realization. Innovation results from the interplay of "science," "technology," and "innovation," which often progresses from scientific research to technological advancements and innovative products.

However, a more nuanced perspective breaks these activities into interconnected components within a

Digital agricultural technology holds immense potential to revolutionize agriculture by improving efficiency, ensuring environmental sustainability, and boosting productivity in crop and livestock production.

multidimensional socio-technological economic network. Entrepreneurship drives innovation, fostering welfare and improving living standards. The government plays a critical role in creating and maintaining the framework within which enterprises can introduce novelties. How innovations are adopted depends on their ability to meet perceived consumer needs, which can be shaped by marketing, cultural trends, or societal inertia.

Economic theory must justify government support for research and development (R&D) through subsidies and incentives for industrial or business research. The Triple Helix model posits that post-industrial economic development is driven by the production and dissemination of socially organized knowledge. Universities (Science), industries (Business), and governments (Governance) play interconnected roles in this process. Research under this model aims to explore the impacts of subsidies on R&D investment and company innovation performance.

The Triple Helix model can be visualized within a Cartesian coordinate system, with the dimensions of Science (S), Business (B), and Government (G) represented orthogonally.

Encouraging Academia-Industry-Government Partnerships

Encouraging the incubation of new technology companies is vital for innovative economic growth. Many countries have established R&D institutions that promote Academia-Industry-Government (AIG) partnerships, supporting the incubation of new companies in the digitalization of agricultural machinery and the commercialization of scientific and technological advancements.

ICAR and SAUs prioritize this growth model. ICAR has urged its institutes to focus on industry collaboration, including R&D funding under Corporate Social Responsibility (CSR). VNMKV Parbhani has secured significant industry support to impart skills to farmers through its KVKs, the Maharashtra Mechanization Centre-cum-J-Farm at its Parbhani campus, and the Marathwada Farmers Training Centre at the Agricultural Technical School in Sambhaji Nagar.

Strong collaboration among research institutions, industries, farmers, FPOs, and government departments is essential to achieve agricultural development and make India a '*Vikshit Bharat*.'

Vice Chancellor
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P S Pandey, P K Pranav and Ravish Chandra

Digital Agriculture Initiative: The RPCAU Perspective

Agriculture is a fundamental necessity for human survival, as it provides the food essential for sustaining life. However, agriculture remains a profession of low profit, significant human drudgery, and limited societal dignity. Farm mechanization has slightly improved the situation, particularly in addressing power requirements; however, crop monitoring is still predominantly manual. Crop monitoring involves farmers' judgment regarding various needs such as irrigation, insecticide, pesticide, fertilizer, and weeding. These judgments are based entirely on experience and are prone to errors, leading to crop damage, resource wastage, and financial losses.

Digital agriculture integrates cutting-edge technologies—such as artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and drones—into traditional farming practices. Digitization has brought about a revolution across sectors, making human life more comfortable, efficient, and economical. The digitalization of agricultural activities enables the precise assessment of plant requirements through sensors and artificial intelligence, reducing input costs and enhancing yield. Additionally, receiving real-time updates on plant requirements via mobile devices through IoT and automating management processes minimizes delays.

Thus, it is evident that the application of sensors, artificial intelligence, machine learning, the Internet of Things, and automation in digital agriculture significantly reduces input costs, enhances crop yields, and ultimately increases farmers' profitability.

India is witnessing a gradual adoption of digital agriculture, driven by government initiatives, private sector involvement, and growing awareness among farmers.

India is witnessing a gradual adoption of digital agriculture, driven by government initiatives, private sector involvement, and growing awareness among farmers. Programs like the *Digital Agriculture Mission 2021-2025* aim to promote the use of technology in farming. Startups and Agritech companies are also playing a pivotal role in providing technology-driven solutions to challenges such as fragmented landholdings, unpredictable weather patterns, and resource inefficiency.

Few Applications of Digital Technology at RPCAU, Pusa

Some viable digital technologies implemented at Dr Rajendra Prasad Central Agricultural University, Pusa, are benefiting various stakeholders in the agricultural system.

Agricultural Drones for Spraying and Surveillance: Smart drones are revolutionizing agriculture by providing farmers with a new perspective on their operations. Equipped with advanced imaging technologies, these drones offer critical insights into plant health across entire fields. Multispectral cameras on drones can detect early signs of crop stress—such as pests, diseases, or drought—before they are visible to the naked eye. This early detection allows farmers to address issues proactively. Additionally, drones are being utilized for precision planting and targeted applications in various regions.

Drones play an important

Application in paddy

Application in pigeon pea

Application in wheat

Application on mango tree

Various application of drone for spraying

role in agriculture, particularly in spraying, as they save significant time and energy. The efficacy of drone-based spraying is reported to be high due to better coverage facilitated by smaller droplets. Autonomous drone operation has further improved precision by ensuring application at exact locations using GPS technology.

Furthermore, drone-based surveillance offers multiple solutions, including monitoring waterlogging conditions, crop health, crop damage, and other requirements as needed. Remedial applications, such as spraying, can also be carried out precisely on affected areas using GPS technology.

IoT based *JioKrishi* Digital Platform: The IoT-based *JioKrishi* Digital Platform is being installed at farmers' fields to assess the efficacy of real-time information, such as weather, soil data, water need prediction, and irrigation/fertigation management, which is delivered to the mobile devices of registered users. In this system, sensors are installed to measure soil and weather parameters and analyze them through a pre-installed decision support system to determine the various applications needed for different crops in nearby localities.

Registered farmers receive advisories on crops (weather conditions, irrigation needs, pest attack warnings, disease warnings, nutritional requirements, etc.) through JioKrishi digital platform on their mobiles. The view of the installed platform and screenshots of the various output screens are shown in.

IoT – based Decision Support System for Disease Forecasting: The IoT-based integrated decision support system (DSS) records real-time soil and crop microclimate data. The data is stored in the cloud database, analyzed by the system, and relevant real-time crop management practices are suggested to stakeholders. Primarily, the device and the integrated sensor module record data on temperature, relative humidity, wind speed, wind direction, rainfall, light intensity, soil temperature, moisture level, canopy temperature, and vapor pressure deficit.

The system forecasts various disease incidences,

Registered farmers receive advisories on crops (weather conditions, irrigation needs, pest attack warnings, disease warnings, nutritional requirements, etc.) through JioKrishi digital platform on their mobiles.

View of Installed IoT based *JioKrishi* Platform

Screenshot of the various output screens of mobile application

> **The college has conducted various sensitization workshops on AR-VR to expose students and faculty to this technology. The AR-VR lab, established in the College of Agricultural Engineering and Technology, Dr Rajendra Prasad Central Agricultural University, Pusa, Provides an immersive experience for studies and facility.**

irrigation schedules, spray schedules, etc., based on real-time data recordings. The Decision Support System module is being verified with the prevailing disease-pest incidences and microclimatological parameters. This device fosters smart horticultural practices through forecasting, which facilitates smart crop management. A view of the IoT-based smart DSS for disease forecasting installed in the Banana orchard of RPCAU is shown.

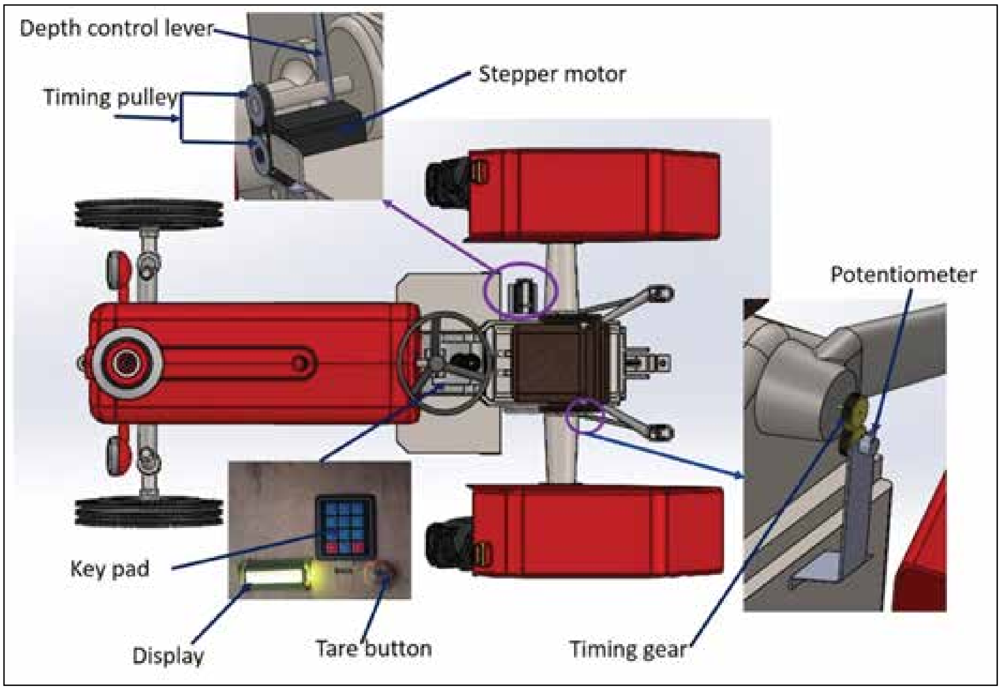
Augmented Reality and Virtual Reality Lab (AR-VR): Augmented Reality (AR) systems operate on three essential components: a coupling of real and virtual environments, real-time interaction, and precise 3D visualization of objects. Virtual Reality (VR), on the other hand, is an entirely simulated, artificial, digital world designed to deliver sensory experiences that closely mimic the physical reality of the user.

The AR-VR lab is equipped with VR kits and virtual reality educational modules that allow users to experience virtual laboratory tours and technologies from various institutes. The VR kits include rechargeable VR headsets (fitted with cameras and internal data storage) and left and right controllers (powered by batteries) to experience and interact with the virtual environment.

With 6 degrees of freedom (DoF), the headset tracks the movement of both the user's head and body, translating them into VR with realistic precision. The college has conducted various sensitization workshops on AR-VR to expose

View of IoT based smart DSS installed in Banana orchard of RPCAU

Student and faculty experiencing the AR-VR laboratory



View of instrumentation system mounted on tractor

With the right policies and partnerships, India can emerge as a global leader in digital agriculture, paving the way for a brighter and more prosperous future for its farming community.

students and faculty to this technology. The AR-VR lab, established in the College of Agricultural Engineering and Technology, Dr Rajendra Prasad Central Agricultural University, Pusa, Provides an immersive experience for studies and facility.

Digital Display of Depth and its Automatic Control: A digital depth display and microcontroller-based automatic depth control system for tractor-mounted implements has been developed to operate the tractor at the required depth of operation. The real-time depth of operation, as measured by the sensor, is temporarily saved as SMD in the microcontroller. The controller then checks whether the SMD is greater than or less than the desired limit, as set by the operator digitally. If it is, the controller sends a signal to rotate the stepper motor by one step to adjust the depth of operation, either by reducing or increasing it, and then repeats the process, starting from the depth sensing.

Conclusion

In an era where global population growth and climate change are exerting enormous pressure on agricultural systems, cutting-edge technologies such as artificial intelligence, the Internet of Things (IoT), and sensor fusion technologies are offering innovative solutions to problems such as labour shortages, accurate weather forecasting, and soil and crop health monitoring, among others.

Based on the discussion of various technologies and tools available, it can be concluded that the application of digital agriculture is the need of the hour to make the agricultural system simpler, more comfortable, and more profitable. It is certain that with the application of these technologies, the agricultural system will become a preferred profession, attracting the younger generation towards agriculture. This will, in turn, initiate capacity building in these technologies, and organizations responsible for this area have already started courses to develop trained manpower under the heading of digital agriculture.

Digital agriculture holds immense promise for India and can significantly improve the livelihoods of millions of farmers. However, realizing this potential requires a concerted effort to address infrastructural, financial, and educational barriers. With the right policies and partnerships, India can emerge as a global leader in digital agriculture, paving the way for a brighter and more prosperous future for its farming community.

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AI-DISC:
An Automated Solution for Diagnosing Plant Diseases and Insect Infestations using Artificial Intelligence

The term Artificial Intelligence (AI) was coined by a small group of scientists and enthusiasts long before the emergence of transformative technologies that have significantly impacted human society and the environment. In the summer of 1956, a workshop at Dartmouth College, led by John McCarthy and attended by just ten participants, explored the concept of intelligent machines, marking a departure from the prevailing automata theory. Since its inception, the development of AI has been accompanied by a persistent divide among stakeholders. While some have passionately advocated for its potential, envisioning futuristic sci-fi applications, others, including foundational thinkers, have remained deeply skeptical. In 2016, Mohanty and his team pioneered the use of deep learning for detecting plant stress caused by diseases and insect pests. Following the publication of this groundbreaking research, academics began to explore and leverage the potential of AI in agriculture for identifying pests and diseases. AI-DISC (Artificial Intelligence-Based Disease Identification Systems for Crops) is a solution in this line, backed by AI, that can identify plant diseases and insect pests via a mobile application with intelligent identification capabilities.

Need for AI-DISC

In a vast country like India, where experts are scarce, it is not feasible to reach every farmer to provide advice on coping with the recurring pests and diseases in their crop fields. The lack of proper and timely disease identification leads to tremendous crop loss and improper pesticide use, causing severe environmental hazards. To properly identify crop diseases and provide scientific advice on time, an app like AI-DISC is highly needed.

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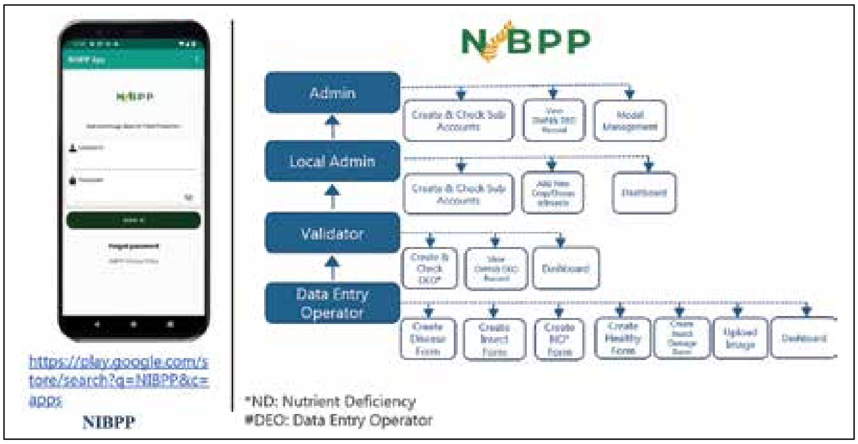
Life Cycle of AI-DISC Solutions

The foundation of any AI solution lies in data collection, followed by data pre-processing to ensure it is suitable for AI model consumption. Once cleaned and prepared, the data is used to build models, which are then deployed in applications to enable AI functionality. AI-DISC follows this process, encompassing data collection, cleaning, model development, and deployment to provide end-users with effective AI-driven solutions.

Data Collection: Deep learning is a data-hungry process, where the quantity of data often outweighs its quality. In this study, the mobile-based application NIBPP (National Image Base for Plant Protection) was used to collect, validate, and annotate crop images across India. NIBPP, managed by the Indian Council of Agricultural Research (ICAR) and 11 State Agricultural Universities (SAUs) from various agro-climatic zones in India, hosts over 500,000 images spanning more than 70 crops. NIBPP offers a structured hierarchy for tasks like image validation and annotation, with various user roles such as admin, validator, and data entry operator.



NIBPP mobile applications with different levels of user and their activities for data upload

Image Pre-processing: In AI-DISC, crop-specific models are deployed, with modeling carried out individually for each crop. Since the number of diseases varies across crops, the data is often imbalanced in terms of quantity, size, and other image attributes. To address this, pre-processing steps play a crucial role in standardizing the data and ensuring uniformity. Standard packages, such as Image Data Generator from Keras and torchvision.transforms from PyTorch, are used for pre-processing tasks like resizing, normalization, augmentation (e.g., flipping, rotation, and zooming), and data scaling, ensuring the data is well-suited for model training.

Modeling: The AI-DISC platform has experimented with a wide range of models, selecting the best-performing ones for deployment. For classification tasks, novel models inspired by GoogleNet and EfficientNet were utilized. Additionally, several pre-trained models, including VGGNet, InceptionV3, ResNet50, Inception ResNetV2 MobileNet and DenseNet, were

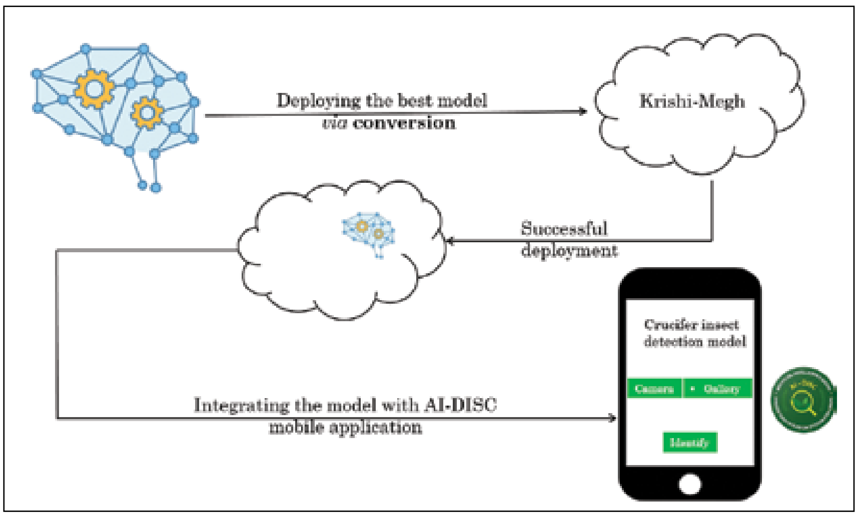
Recently, the AI-DISC team has shifted focus to single-stage object detection, utilizing the YOLO family of models for enhanced performance in insect detection tasks.

leveraged for their efficiency in classification. Object detection models were employed for identifying insect pests, with VGGNet used for two-stage object detection. Recently, the AI-DISC team has shifted focus to single-stage object detection, utilizing the YOLO family of models for enhanced performance in insect detection tasks.

Deployment: The deployment of AI-DISC models in the *Krishi Megh* cloud infrastructure ensures scalability, accessibility, and

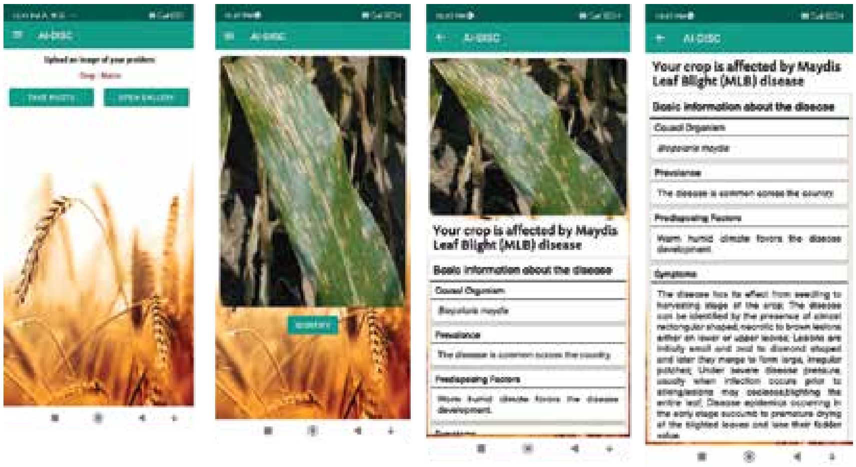
By leveraging Krishi Megh, AI-DISC provides a scalable, secure, and remotely accessible AI solution, empowering farmers, researchers, and extension workers with reliable tools for pest and disease identification.

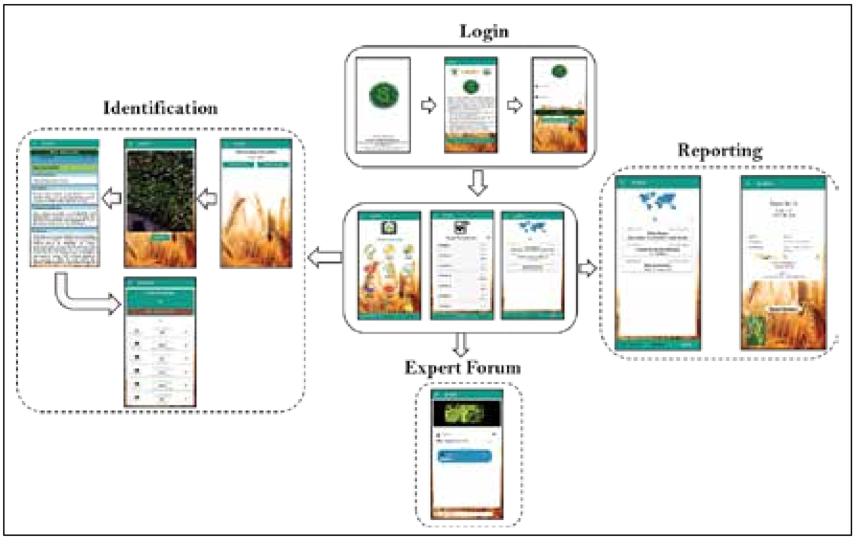
high-performance computing for agricultural applications. Each crop-specific model is trained individually using frameworks like Keras and PyTorch. The trained models are optimized for inference using ONNX to ensure cross-platform compatibility and are then containerized with Docker, bundling the model, dependencies, and preprocessing logic for consistent execution. *Krishi Megh's* high-performance



Deployment of the crop wise deep leaning model in Krishmegh cloud infrastructure.

servers provide the computational power to host these models, while distributed storage securely manages large-scale image data. Load balancers evenly distribute requests, ensuring uninterrupted service during high-demand periods. The models are integrated into the infrastructure via RESTful APIs, enabling real-time pest and disease detection for end-users through mobile and web platforms. The system uses a combination of single-stage (YOLO family) and two-stage (e.g., VGGNet) object detection frameworks to deliver accurate and timely results. By leveraging *Krishi Megh*, AI-DISC provides a scalable, secure, and remotely accessible AI solution, empowering farmers, researchers, and extension workers with reliable tools for pest and disease identification.


Disease Identification module in AI-DISC



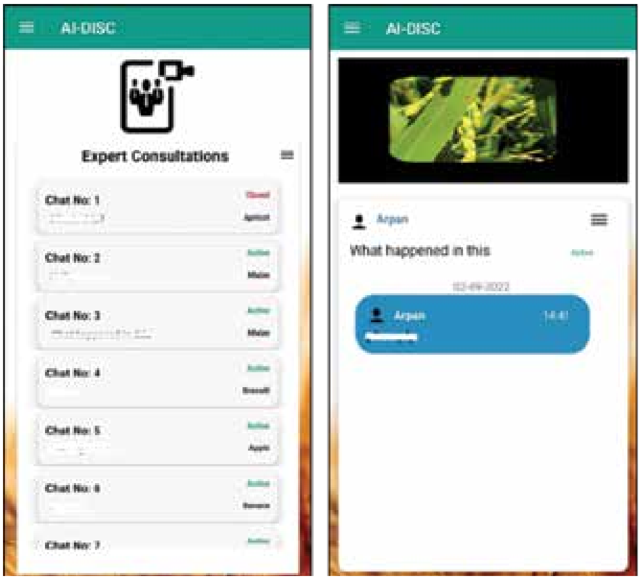
Modules available in AI-DISC


Log in module for AI-DISC

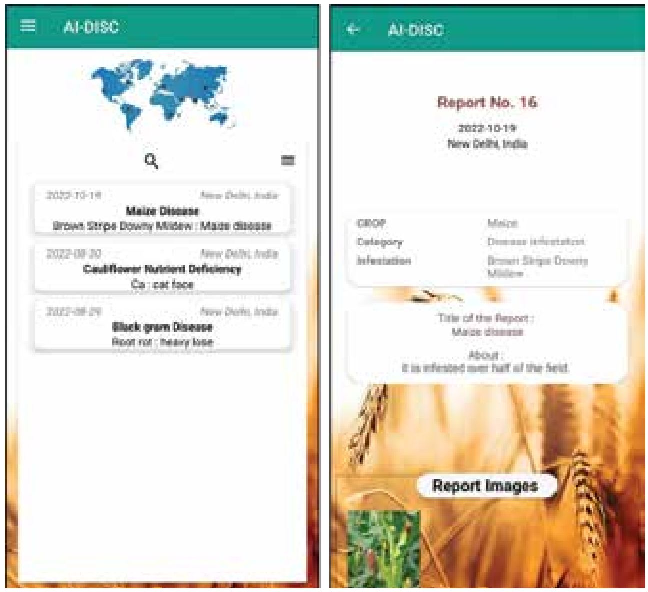
Development of Android Based mobile application: AI-DISC is a native Android App which is built using latest versions of Java, Android SDK and MS SQL Server as database server. It incorporates Deep Learning models that are built using python libraries and Deep Learning frameworks like TensorFlow and Keras. The models are trained, tested and deployed on highly efficient NVIDIA DGX GPU Clusters. This app will work smoothly in different version of android phones ranging from **Android 7 (Nougat) to Android 12 (R)**.

Modules in AI-DISC

Login Module: This module is used for user management in AI-DISC.Registered farmers can identify the diseases by own self with the help of the AI-DISC and get the advisory. Farmer also can send the query to the crop-wise experts to get any solution.



Real-Time Expert Forum for Farmers via Text and Images



Real-Time Crop Protection Information Nationwide

Disease Identification Module (DIM): The DIMprovides an interface for the identification of diseases acrossmultiple crops and provides crop management package and practices based on the identified disease for the **extension workers**. Steps are followings:

STEP 1: Login into AI-DISC

STEP 2: Select disease/ insect

STEP 3: Select crop

STEP 4: Upload images

STEP 5: Identification and Advisories

Expert Forum Module (EFM): The EFM facilitates the way of communication between users (**extension workers**) and subject matter specialists or domain experts working in different ICAR-institutes and SAUs for the consultation plant protection relatedproblem.

Real-Time Expert Forum for Farmers via Text and Images

News Feeds Module (NFM): This module provides real-time information regarding crop-protection related problems happening across the country, reported by verified users of this application.

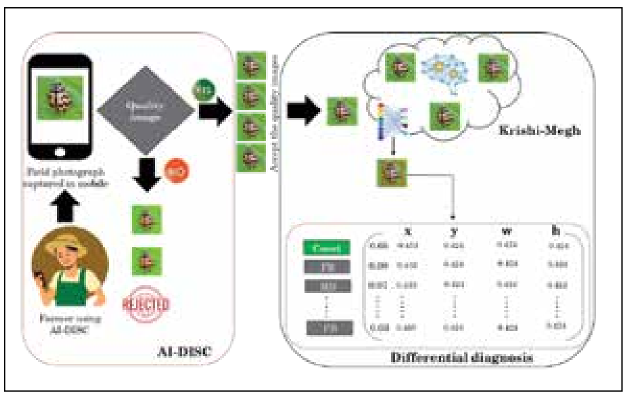
Inference in AI-DISC

The AI-DISC application includes robust client-side validation to filter out low-quality images, incorrect crops, and any irrelevant objects that do not relate to plant parts or insects with a natural background. Once the image passes this validation, it is processed by the deployed model on the server. After the model identifies the subject, it only provides stress advisories if the model's confidence level exceeds 85%.

Intended Audience and other collaboration

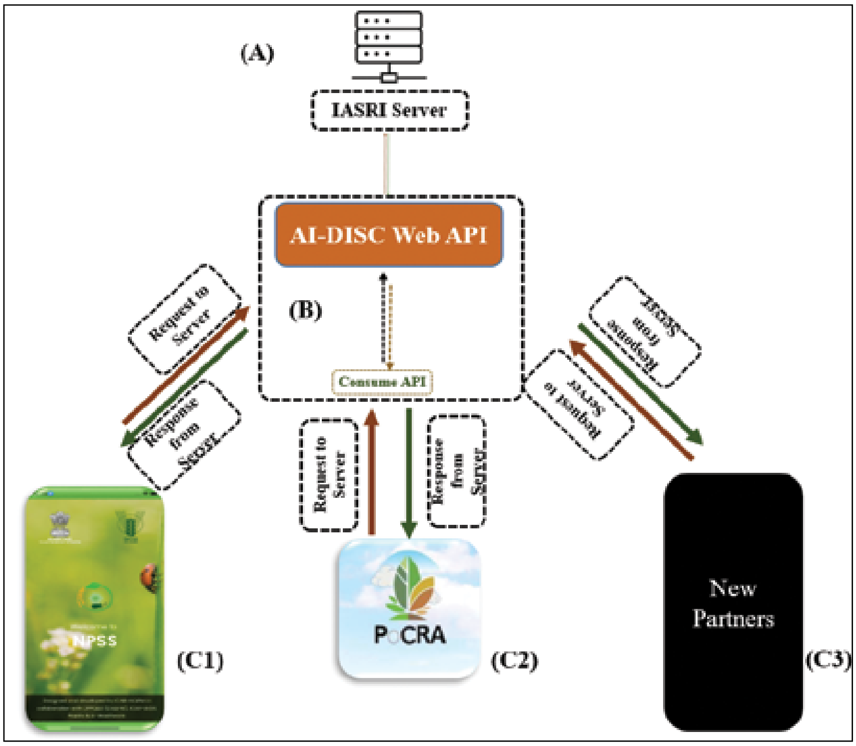
AI-DISC serves as a tool for farmers, research scholars, and plant protection experts to identify plant diseases at early, middle, and severe stages. It provides general scientific advice for controlling these diseases. The identification APIs of AI-DISC can be easily integrated with other applications. ICAR-IASRI is seeking to integrate AI-DISC APIs with other government and private applications to

ICAR-IASRI is seeking to integrate AI-DISC APIs with other government and private applications to reach the maximum number of farmers.



Inferencing of insect identifications in AI-DISC reach the maximum number of farmers. Figure 10 illustrates how potential partners can harness the power of AI-DISC for disease and insect pest identification. Section A shows the server where the deep learning models are deployed. Section B shows the exposure of web APIs for potential clients C1 and C2. Figure 10 (C3) demonstrates new partners integrating AI-DISC APIs into their applications, enabling AI-powered automation for disease and insect pest identification.

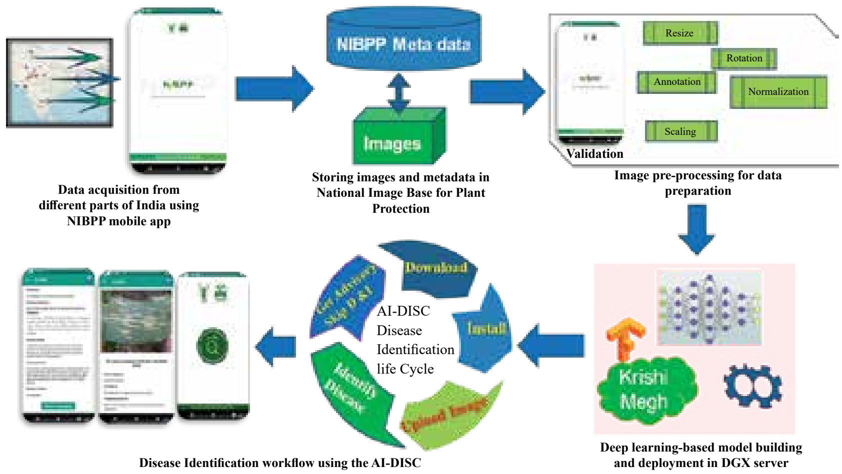
Utilization of AI-DISC APIs for AI-Driven Disease and Pest Identification in Client Applications



Utilization of AI-DISC APIs for AI-Driven Disease and Pest Identification in Client Applications

CONCLUSION

AI-DISC is a powerful tool that empowers farmers, researchers, and plant protection experts to efficiently identify and manage plant diseases at various stages of progression. By providing accurate disease detection and actionable scientific advisories, it aids in timely interventions to safeguard crops. With its easy integration capabilities, AI-DISC can be integrated with various applications in agriculture and allied sector. Through continuous innovation and collaboration, AI-DISC plays a pivotal role in advancing plant protection practices and enhancing agricultural sustainability.



Disease identification model development using large image database and deep learning techniques

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Sourabh Debbarma and Sugumar G

Smart Aquaculture:
Through Intelligent Diagnostics of Fish Diseases

Fisheries in India contribute significantly to the economy, accounting for 1.25% of VAA and export earnings of ₹63,969 crore (8.09 billion USD) in 2022-23. Total fish production in 2022-23 was 17.4 MMT, with over 70% contributed by aquaculture. Marine catch remains stagnant, making aquaculture the only way to increase fish production. However, diseases and infections spread quickly through aquatic systems, posing a major threat to productivity.

Fish infections are a serious concern for fishermen. Traditionally, fish farmers diagnosed diseases through visual observation and laboratory tests, a time-consuming and sometimes misleading process. Early detection of diseases is crucial to prevent the spread of infections and reduce economic losses. Aquaculture faces challenges such as maintaining water quality and identifying fish health issues in a timely manner. Common fish diseases include pop-eye, fin and tail rot, gill damage, and Epizootic Ulcerative Syndrome (EUS), which are caused by bacteria, viruses, and fungi.

Automated disease detection is vital for smart aquaculture. Recent advancements in computer vision, image-based diagnosis, and expert systems have improved fish disease detection. Traditional methods, relying on expert systems, depend on the experience and skill of the experts, which can affect accuracy and speed. Image-processing technologies,

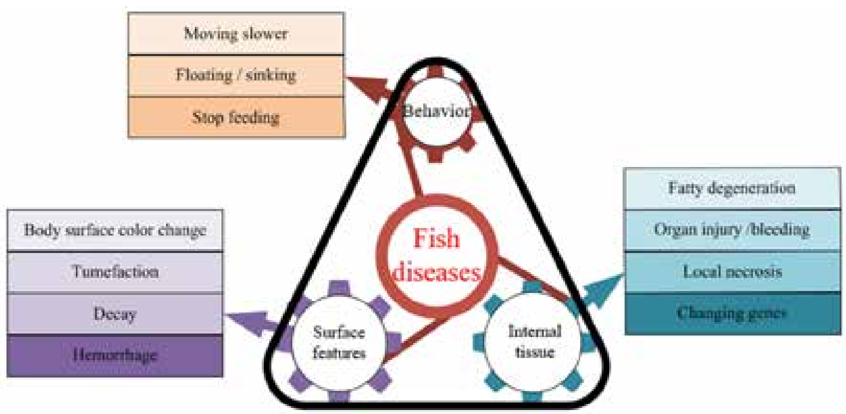
> **Common fish diseases include pop-eye, fin and tail rot, gill damage, and Epizootic Ulcerative Syndrome (EUS), which are caused by bacteria, viruses, and fungi.**

using characteristics like texture, shape, and color from disease images, have shown promise in diagnosing fish diseases. Techniques like camera, microscopic, spectral, ultrasound, and fluorescence imaging have proven effective for fish disease diagnosis.

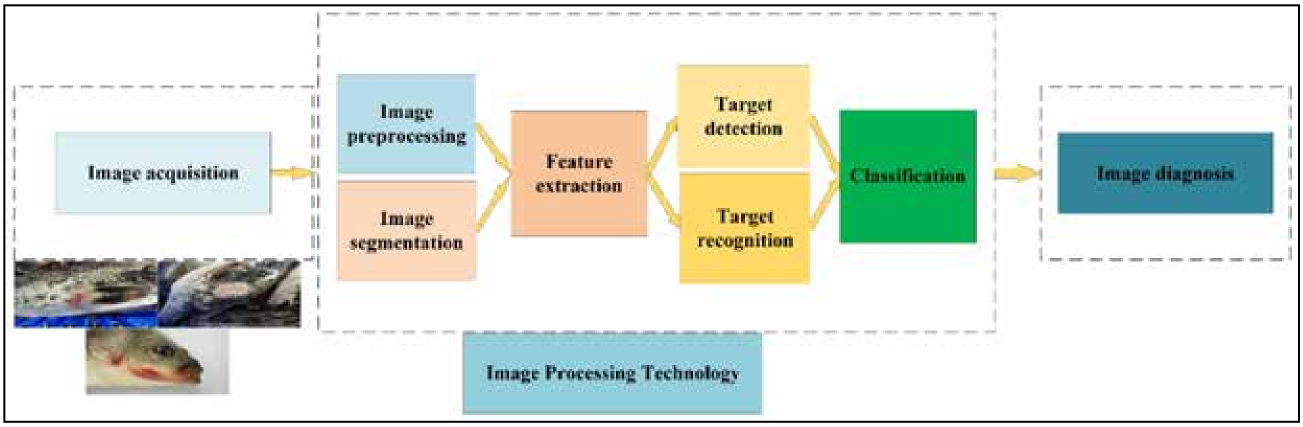
Combining image-processing technology and computer vision has led to safer, faster, and more accurate diagnostics, making fish disease detection automated, cost-effective, and environmentally friendly. This integration has made significant progress in the development of intelligent aquaculture systems, offering better tools for diagnosing fish diseases and improving fish health.

Intelligent and Rapid Diagnostic Methods of Fish Diseases

Fish diseases can be brought about by a variety of regularly occurring ailments as well as chemical compounds and prevalent pathogens including bacteria, viruses,



How diseases affect fish (*Source:* Li et al., 2022)



Process of diagnosing fish diseases using image processing, (*Source*: Li et al., 2022)

fungi, and parasites. Variations in the aquatic environment may also put fish health under stress. Figure below illustrates how diseases affect fish, resulting in changes to their surface, behaviour, and internal tissues.

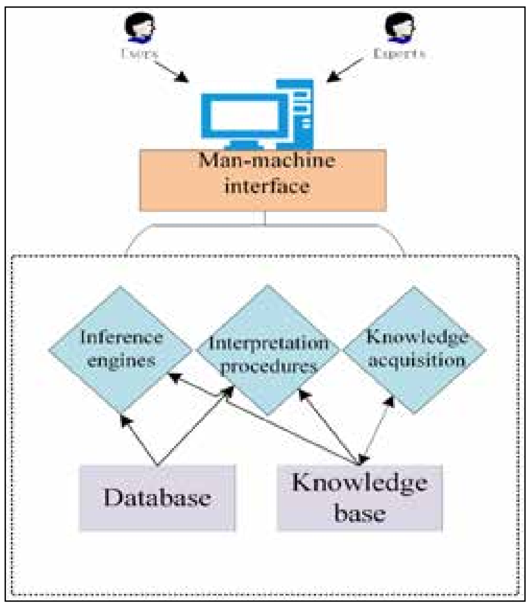
Pattern recognition is essential for automated disease diagnosis, involving three main functions: segmentation (isolating lesions), feature extraction (gathering information about the lesions), and categorization (combining features for accurate disease identification). In aquaculture, image-processing technology is used for tasks like measuring fish weight and length, classifying and counting fish, and detecting diseases. However, diagnosing fish diseases is challenging due to the variety of diseases, complex survival conditions, and diverse symptoms. Image-processing technology aims to improve photo quality and eliminate irrelevant data, enabling more accurate and reliable fish disease diagnosis and identification by computers.

Accurate detection of diseases must be performed with the help of high-quality images. Firstly, image-processing technology is used to improve the quality of fish images; then, high-quality images are used for segmentation, detection, and identification. Finally, fish diseases are diagnosed based on fish classification. There are several intelligent automated diagnostic methods presently applied in detecting fish diseases such as:

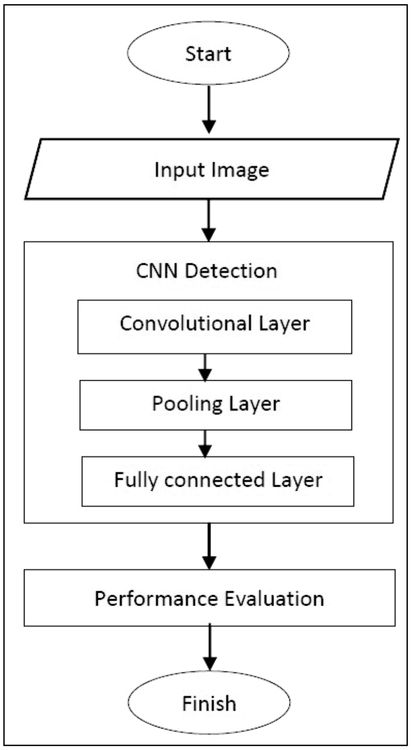
Aquaculture Expert Systems

An early expert system frequently used for fish disease diagnosis in aquaculture environments consists of computers integrated with expert knowledge about fish diseases. The fundamental components of such a system include a knowledge base, a database, a reasoning machine, a user interface, and an expert learning module. The system mimics a human expert's decision-making process in detecting diseases. Zhang et al. (2004) developed a system for diagnosing fish diseases that could replicate extensive specialized knowledge and incorporate a large database of fish disease data and images. Through the user interface, the technology was capable of diagnosing 126 fish diseases. While this expert system could enhance the accuracy of fish

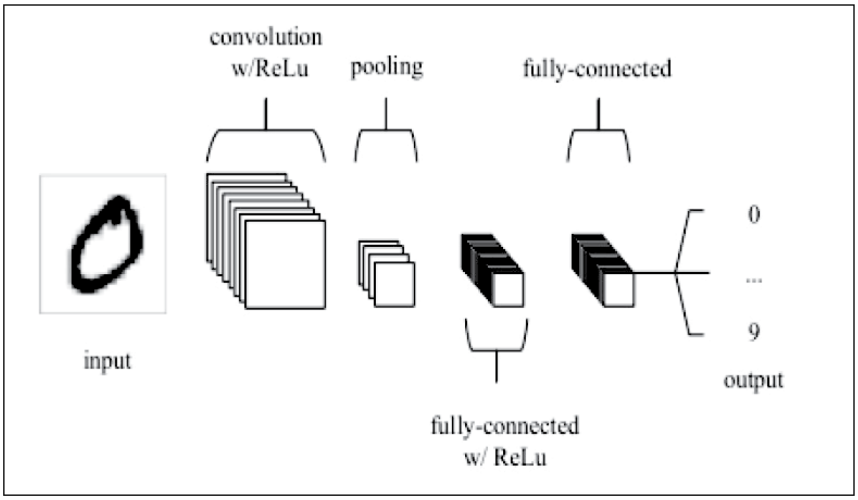
Expert systems have the potential to function as semi-automated diagnostic tools, but they still require human assistance from fish disease specialists.



An example of the expert system's structure and the diagnosing process (*Source:* Li et al., 2022).



Flowchart for using the CNN approach to identify fish diseases (*Source:* Hasan et al., 2022).



Three classes layers of CNN (*Source:* Hasan et al., 2022).

disease identification with abundant data and expert knowledge, it did not address the challenge of remote diagnosis or the complexity of the expertise required. To reduce the reliance on experts and improve diagnostic accuracy, Lou et al. (2010) proposed an image retrieval-based case-based reasoning system. By using criteria like color, morphology, texture, and other attributes, the system could search for and match images stored in the database. Employing a multi-feature search significantly improved detection accuracy.

Using an Android system and an expert system, Sun and Li (2016) created a diagnostic system for aquatic animal diseases. When coupled with the conventional expert system, it exhibited quicker detection. Experts cannot be informed about the true state of the fish illness site or the level of water pollution via mobile phones; however, these issues may be partially resolved with the use of aquaculture monitoring video. In order to enable accurate and prompt diagnosis of fish diseases by remote experts through direct communication between field personnel and experts, Ma et al. (2017) proposed a remote fish disease video-based diagnosis expert system. This system used remote video to provide experts with information on the aquaculture environment and dynamic fish conditions.

Expert systems have the potential to function as semi-automated diagnostic tools, but they still require human assistance from fish disease specialists. Since fish diseases can spread quickly, this semi-automated model is no longer suitable for the large-scale aquaculture operations present today. In the future, expert systems for fish diseases could be interconnected, sharing a common database of various fish diseases and creating augmented reality (AR) models by combining the latest 3D images. This would allow experts to better understand the conditions of diseased fish and diagnose them more rapidly and accurately.

Convolutional Neural Networks

Convolutional Neural Networks (CNNs) are among the most widely used deep neural networks. Due to their exceptional performance in various computer vision and machine learning tasks, CNNs are crucial for image-related applications such as image classification, interpretation, and object detection. Their minimal pre-processing requirements and low input variability make them highly recognizable. CNNs consist of convolutional, nonlinearity, pooling, and fully-connected

CNNs are ideal for image classification as they provide higher precision while using fewer parameters.

layers. Parameters are present in the convolutional and fully-connected layers, but not in the pooling and non-linearity layers. CNNs are ideal for image classification as they provide higher precision while using fewer parameters.

Method: Figure 4 illustrates the detailed process flow for using the CNN approach to identify fish diseases. The process begins with the fish image as the input. This image is then processed through the three-layer CNN detection method, which includes fully connected, pooling, and convolutional layer processes. The third stage, performance evaluation, assesses the effectiveness of CNN in identifying diseases in fish images.

Input Image: Images showing various symptoms and stages of fish diseases, as well as healthy fish, are provided as input. When infected by agents such as bacteria, viruses, parasites, and fungi, fish may lose scales, become agitated, and show signs of decay, such as swimming erratically or rubbing against net surfaces. They may lose their appetite, become thin, move slowly, and develop cloudy white eyes. Severe damage to the gill tissues may lead to suffocation and death.

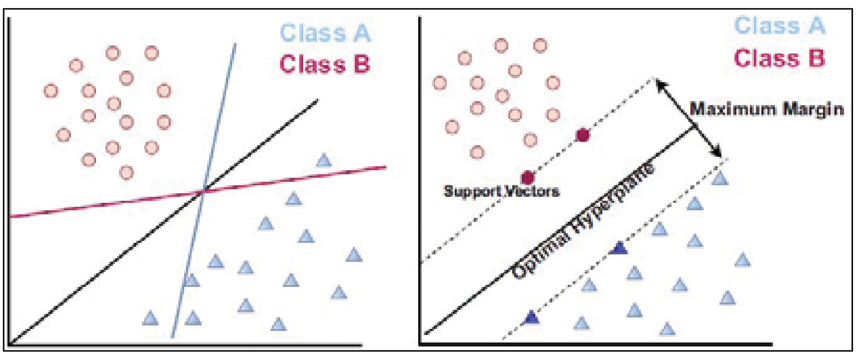
CNN Detection: A CNN is composed of concatenated discrete blocks, or layers, that each performs a distinct task. The CNN is used to identify and classify fish images into three classes: healthy, red spot disease, and white spot disease. The images are fed into the network through an image input layer that is normalised, with the image height, width, and channel size set to 200, 200, and three (Red, Green, Blue), respectively.

Convolutional Layer: The convolutional layers encode a range of lower-level features into more discriminative ones by spatially-aware processing. Consider the convolutional layer as a set of filters that work together to create various feature patterns from an input image. This layer is used to extract features from the input images, which in this case are fish images. After applying a raw pixel filter to the image, the RGB colour channels are used to compute the dot product between the input and filtered pixels. A 3×3 matrix is chosen as the weight matrix to extract features from the images. During training, the CNN learns the values of these filters. The next layer is non-linearity, which can modify or deactivate the output. This layer limits or saturates the resulting output. The Rectified Linear Unit (ReLU) is commonly chosen due to its simple function and gradient definition. Each input element undergoes a threshold operation, where any value not equal to zero is set to zero.

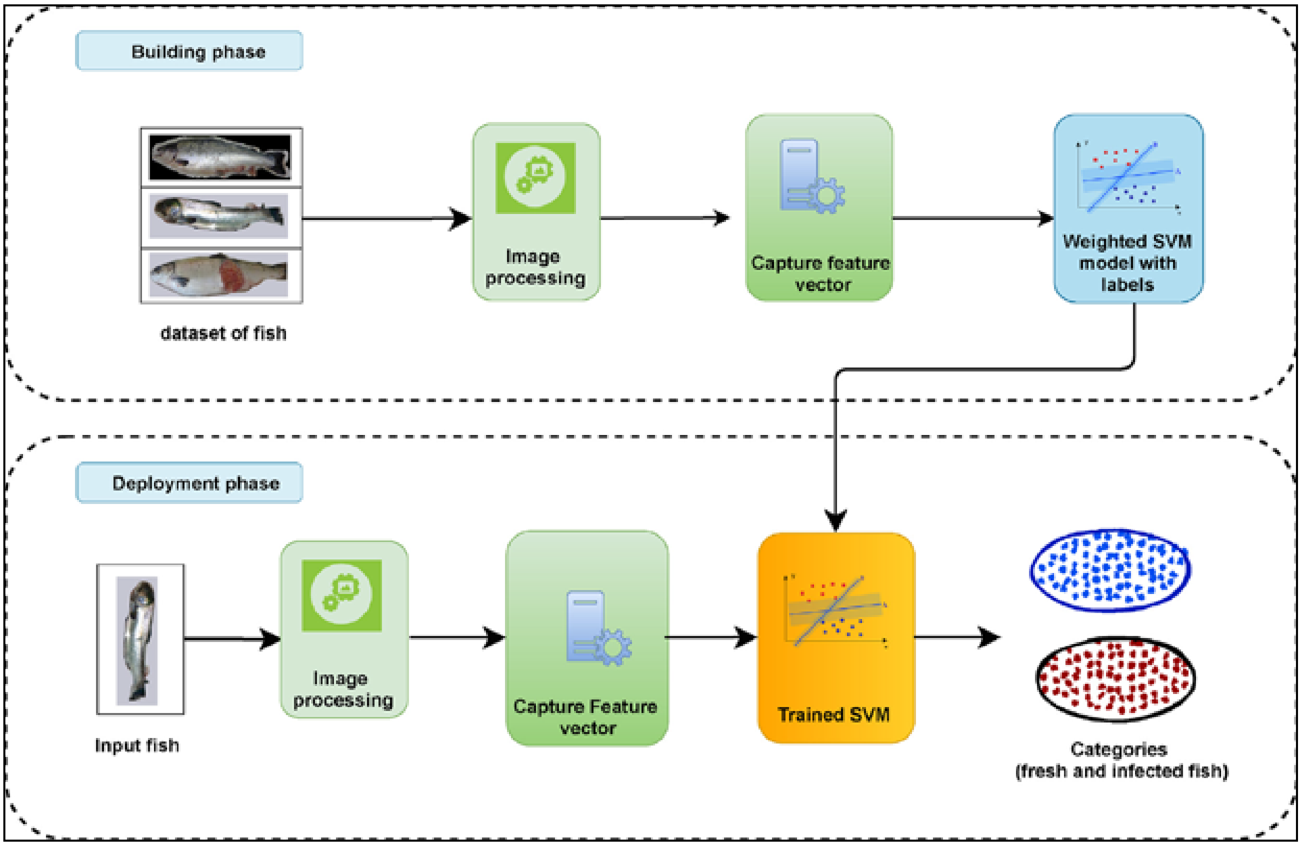
The Rectified Linear Unit (ReLU) is commonly chosen due to its simple function and gradient definition. Each input element undergoes a threshold operation, where any value not equal to zero is set to zero.

Pooling Layer: The pooling layer shrinks the fish image data, enhancing the feature position invariance in image processing. Max pooling, the most common subsampling strategy in CNNs, divides the output of the convolutional layer into small grids and selects the maximum value from each grid to produce a reduced image matrix. The pooling layer serves to minimize the image size, and it can be effectively adjusted by a convolution layer with the same stride value as the corresponding pooling layer.

Fully Connected Layer: The final fully connected layer handles feature categorization for the image. Similar to neurons in a conventional neural network, the fully connected layer adjusts the information so it can be categorized linearly. Each node in this layer is connected to all other nodes in the preceding and succeeding layers. A vector from the fully



Support vector machine (identification of the ideal hyperplane and classification of ideal hyperplane classes) (*Source:* Ahmed et al., 2022).

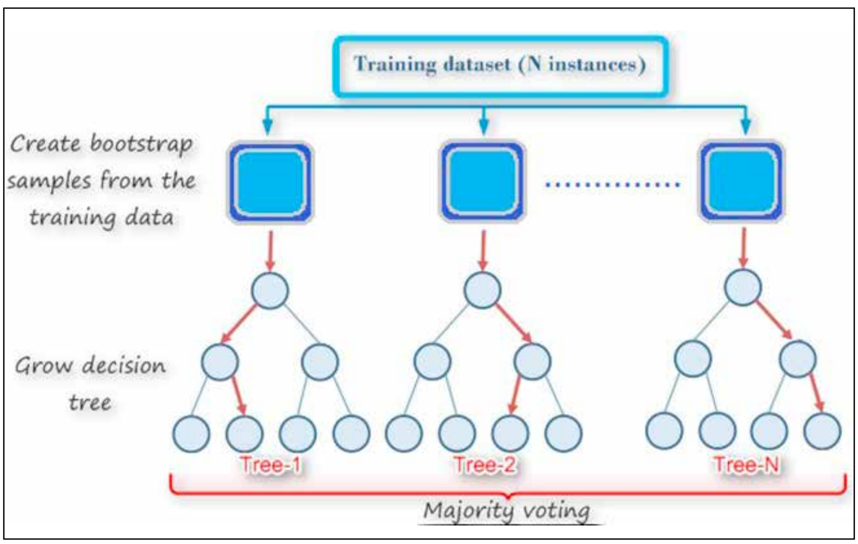


An orderly graphic showing the complete procedure of SVM from data collection to model training to class prediction (*Source:* Ahmed et al., 2022)

connected layer links each node from the last pooling layer to the main layer. These parameters, often used in these layers, require training time. The final output of the fully connected layer is a size equal to the target class count for classification.

This process involves realizing the fully connected layer at the network's end, as it loses spatial information and is irreversible. The output consists of positive values summing to one, which are used as classification probabilities by the classification layer. The classification process identifies the type of fish disease based on the image. For multi-class classification, the classification layer calculates cross-entropy loss using the probabilities provided by the SoftMax activation function, assigning each input to one of the mutually exclusive categories.

With datasets divided into 60:40 ratios for training and testing, respectively, the results of the fish disease identification experiment are displayed using a confusion matrix. Equations calculate classification accuracy, sensitivity, and specificity rates based on the confusion matrix.



Pictorial demonstration of random forest (*Source:* Amrani et al., 2018)

True positive (TP) and true negative (TN) values are used to determine accuracy, while TP is used for sensitivity and TN for specificity.

Support Vector Machine (SVM): Support Vector Machine (SVM) is a widely used supervised machine learning technique for classification problems. It is highly effective for producing accurate predictions for unlabeled data. Khan et al. (2016) developed an SVM model using three kernel functions to differentiate between healthy and infected blood sera. Agarap (2017) proposed an SVM architecture combining CNN with SVM for image classification, showing remarkable accuracy in various contexts. In this approach, features are extracted using image processing techniques, followed by the use of SVM for accurate classification of infectious diseases.

Due to its increased accuracy rate, the supervised machine learning technique known as Support Vector Machine (SVM) is frequently employed to solve classification problems. SVM aims to create a hyperplane with a margin between multiple classes to categorize items. By constructing the hyperplane in a multidimensional space, data points can be separated. Figure 6 illustrates the basic diagram of the support vector machine.

SVM often outperforms other classifiers, achieving high accuracy across a wide range of application domains. It is primarily designed for use with binary classification problems, as discussed in this article. To ensure strong performance on the test dataset, the SVM is trained using feature training datasets.

Random Forest

Leo Breiman and Adèle Cutler formally introduced Random Forests in 2001; it is a type of supervised learning approach. This algorithm combines the concepts of "bagging" with random subspaces. The Random Forest algorithm is trained using multiple decision trees, each powered by slightly different data subsets.

Random Forest is part of a series of algorithms based on bagging, randomizing outputs, and random subspace methods, with boosting excluded. It uses decision trees as individual predictors. Among classification algorithms, Random Forest is one of the best, as it can accurately classify large volumes of data. It is an ensemble learning technique for both regression and classification that constructs multiple decision trees during the training phase and outputs a class that is the majority vote from the predictions of each individual tree.

Random Forest is part of a series of algorithms based on bagging, randomizing outputs, and random subspace methods, with boosting excluded. It uses decision trees as individual predictors.

The Random Forest classification approach generates a large number of classifiers from smaller subsets of the input data and then aggregates each classifier's output based on a voting process to obtain the desired output for the input data set. This type of ensemble learning has gained significant popularity recently. Prior to Random Forest, boosting and bagging were the only two ensemble learning techniques employed. Random Forest has seen substantial use in various fields, including modern drug development, network intrusion detection, land cover analysis, credit rating analysis, remote sensing, and gene microarray data analysis.

Conclusion

This article discusses the application of image-processing technology in aquaculture, focusing on image-based fish disease identification. Expert systems are limited in their speed of diagnosis and their ability to identify unknown diseases due to their reliance on expert knowledge and usage protocols. However, they can provide accurate diagnoses with the aid of information or images. When combined with computer vision, image processing offers a cost-effective, non-invasive, and real-time method for diagnosing diseases, partially overcoming the limitations of expert systems. In the future, different Convolutional Neural Network (CNN) architectures will be applied to more accurately and thoroughly diagnose fish diseases.

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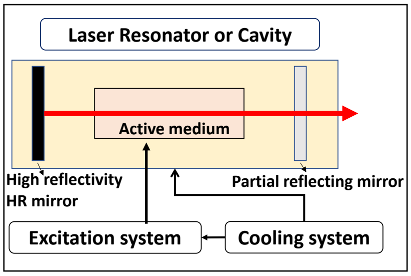
Lasers in Agriculture

A laser, which stands for "Light Amplification by Stimulated Emission of Radiation," is a light source that produces highly focused, coherent, and narrow electromagnetic radiation. Lasers span the ultraviolet, visible, and infrared spectra and were invented in the 1960s. They have since become essential in fields like defense, medicine, telecommunications, and entertainment. Thou gh their use in agriculture is still emerging, interest is growing due to their potential benefits.

A laser is created by exciting atoms or molecules in a gain medium using external energy, which causes them to emit photons. These photons reflect between two mirrors, stimulating more photons to be emitted in the same direction, creating a coherent, intense beam of light. Lasers are known for their narrow wavelength and highly collimated beams, which can be amplified by increasing the number of excited atoms and reflections.

Components of a Laser Source

A laser source consists of several essential components that work in harmony to produce a coherent beam of light.



Schematic of a typical laser source

- **Active Medium**: The active medium is a material capable of producing photons when excited. This material can be in the form of a gas, solid, or liquid.
- **Excitation Source or Pumping System:** The pumping source, typically a high-energy device such as a flash lamp or electrical discharge system, excites the active medium to create a population inversion.
- **Laser Resonator or Optical Cavity:** The optical cavity is the region between two mirrors where photons are reflected back and forth to amplify the light.
- **Mirrors:** The mirrors at either end of the optical cavity reflect photons through the active medium. This repeated reflection stimulates the emission of additional photons, amplifying the light.
- **Output Coupler:** The output coupler is a partially reflecting mirror that allows a portion of the photons to escape the optical cavity, forming the laser beam.
- **Cooling System:** A cooling system dissipates heat and ensures the laser operates within its optimal temperature range. Since not all the energy absorbed by the gain medium is converted into laser light, a significant portion is converted into heat.

Lasers span the ultraviolet, visible, and infrared spectra and were invented in the 1960s.

How a Laser Works

When the pumping source is activated, it excites the active medium, causing electrons to jump to higher energy levels, thereby creating a population inversion. As photons pass through the active medium, they stimulate electrons to drop back to lower energy levels, releasing additional photons of the same wavelength and phase.

This process triggers a cascading effect, with each photon stimulating the release of more photons. The photons bounce back and forth between the mirrors, continuously amplifying their number until they are emitted through the output coupler as a coherent laser beam.

Controlling Laser Properties

The properties of the laser beam—such as wavelength, power, and beam profile—can be adjusted by modifying the characteristics of the active medium, the pumping source, and the mirrors.

Laser Properties

Laser properties refer to the key characteristics of laser light, which include:

Coherence: Laser light is coherent, meaning the waves in the beam are in phase with one another. This allows the laser beam to travel long distances without significant spreading and enables it to be focused into a very small spot.

Monochromaticity: Laser light is monochromatic, consisting of a single wavelength. This property is crucial for applications such as spectroscopy.

Directionality: Laser light is highly directional, allowing it to be focused into a narrow beam. This property is useful for precision tasks like laser cutting and welding.

High Intensity: Laser light is extremely intense, capable of heating and vaporizing materials. This property makes it ideal for industrial applications like cutting, drilling, and engraving.

Types of Lasers

There are various types of lasers, each with specific applications:

Gas Lasers: Use a gas mixture as the active medium. Examples include:

- Helium-neon (HeNe) lasers
- Carbon dioxide (CO_2) lasers
- Argon-ion lasers

Solid-State Lasers: Utilize solid materials such as crystals or glasses as the active medium. Examples include:

- Neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers
- Ruby lasers

Semiconductor Lasers: Employ semiconductor materials like gallium arsenide (GaAs) as the active medium. Examples include:

- Laser diodes
- Vertical-cavity surface-emitting lasers (VCSELs)

Dye Lasers: Use a liquid dye as the active medium. Commonly applied in scientific research and medical fields.

Fiber Lasers: Use optical fibers as the active medium. Widely utilized in telecommunications, industrial, and medical applications.

Free-Electron Lasers: Operate using a beam of free electrons to generate laser light. Primarily used in scientific research and advanced industrial applications.

Excimer Lasers: Utilize a gas mixture of noble gases and halogens as the active medium to produce ultraviolet light. Commonly used in medical and industrial applications.

Chemical Lasers: Rely on chemical reactions to generate laser light. Frequently employed in military and scientific research applications.

Laser applications

Lasers have a wide range of applications, and their use continues to grow as new technologies and innovations emerge. Some of the most common applications of lasers include:

Medicine: Lasers are widely used in medical applications such as laser surgery, skin treatments, eye surgery, and cancer treatment.

Communications: Lasers are integral to fiber-optic communication systems, enabling data transmission over long distances with minimal signal loss.

Manufacturing: Lasers are used for precision cutting, drilling, welding, marking, and engraving of materials like metal, plastic, and wood.

Entertainment: Lasers are used in laser light shows, laser pointers, and laser projection systems for entertainment purposes.

Scientific Research: Lasers are employed in research applications such as spectroscopy, microscopy, and holography.

Defense: Military applications of lasers include target designation, missile defense, and disrupting enemy sensors.

EnvironmentalMonitoring: Lasers are used for remote sensing of atmospheric and surface conditions in environmental monitoring.

Art Conservation: Lasers are utilized in art conservation to remove dirt and contaminants from delicate surfaces without causing damage.

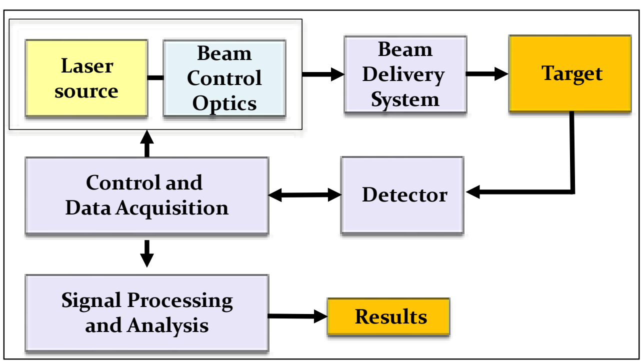
Typical Laser System

A laser system includes the laser source and other essential components required to deliver and control the laser beam. It comprises various subsystems critical for its functionality and operation. The block diagram of a typical laser system is depicted in Figure 2, and the descriptions of its subsystems are provided below:

Laser Source: The laser source provides a highly monochromatic and coherent light beam, emitting light at a specific wavelength or a narrow range of wavelengths, depending on the application.

Beam Control Optics: Optics are crucial for guiding, shaping, and manipulating the laser beam. Components such as lenses, mirrors, beam splitters, and filters focus the laser beam onto the target or sample and collect scattered or emitted light for detection.

Beam Delivery System: The beam delivery system transports the laser beam from the source to the target or sample, whether in an outdoor setting or an enclosed sample chamber. It typically includes optical fibers or free-space optics to guide and direct the beam with minimal loss or distortion.



Block diagram of a typical Laser System

Sample Chamber: The sample chamber holds the material or sample under investigation. It can accommodate various sample types, such as gases, liquids, or solids. The chamber may include mechanisms for controlling temperature and pressure to facilitate studies under specific conditions.

Detector: The detector measures the intensity or other properties of the light interacting with the sample. Depending on the desired measurement, various types of detectors can be used, such as photodiodes, photomultiplier tubes (PMTs), charge-coupled devices (CCDs), or spectrometers. These detectors convert the light signal into an electrical signal for further processing and analysis.

Signal Processing and Analysis: Signal processing components amplify, filter, and analyze the electrical signal from the detector. These may include amplifiers, lock-in amplifiers, digitizers, and computer interfaces. Sophisticated software is often employed to extract and interpret spectral information, perform data analysis, and generate graphical representations.

Control and Data Acquisition: The control and data acquisition system oversees the operation of the laser system. It manages laser parameters, data acquisition settings, and synchronization between components. This system ensures precise timing and coordination among the laser, sample chamber, detector, and data acquisition software.

Advantages of Lasers for Agricultural Applications

Lasers have the potential to revolutionize agriculture by enabling more precise, efficient, and sustainable farming practices. The key advantages include:

Precision: Lasers allow for the targeted delivery of energy to specific areas of plants or soil, optimizing the use of resources such as water, fertilizers, and pesticides.

Speed: Lasers operate at high speeds, enabling rapid and efficient processing of crops or other agricultural products.

Safety: Lasers reduce the reliance on harmful chemicals or unsafe practices, minimizing risks to farmers, workers, and the environment.

Non-Contact Operation: Lasers can operate without physically touching crops or soil, preserving delicate plants and soil structures.

Cost-Effectiveness: While the initial investment in laser technology may be high, long-term savings from reduced resource usage, increased efficiency, and improved crop yields make it a cost-effective solution.

Versatility: Lasers support diverse applications, such as crop growth stimulation, pest control, and weed suppression.

Laser Applications in Agriculture

Laser technology has been integrated into modern agriculture for various applications:

Precision Agriculture: Laser technology is employed to create high-resolution field maps, enabling farmers to identify areas requiring varying levels of inputs like water, fertilizers, or pesticides. This optimizes crop yields and minimizes waste.

Weed Control: Lasers selectively eliminate weeds without damaging crops by heating the weeds, causing them to wither and die.

Pest Control: Lasers target pests like fruit flies and mosquitoes with precision, effectively eliminating them while sparing beneficial insects.

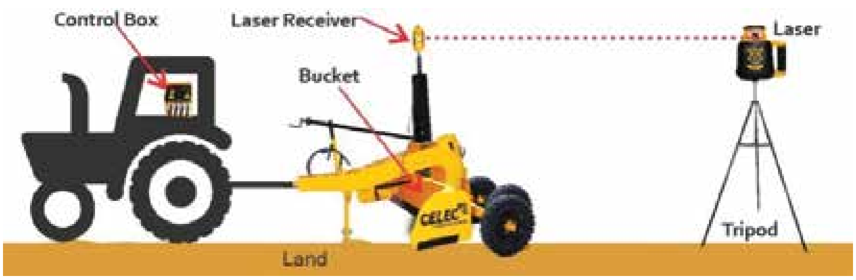
Plant Growth Regulation: Specific wavelengths of laser light stimulate plant growth, enhancing crop yields, improving quality, and reducing maturation time.

Irrigation Management: Lasers monitor soil moisture levels and optimize irrigation systems, conserving water and boosting crop yields.

Harvesting: Laser systems automate the harvesting of fruits and vegetables, reducing labour costs and increasing efficiency.

Examples of Laser Systems in Agriculture

Laser Land Leveler: A laser land leveler is a precision agricultural tool that uses laser technology to level fields, improving irrigation efficiency and crop management. The equipment typically includes a tripod-mounted laser transmitter, a receiver, and a GPS-guided tractor.



Laser land lever system, *Source:* www.celec.com

The laser transmitter emits a beam picked up by the receiver mounted on the tractor. The receiver measures the laser beam's height and sends signals to the tractor's hydraulic system to adjust the blade height accordingly.

Laser Systems for Farm Leveling: The laser system for farm leveling provides a highly accurate and efficient method for achieving a level surface across large areas of land. By using this technology, farmers can significantly reduce the time and resources required for manual grading while ensuring that their fields are optimized for irrigation and crop production.

LiDAR (Light Detection and Ranging): LiDAR technology is increasingly being adopted in agriculture to gather precise and detailed information about crops, terrain, and environmental conditions. A LiDAR system uses laser pulses to measure distances and create highly detailed 3D maps of terrain, vegetation, and structures.

Common Applications of LiDAR in Agriculture

Terrain Mapping: LiDAR is used to create high-resolution, three-dimensional maps of agricultural fields. This information helps farmers understand the topography, identify slopes, and determine soil erosion patterns, aiding in effective land management and irrigation planning.

Crop Health Assessment: LiDAR measures the height and density of crops, providing valuable data about their health and growth. By comparing measurements over time, farmers can monitor crop development, detect abnormalities, and make informed decisions about irrigation, fertilization, and pest control.

Weed Detection and Management: LiDAR can differentiate between crops and weeds based on their height and structure. This enables targeted weed control, reducing herbicide use, minimizing crop damage, and enhancing productivity.

Navigation and Autonomous Vehicles**:** LiDAR sensors integrated into agricultural machinery and autonomous vehicles facilitate navigation and obstacle avoidance. By providing accurate distance measurements and 3D mapping, LiDAR supports safe and efficient operations such as autonomous tractors, robotic harvesters, and precision

Agrointelli's ROBOTTI autonomous farm vehicle

spraying systems.

Canopy Management: LiDAR provides detailed information about tree or vine structures, aiding in canopy management practices such as pruning and thinning. This data helps assess canopy density, identify areas of concern, and implement strategies for optimal light penetration and fruit quality.

Soil Analysis: LiDAR assists in soil analysis by mapping soil variability across a field. When combined with soil sampling data, it allows for the creation of soil fertility maps, enabling targeted fertilization and nutrient management.

Irrigation Management: LiDAR data is used to map soil moisture content across a field. By integrating this information with weather data and plant water requirements, farmers can optimize irrigation schedules, conserve water, and reduce costs while improving water-use efficiency.

Pest and Disease Monitoring: LiDAR aids in the early detection of pest infestations and diseases by identifying abnormal plant growth patterns. This enables timely intervention, such as targeted pesticide applications or disease mitigation strategies, reducing the risk of significant crop losses.

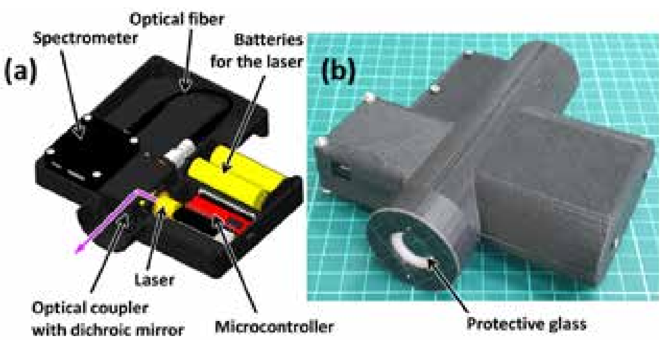
These examples highlight the versatility and accuracy of LiDAR technology, making it a valuable tool for enhancing efficiency, sustainability, and productivity in agriculture. Depending on the application, LiDAR systems can be hand-held, mounted on ground vehicles, or integrated into UAVs.

Drone-based LiDAR technology has also emerged as a game-changer in agriculture applications, revolutionizing the way farmers optimize their crop management. With its ability to capture extensive data quickly and cost-effectively, drone-based LiDAR is transforming agriculture, enhancing productivity, and driving sustainable farming practices.

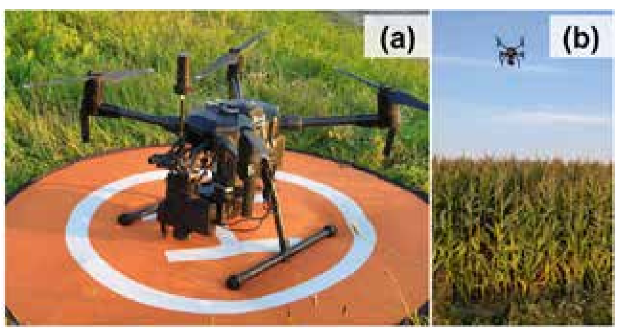
Figures below present the example of a compact and low-weight LiDAR instrument developed by Prokhorov General Physics Institute of the Russian Academy of Sciences, and Federal Scientific Agroengineering Center, Moscow, Russia, for laser-induced fluorescence spectroscopy sensing of maize fields. Fluorescence LiDAR is installed on a small industrial drone, its mass was <2 kg and power consumption was <5 W. The LiDAR instrument utilized a continuous wave diode laser (405 nm, 150 mW).

Laser-induced fluorescence sensors

Laser-Induced

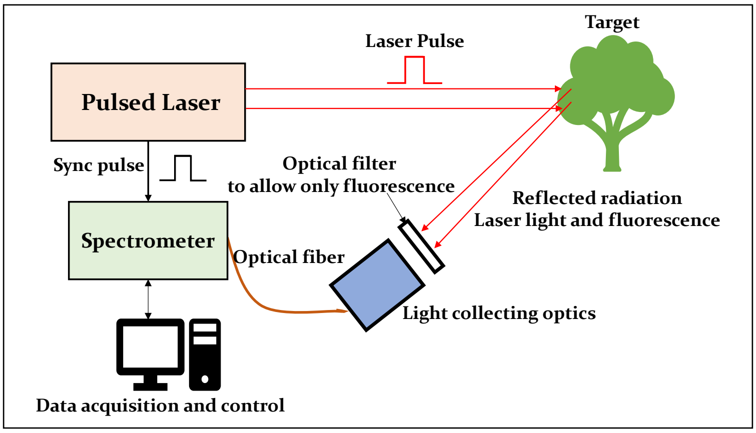


(a): Principal scheme of the LiDAR components
(b): Ultracompact LiDAR



(a): Photo of the LiDAR
(b): Maize field sensing

Source: Photonics 2022, 9, 963. https://doi.org/10.3390/photonics9120963



Schematic of a typical LIFT system

LIFT-REM fluorometer
Source: www.Soliense.com

Fluorescence Transient (LIFT) instruments measure the fluorescence emitted by chlorophyll in plants to assess their health, photosynthetic activity, and nutrient status. The system consists of a laser, optics, a sample chamber, and detectors. The laser emits short pulses of light that excite plant pigments, like chlorophyll, causing them to fluoresce. By analyzing the emitted fluorescence, the instrument provides insights into plant factors such as photosynthesis efficiency, stress responses, nutrient deficiencies, and the impact of environmental conditions on plant health.

For example, the LIFT-REM fluorometer from Soliense, USA, measures photosynthetic characteristics remotely, up to 3 meters away. A laser-based version can operate at distances of up to 50 meters but requires strict access limitations for eye safety. This technology is valuable for monitoring plant health in various environmental conditions.

Laser-based soil analysis

A laser soil analysis system uses Laser-Induced Breakdown Spectroscopy (LIBS) to analyze soil samples, providing rapid elemental analysis for assessing soil composition and fertility. The system focuses a high-energy laser on the sample, vaporizing the soil and creating a plasma. As the plasma cools, it emits light specific to each element, which is analyzed. The LaserAg Quantum system can process 60 samples per hour. LIBS offers advantages like rapid analysis, minimal sample preparation, and in-situ, non-destructive analysis. It provides both qualitative and quantitative results. The principles remain consistent across systems, such as the one offered by LaserAg, Canada.

Laser system for sorting fruits and vegetables

A laser system for sorting fruits and vegetables combines sensors, optics, and computing technologies to categorize produce based on characteristics like size, shape, colour, and texture. The produce moves along a conveyor belt through a scanning area, where a laser beam creates a unique digital signature. This signature is analyzed by a computer using algorithms to identify the produce and assess its quality. Mechanical arms or jets then sort the items into appropriate bins based on their characteristics. These systems, used in large-scale processing facilities or smaller-scale operations, improve efficiency, reduce waste, and enhance product quality. Examples include the Cherry Vision system from Unitec, Italy, and

Laser soil analysis system from LaserAg
Source : www.laserag.com

Cherry Vision system from Unitec
Source: www.unitec-group.com

Compac Sorter system
Source: www.foodprocessing-technology.com

the Compac Sorter from New Zealand.

laser systems for sorting fruits and vegetables offer a high degree of accuracy and efficiency, allowing growers and processors to quickly and effectively sort large quantities of produce while minimizing waste and maximizing profits.

Laser-based weed control systems

Laser-based weed control systems use lasers to identify and eliminate weeds without harming crops. These systems employ computer vision or spectral analysis to detect weeds, targeting them with precise laser beams. The intense heat from the laser destroys the weeds by disrupting their cellular structure. Integrated with computer vision, the system can target specific weed species, enhancing efficiency. Laser weeding offers an eco-friendly alternative to herbicides and manual labour, promoting sustainable agricultural practices. This technology addresses environmental and health concerns, making it a promising solution. The image (right) presents a specification sheet for a system from Carbon Robotics, USA.

While laser-based weeding offers many advantages, it's important to note that it may not completely replace conventional methods in all situations. Factors such as cost, availability of equipment, specific crop requirements, and field conditions must be considered when determining the most appropriate weeding approach for a particular farming operation.

Laser bird deterrent systems (Modern-day Scarecrow)

A laser-based bird deterrent system, or modern scarecrow, protects crops from avian pests using laser beams in a humane and effective manner. The system features strategically placed laser projectors around agricultural areas that emit safe laser beams for both birds and humans. Many systems operate autonomously, triggered by motion sensors or timers to activate lasers when birds are detected. The laser beams can be programmed to move or flicker, simulating the movements of predators, which frightens birds and discourages them from entering the area. This minimizes crop damage, as shown in the bird deterrent system from the Bird Control Group, Netherlands.

Laser-based bird deterrent systems do not involve the use of chemicals, traps, or other harmful substances, making them environmentally friendly and sustainable. However, their use may be subject to local regulations and guidelines. Therefore, it is important to

Laser weeder from Carbon photonics
Source: www.carbonrobotics.com

The AVIX Autonomic bird repellent system from Bird Control Group
Source: www.birdcontrolgroup.com

ensure compliance with any relevant laws and consider the specific needs and conditions of the area where they are deployed.

Cost-effectiveness of agriculture laser systems

Agriculture laser systems offer cost-effectiveness in precision farming by increasing efficiency and reducing labour costs. Despite their high initial cost, lasers enable precise application of fertilizers, herbicides, and pesticides, minimizing wastage and lowering input costs. Integrated with technologies like remote sensing and GPS, these systems provide real-time crop data, allowing farmers to optimize resources and improve productivity. Additionally, their durability and low maintenance further enhance cost-effectiveness. By adopting laser systems, farmers can maximize returns, reduce costs, and implement sustainable, profitable farming practices.

Associated risks and their mitigation in agriculture laser systems

Agriculture laser systems offer significant advancements but also come with inherent risks. One primary concern is the potential for eye injuries to humans and animals due to intense laser beams used in tasks like crop monitoring and bird control. To mitigate this, protective eyewear and controlled laser paths are essential. Another risk is accidental fires, as high-powered lasers can ignite flammable materials like dry crops. Proper training, monitoring, and fire safety protocols are necessary to reduce this danger. Additionally, lasers interacting with chemicals or fertilizers may lead to hazardous reactions, requiring strict operational guidelines and maintenance.

Future prospects

The future of agriculture laser systems is promising, offering precision for crop management, pest control, and soil analysis. With advanced scanning and imaging, lasers can provide real-time data on crop health, nutrients, and water, optimizing resource allocation and increasing yields. Laser-based weed control systems can selectively target weeds, reducing herbicide use and manual labour. Integration with AI and machine learning enables autonomous decision-making and predictive analytics, enhancing farming efficiency and sustainability.

However, agriculture laser systems are still in the early stages, and the high cost can limit adoption, especially among small-scale farmers. Challenges like regulatory frameworks and safety standards must also be addressed. Ongoing research, development, and collaboration between scientists, engineers, and farmers are crucial for unlocking the full potential of these systems. As these technologies evolve, they hold the potential to revolutionize farming, making it more sustainable and productive.

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Center for Innovation and Development in Smart Agriculture: Advancing Smart Agriculture through Innovation and Technology

The Center for Innovation & Development in Smart Agriculture (CIDSA) is a multi-phased project that intends to build the skills of students/engineers for the agricultural industry through a series of well-structured engagement models to make them industry-ready and conduct industry connection programs that facilitate job placements and projects. It is established at the University of Agricultural Sciences, GKVK, Bengaluru (www.uasbangalore.edu.in/) in collaboration with the Government of Karnataka and Hexagon (www.hexagon.com).

Significance of technological innovations in India's agriculture

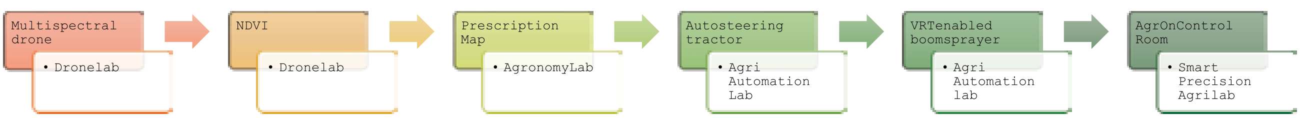
In recent years, India has witnessed a significant shift in its agricultural landscape, driven by the rise of digital technologies. With over 50% of the population relying on agriculture for their livelihood and contributing about 18% to the national GDP, the need for modernization in this critical sector has never been more urgent. Digital agriculture, characterized by the integration of information and communication technologies (ICT) into farming, is paving the way for increased productivity, sustainability, and resilience in Indian agriculture. One of the fundamental aspects of digital agriculture is the data-driven approach it employs. Through the use of sensors, drones, and satellite imagery, farmers can gather and analyze data about soil health, crop conditions, and weather patterns. This access to real-time information allows them to make informed decisions that optimize crop yields and reduce resource wastage. For instance, precision farming techniques can enable farmers to apply water, fertilizers, and pesticides more efficiently, leading to enhanced productivity while minimizing environmental impact.

The technologies offered at CIDSA include five labs: Agriculture Automation, Agriculture Drone, Smart Precision Agriculture, Advanced Agronomy, and Farm Equipment - Design & Manufacturing labs.

What is offered at CIDSA?

CIDSA encompasses various technologies that enable a farming ecosystem to address a few of the farming challenges. The technologies offered at CIDSA include five labs: Agriculture Automation, Agriculture Drone, Smart Precision Agriculture, Advanced Agronomy, and Farm Equipment - Design and Manufacturing labs.

Agriculture Automation Lab: Farmers, agriculturalists, young engineers, and entrepreneurs can understand methods to convert regular farm machinery and implements such as tractors, sprayers, tillers, etc., into automated systems for various farm operations. Simulator training on autonomous steering control of tractors will be demonstrated through available tractor models on the field.



An illustration of technology integration in different labs

Smart Precision Agriculture Lab: This lab introduces solutions for smart planning, efficient field execution, precise machine controls, and automated workflows that optimize operations through Hexagon AgrOn precision agriculture. It is an end-to-end setup to monitor complete agricultural operations, starting from cultivation to planting to harvesting and even logistics.

Farm Equipment Design and Manufacturing Lab: In-house design and development of robust systems with short development time and low-cost dynamics is crucial for quicker testing and evaluation. The unstructured nature of the external environment enables robust improvements to avoid failure.

Agriculture Drone Lab: With agriculture drone development, farmers, agriculturalists, and engineers will learn, understand, assemble, and operate drones for smart agricultural purposes such as land management, vegetative health mapping, nutrient management, drainage line management, disease detection, crop insurance, weed detection, and pesticide spraying.

Agronomy Lab: This lab encompasses new ways in which agricultural operations can be carried out by using various technologies deployed in other labs and technologies available elsewhere in the world. Each lab is interdependent on the others, working in tandem.

A sample case study of technology integration in crop production:

A multispectral camera drone in the drone lab captured crops images and provides information on crop health through NDVI, created with the help of ERDAS Imagine software. This geotagged image was analyzed by an agronomist, and ground truthing was carried out. A 'Prescription Map' was prepared using Geomedia software to address specific agricultural operations such as plant protection or nutrient management. This map was used by the GNSS-guided auto-steering tractor connected to a VRT-enabled Hexagon AgrOn boom sprayer. The equipment performs the spray operation in the field with the highest precision level. A unique feature of such VRT is that, even if there are multiple dosage chemicals to be applied to a single piece of land, the equipment performs the precise operation using GPS, sensors, electronic control units, and regulated valves, avoiding any over and under application of inputs. This is precision agriculture. Until now, this concept was limited to greenhouse cultivation in India. Now, such technologies are available for open-field cultivation as well. If higher accuracy is required for the operations, it can be equipped with an RTK base station, and the same RTK can be used for land surveys within a radius of 25 km. All these tractor operations can be monitored through the AgrOn Control Room, a web-based application.

The key aspect of these technologies is that they are brand-agnostic, meaning these technologies can fit into any equipment/tractor manufactured by any company.

Few technologies adopted at CIDSA are:

- Tractor with Hexagon AgrOn Track Controller (Auto Steering)
- Ti10 display for system control
- VRT enabled Hexagon AgrOn boom sprayer
- VRT enabled Hexagon AgrOn fertilizer broadcaster

Students learning on VRT enabled Fertilizer Broadcaster

Ti10 display for system control and Hexagon powered Autosteering tractor

- Hexagon AgrOn Depth Monitoring System
- Autosteering simulator
- RTK Base station
- Geomax GNSS survey kit

A unique feature of such VRT is that, even if there are multiple dosage chemicals to be applied to a single piece of land, the equipment performs the precise operation using GPS, sensors, electronic control units, and regulated valves, avoiding any over and under application of inputs. This is precision agriculture.

- Drones: Multispectral camera, RGB camera, Weather, Agri Spray (each drone has its specific usage in agriculture), DIY (Do It Yourself) drone kit
- Various sensors
- Easy-to-use ICRA-IARI approved soil testing kit

The center is equipped with advanced software for various applications in both processes and equipment manufacturing aspects. In India, the agri-equipment manufacturing industry is currently highly unorganized. Very few companies use advanced software for design, simulation, analysis, and manufacturing of equipment. Most companies either do not have software products or enough knowledge to use sophisticated industry-grade software. Software adoption can reduce the TAT (Turnaround Time), shorten the design cycle, and avoid prototype errors/costs, thereby enabling equipment manufacturing units to get skilled manpower from the institute. Typically, the current curriculum in engineering and agri-engineering colleges primarily focuses on a few design software programs:

- **ERDAS Imagine and Geomedia Software** for GIS applications.
- **AgrOn Control Room** modules for remote monitoring of various agri operations.
- **AgrOn Harvest Planning** (software to simulate the sugarcane harvesting schedule, most suitable for cane milling industries. Farmers can benefit by optimizing harvest dates to avoid waiting at the mill for days).
- **Adams** (for multibody dynamics), **Simufact Forming-Welding**, **MSC Apex** (weight optimization), **Nastran** (structural strength analysis), **Easy5** (system control simulation), **scFLOW** (air and fluid simulation), **CREO** (design), **VISI** (design), and **Actran** (acoustics and vibro-acoustics).

What is the Operating Model of CIDSA?

The Center for Innovation and Development in Smart Agriculture (CIDSA) operates as a 'Hub and Spoke' knowledge and technology dissemination center, ensuring a wider reach of smart future agricultural practices for farmers, agriculturalists, entrepreneurs, and young engineers across districts and villages.

Central Hub: The Central Hub is located at GKVK, UAS Bengaluru. It holds information

Students learning in the Drone Lab

on all major technology labs associated with CIDSA and provides access to the training rooms. The Hub houses the governance committee members and serves as the local contact for course delivery. *'Train the Trainer'* programs are conducted at the

The center is equipped with advanced software for various applications in both processes and equipment manufacturing aspects.

Central Hub. Trainees could be representatives from GKVK, other local colleges and villages, government officials, and government-appointed faculty members. The Hub also hosts localized events, specialist talks, training sessions, industry connections, and marketing activities. The Incubation and Innovation activities of CIDSA will also take place inside the Central Hub.

Spoke: The Spoke is a group of extension units of the Central Hub and acts as an assistance center for local farmers, agriculturalists, young engineers, and entrepreneurs for the demonstration and training of deployed technologies.

Team and Courses: There are six courses offered, varying in duration from 3 to 18 days. A full-fledged team of nine members, representing various domains—Agriculture, Horticulture, Electrical, Mechanical, and Electronics—oversees the functions. A Center Manager supervises CIDSA operations. This integrated

Lab

Agriculture Automation Lab

Smart Precision Agriculture Lab

Agronomy Lab

Agriculture Drone Lab

Agriculture Drone Lab

Farm Equipment Design and Manufacturing

Course

Agricultural Automation & Machine Control

Precision Agriculture

Advanced Agronomy

Drones for Smart Agriculture

Reality Capture & Digitization

Agriculture & Farm Equipment Design

Students learning various advanced software for design, simulation, and manufacturing

There are six courses offered, varying in duration from 3 to 18 days.

approach means agriculture and hardware engineering meet the digital world.

Institutional Setup for CIDSA Monitoring

Each lab has a specific scientist monitoring the lab setup and overseeing training. A monitoring committee is established, headed by the Director of Education of UAS-B. The Dean and lab-in-charge scientists are part of the committee, along with representatives from Hexagon and the Center Manager. This committee meets at regular intervals to review the project. The Vice Chancellor also reviews the project's progress with the Project Monitoring Committee.

Sustainability of the Center

Setting up a Center of Excellence is not sufficient; it needs to be made sustainable. Hexagon supports the University in ensuring sustainability.

Institutionalization of Technologies and Courses: The center has successfully trained about 180 UAS-B students during August and September. Final-year BTech (Agri Engg.) students attended the CIDSA course as part of their 7th semester 'Industrial Attachment'. This course is on the verge of becoming an integral part of UAS-B, with discussions in progress to include CIDSA training for 4th-year BSc (Agri) students as well. This could ensure the center's long-term survival and address future agricultural needs.

Financial Sustainability: Recently, the center completed a paid training session for 24 trainees from an external institute. They trained in three labs over 10 days in CIDSA's first revenue-generating training course. Moving forward, CIDSA seeks more trainees from various institutions, government departments, farming communities, and industries.

How Can CIDSA Help Farmers?

- Emphasis on technology and modern agricultural methods, which will help improve the economy of the farming community and lead to sustained agricultural outcomes.
- Establishment of custom hiring centers by entrepreneurs trained at CIDSA, enabling farmers to access this technology.
- Motivating farmers to move away from orthodox agricultural practices and adopt the latest technologies.
- Providing farm advisory and demonstration services to farmers.

Why Do We Need Such Technological Advancement Centers at Academic Institutions?

- To establish themselves as premier centers for high-skill competence in smart agricultural practices.
- To address skill gaps projected to appear in the coming years.
- To offer the ability to use techniques, skills, and modern engineering tools for innovation, design, and agricultural practices.
- To develop precision machinery and strategies for timely and efficient agricultural operations.
- To improve R&D and create bankable projects.
- To encourage entrepreneurship in agriculture.

How Will CIDSA Help in India's Economy?

- Increased investment in the MSME sector for agricultural technologies and allied areas, leading to better economic performance in the state and increased employment opportunities.
- Increased tax revenue, a higher standard of living, and the potential to become a global hub for advanced manufacturing.
- Reduction of post-harvest losses, value addition to agricultural produce, agro-processing, and utilization.
- Functioning as a marketing establishment to encourage foreign investment.

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[2]Scientific Officer to Vice Chancellor, University of Agricultural Sciences, Bangalore
https://youTube/Isf0UY4pOQk.

B Hemla Naik[1], R C Agrawal[2] and P S Pandey[3]

E-Learning Multimedia Course Contents for Horticultural Education in India: **An overview**

Higher education has moved significantly from traditional educational system to modern techniques that use computer technology to promote information delivery and knowledge acquisition efficiently and effectively. The information technology particularly the Internet has made the world a true global village, 'information is always available, always updatable and always accessible'. This communication revolution has a tremendous effect in globalizing education as well as creating global students.

Information and Communication Technology (ICT) has enabled teachers to enhance their skills and students to study more effectively. E-learning is an example of an emerging technology utilized for higher education worldwide, including in India. Moreover, many educational institutions globally are using e-learning to train new staff by leveraging information technology and the internet to improve the quality of education.

The e-learning technologies can assist students, scientists, and farmers in improving their learning skills by analyzing and

resolving various farming issues, answering online quizzes, and submitting assignments and projects, among other activities. E-learning has transform the education by transitioning traditional classroom blackboard settings to online platforms. The use of e-learning has grown considerably over the years as both teachers and students recognize its value.

Today, most teachers adopt a blended learning approach

E-learning has transform the education by transitioning traditional classroom blackboard settings to online platforms.

in physical classrooms, with e-learning materials serving as a supplement to instructional delivery. They employ diverse teaching methods, incorporating a wider range of media such as video clips, short films, and voice-over PowerPoint presentations alongside traditional blackboard teaching.

E-learning assets can be utilized in various ways to enhance the teaching and learning experience:

- Developing engaging study methods in classes by using multimedia tools, quizzes, polls, and interactive content to keep students involved.
- Collaboration is promoted through interactive elements such as discussion boards that enable students to exchange ideas and learn from each other.
- Enhancing learner engagement by actively

involving in process. Support teachers in refining their teaching strategies and gathering statistics on student progress.

- Provids access to a vast array of resources, e.g. e-journals, scholarly databases, and information gateways.
- Enabling parents to support their children's learning more effectively by accessing online content.
- Allow tutors to make their teaching more interesting and engaging using e-learning materials.

Previously, teaching primarily involved lectures delivered by teachers, which students transcribed and used for examinations. A limited number of objective or multiple-choice textbooks were available, and there was considerable variation in content delivery from teacher to teacher. This traditional scenario prevailed in most State Agricultural Universities (SAUs) and State Horticultural Universities (SHUs), where class hours were largely consumed by lectures, leaving minimal time for interaction and knowledge sharing.

To improve the quality of education, the Indian Council of Agricultural Research (ICAR) - National Agricultural Innovation Project (NAIP), Component-1, initiated the development of e-contents for all courses as per the Fourth Dean's Committee syllabus. This effort targeted seven undergraduate degree programs: Agriculture, Horticulture, Fisheries, Dairy Technology, Home Science (Community Science), Veterinary & Animal Husbandry, and BTech (Agricultural Engineering). These e-contents, hosted on the national server of ICAR-IASRI, New Delhi, allow global stakeholders, including students to access learning materials anytime and anywhere. The era is shifting from traditional teaching methodologies to advanced educational systems, which is becoming the need of the hour. E-learning systems complement and supplement traditional classroom education as well as distance education, enhancing teaching quality and learning ability. This innovative technology has made learning more experiential and memorable.

These e-contents, hosted on the national server of ICAR-IASRI, New Delhi, allow global stakeholders, including students to access learning materials anytime and anywhere.

For the horticulture degree program, the ICAR-NAIP Component-1 subproject, 'Development of e-Courses for BSc (Hort.) Degree Programme', was launched on 7 November 2008, at the College of Horticulture, Mudigere, under the leadership of UAS Bangalore/UHS Bagalkota and UAHS Shivamogga (20 courses) and TNAU Coimbatore and Dr YSPUH & F, Solan (16 courses each) as partners. E-contents were developed for 52 courses comprising 124 credit hours (1,354 modules/lectures) based on the syllabi recommended by the Fourth Dean's Committee. Subject matter experts—two per course—were involved in content creation and peer review. The e-contents included relevant text, images, diagrams, quizzes, animations, PowerPoint presentations, audio and video clips, and FAQs. These resources were uploaded into a user-friendly software

Dr S B Dandin, Vice-Chancellor, web hosting the e-contents for online and CDs for Offline platform to support students of the BSc (Horticulture) program and other stakeholders, such as farmers, extension scientists, and development line departments.

The e-contents were officially web-hosted during the National Workshop on E-Courseware for the Horticulture Degree Programme, at the College of Horticulture, Mudigere, Chikkamagaluru district, Karnataka. Subsequently, the contents were uploaded to the national server at ICAR-IASRI, New Delhi, for both online and offline use. A set of 52 CDs containing these materials was distributed to various universities and colleges across the country, along with a copy sent to the NAIP National Coordinator-1.

For the online delivery of e-courses, the platform used is MOODLE, a widely recognized software for e-learning across the globe. The software has been customized as per the requirements within permissible limits, and the courses have been uploaded to the platform. Furthermore, the software is integrated into a website, making it accessible online.

For offline delivery of e-contents, a software called POODLE (the offline version of MOODLE) is used. Courses integrated with POODLE have been loaded onto CDs/DVDs and made available for offline use. The interface and layout of the courses remain consistent across both online and offline formats.

The impact of the e-courseware has been significant, reaching millions of stakeholders and learners (27,56,735 since 20 September 2015), worldwide, including 5,921 visitors from India through the 'e-Learning Portal on Agriculture Education (e-*KrishiShiksha*)' https://ecourses.icar.gov.in/, which has recorded an impressive 79,71,289 hits.

Impact of e-learning

Students/Learners: Students

For the online delivery of e-courses, the platform used is MOODLE, a widely recognized software for e-learning across the globe.

benefit from e-learning in several ways:

Flexibility in Learning: In traditional classrooms, lectures are scheduled at fixed times, which may not be convenient for employed individuals. E-learning allows students to learn at their own pace and schedule, making it easier to balance work and studies.

Cost Efficiency: E-learning reduces expenses such as transportation, tuition, textbooks, and course materials, making education more affordable.

Enhanced Classroom Interaction: Multimedia e-contents enable teachers to cover more topics efficiently, allowing for greater classroom discussion. With just a digital device and internet connection, students can access tools to pursue their education and earn degrees at their convenience.

Time Management Skills: Online learning fosters time management as students need to plan and complete assignments independently. This skill benefits both academic and professional growth.

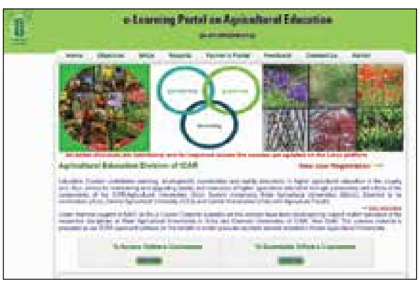
Improved Self-Confidence: Virtual learning provides career advancement opportunities and helps students build confidence as they manage their schedules and responsibilities.

Avoiding Monotony: Multimedia resources make learning engaging, offering self-paced education and enabling quieter students to participate more actively in discussions.

Independent Learning: Students develop self-directed learning skills and collaborate with peers through virtual group work and discussion boards.

Direct Interaction with Professors: Online courses allow students to communicate directly with professors and receive personalized feedback, enhancing learning and networking opportunities.

Repeated Access to Materials: Video lectures



can be revisited for better understanding, supplementing note-taking during live sessions.

Immediate Feedback: Digital platforms enable students to receive timely feedback, helping them improve and adapt quickly.

Professors: E-learning also benefits professors significantly:

Course materials are made available online, allowing students to prepare independently if they miss a class.

Professors have more time for student interaction and can respond to queries with prior intimation.

- Knowledge sharing with colleagues becomes easier, fostering professional growth.
- Rich multimedia e-contents reduce preparation time and allow professors to engage in additional activities beyond teaching.
- Updated materials with recent developments can be incorporated seamlessly.

University Perspective: From the university's standpoint, e-learning offers several advantages:

- ***Increased Enrollment***: Universities can enroll more students without the need for additional infrastructure.
- ***Efficient Teacher Training***: Newly recruited teachers and scientists can be trained effectively.
- ***Improved Student Performance***: Students achieve better career outcomes through enhanced educational quality.
- ***Shared Infrastructure***: IT infrastructure can be utilized for multiple purposes.
- ***Reduced Space Requirements***: Instructional spaces are used more efficiently, and virtual classrooms enable effective teaching.

All SAUs/SHUs/DUs/CAUs/CUs in the country will adopt the VI Dean's recommendations starting in the academic year 2024-25.

- ***Resource Sharing***: E-courseware can be shared with less-equipped institutions, promoting equitable learning opportunities.
- ***Faculty Empowerment***: Teachers benefit from advanced technological infrastructure, improving their efficiency and expertise.

Curriculum Updates and Future Prospects

The e-contents were initially developed based on the IV Dean's Committee recommendations. However, all SAUs/SHUs/DUs/CAUs/CUs in the country will adopt the VI Dean's recommendations starting in the academic year 2024-25. These include advanced courses aimed at producing skilled graduates with options for multiple entry and exit levels, enabling students to earn UG certificates, diplomas, or degrees.

To align with these updates, e-contents must be revised to reflect the new curriculum. The ICAR-Education Division's support is crucial for updating the e-learning portal, addressing the growing demand among students for upgraded content. These changes will ensure that the e-contents remain relevant and effective in preparing students for modern challenges.

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Dinesh Kumar

Improving Agricultural Research and Education in India: IAUA's Efforts

The Indian Agricultural Universities Association (IAUA) was established on 10 November 1967, (Registration No. 3489), with nine agricultural universities as founder members. The universities and their Vice-Chancellors (VCs) were as follows:

Founder President:

Dr P N Thapar, VC, Punjab Agricultural University, Chandigarh (now Ludhiana).

Members:

- Shri V Pulla Reddy, VC, Andhra Pradesh Agricultural University, Hyderabad (now Acharya N G Ranga Agricultural University, Guntur)
- Dr J S Patel, VC, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur
- Dr D P Singh, VC, Uttar Pradesh Agricultural University, Pantnagar (now G B Pant University of Agriculture and Technology)
- Dr K C Nair, VC, University of Agricultural Sciences, Bengaluru
- Dr S N Das Gupta, VC, Kalyani University, Kalyani (now Bidhan Chandra Krishi Viswavidyalaya, Mohanpur)
- Dr Ramaiya, VC, Odisha University of Agriculture and Technology, Bhubaneswar
- Dr G S Mahajani, VC, Udaipur University, Udaipur (now Maharana Pratap University of Agriculture & Technology)
- Dr M S Swaminathan, Director, Indian Agricultural Research Institute, New Delhi

Presently, IAUA has 73 member universities, which include 65 State Agricultural Universities; 4 Deemed-to-be Universities, namely, the Central Institute of Fisheries Education (CIFE), Mumbai; the Indian Agricultural Research Institute (IARI), New Delhi; the Indian Veterinary Research Institute (IVRI), Izatnagar; and the National Dairy Research Institute (NDRI), Karnal. It also includes 3 Central Agricultural Universities: the Central Agricultural University (CAU), Imphal; Dr Rajendra Prasad Central Agricultural University (Dr RPCAU), Pusa; and Rani Lakshmi Bai Central Agricultural University (RLBCAU), Jhansi. Additionally, one Central University with an Agriculture Faculty, Banaras Hindu University (BHU), Varanasi, is a member.

The main objective of the Association is to promote agricultural research, education, and extension in universities and states.

Considering their specializations, there are 46 Agricultural Universities, 7 Horticultural Universities, 17 Veterinary and Animal Sciences Universities, and 5 Fishery Science Universities within IAUA. All State Agricultural Universities (SAUs), deemed-to-be universities, and Central Agricultural Universities in India that offer integrated programs in teaching, research, and extension education in agricultural sciences qualify for regular membership in the IAUA.

Objectives

The main objective of the Association is to promote agricultural research, education, and extension in universities and states. It acts as a bureau of information to facilitate communication, coordination, and mutual consultation among agricultural universities. The Association serves as a liaison between agricultural universities, the Indian Council of Agricultural Research (ICAR), and the Government (both Central and State), and acts as a service agency to agricultural universities as required or prescribed. Additionally, the

IAUA undertakes, organizes, and facilitates conferences, seminars, brainstorming sessions, and symposia in agricultural and allied programs.

Management

The Vice Chancellors of member universities constitute the Association's General Body. The General Body meets once a year to decide the agenda for the next convention and other programs, adopt the audited accounts for the year, approve budget estimates for the next financial year, and elect the Executive Committee (EC) for the following calendar year.

The EC consists of the President, Vice President, Secretary General, Treasurer, and three members. The Deputy Director General (Agricultural Education) of ICAR serves as an Ex-officio member of the EC. The EC meets quarterly. The Association's office, located at the NASC Complex, Pusa Campus, New Delhi, is managed by the Executive Secretary, who implements the decisions of the General Body and the Executive Committee on behalf of the Association.

Programs of IAUA

The IAUA facilitates conferences, seminars, workshops, lectures, brainstorming sessions, and similar events in agricultural and applied programs. To fulfill its objectives, the IAUA has so far organized 46 Vice Chancellors' Conventions, 15 National Symposia, 13 Brainstorming Sessions, and 9 Regional Meetings on various issues of national importance and priorities related to agricultural research and education. Additionally, the IAUA organized an international conference titled 'Agricultural Education-Sharing Global Experiences' in November 2018.

Events organized by IA UA during 2015-2023: In pursuit of improving the quality of agricultural research, education and extension, the IAUA continued its efforts and organized following Symposia, Brainstorming Sessions, Vice Chancellors' Conventions, etc, in recent years involving the Vice Chancellors of the agricultural universities including veterinary/ animal science/ fisheries universities and experts from the National Agricultural Research and Education System (SAUs & ICAR) and abroad, and other stakeholders. A brief description of these events/ programmes organized by IAUA jointly with member Agricultural Universities during 2015-2023 is given in the following paragraphs.

To fulfill its objectives, the IAUA has so far organized 46 Vice Chancellors' Conventions, 15 National Symposia, 13 Brainstorming Sessions, and 9 Regional Meetings on various issues of national importance and priorities related to agricultural research and education.

Ranking of Agricultural Universities in India (2015): The National Institutional Ranking Framework (NIRF), launched by the Ministry of Human Resource Development (MHRD) on 29 September 2015, ranks higher education institutions in India based on parameters like 'Teaching, Learning and Resources', 'Research and Professional Practices', 'Graduation Outcomes', 'Outreach and Inclusivity', and 'Perception'. However, it overlooks agricultural-specific factors like Krishi Vigyan Kendras (KVKs), seed production, and technological interventions.

To address this, the Indian Council of Agricultural Research (ICAR) began ranking agricultural universities in 2016, focusing on resources and individual performance. While NIRF requires three years of data, ICAR considers only one year.

To create a unified ranking system, a symposium on 'Ranking of Agricultural Universities in India' was organized with Ch. Charan Singh Haryana Agricultural University, Hisar, aiming to align NIRF and ICAR rankings and explore the creation of an independent category for agricultural universities.

Convergence Building for Resource Sharing in Agriculture Research and Extension Sectors – Formation of State-Wise Agriculture Cabinet (2017): Indian agriculture has seen significant growth, from the Green Revolution to the Gene Revolution. However, key issues such as climate-smart crop varieties, smart agriculture, big data applications, IPR, women empowerment, farm mechanization, and livestock productivity need further discussion to align research with extension services and shape national policy.

To address these challenges, IAUA organized a two-day National Symposium at Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, on 27-28 April 2017, focusing on 'Convergence Building for Resource Sharing in Agriculture Research and Extension Sectors – Formation of State-Wise Agriculture Cabinet'.

Globalization of Agricultural Education: Role and Responsibilities of Indian Agricultural Universities (2017): The 42nd Agricultural Universities Vice Chancellors' Convention, organized by Maharana Pratap University of Agriculture and Technology, Udaipur, on 17-18 November 2017, focused on the theme 'Role and Responsibility of Indian Agricultural Universities in Globalization of Agricultural Education'.

The two-day conference included five thematic sessions:

- Learning from Ancient Agricultural Systems: Contribution of Maharana Pratap
- Status and Future Challenges in Agricultural Education
- Changing Scenario of Global Agricultural Education
- Restructuring Higher Agricultural Education in SAUs through Technological Interventions
- Institutional Reforms for Increased Competitiveness in Indian Agricultural Education

45th Vice Chancellors' Convention Group Photograph with Governor, Jharkhand (sitting 6th from left)

Alternative Farming Systems Involving Horticulture to Increase Crop Productivity and Doubling Farmers' Income (2018): The 9th Brainstorming Session of Vice Chancellors of Agricultural Universities on 'Alternative Farming Systems Involving Horticulture to Increase Crop Productivity and Doubling Farmers' Income' was organized by Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, in collaboration with IAUA, New Delhi, on 3-4 May 2018.

The deliberations took place across five technical sessions:

- Mechanization and High-Density Planting
- Biotechnological Approaches and Cultivar Development
- Integrated Farming Systems and Marketing
- Nutrient and Pest Management in Horticultural Crops
- Natural/Organic Farming for Sustainable Crop Production

Creating Enabling Ecosystem for AgriTech Innovations in Agricultural

Group Photograph of Participants of 14th National Symposium

Governor of Uttar Pradesh, Smt Anandiben Patel, delivered the inaugural address (online) at the 46th VCs' Convention held at DUVASU, Mathura

Group Photo of participants of 46th VCs' Convention, DUVASU, Mathura

Universities (2022): The global agri-food sector is growing rapidly, driven by digital innovations like IoT, precision farming, blockchain, and big data, addressing challenges such as climate change and resource efficiency.

Indian agriculture is shifting from food production to food processing, emphasizing mechanization and market-driven practices. This transformation requires improved infrastructure and tech-savvy manpower. Collaboration among stakeholders is essential for effective technology use.

The 14th National Symposium of IAUA, held at Professor Jayashankar Telangana State Agricultural University, Hyderabad, on 9-10 June 2022, focused on building an AgriTech ecosystem in agricultural universities. It featured four technical sessions:

- Emerging Technologies in the Agri-Food Value Chain
- Agriculture 4.0 Ready Manpower: Stakeholder Perspective
- Challenges and Opportunities for Emerging Technologies in Agricultural Universities
- Converging Partnerships – Academia, Industry, Incubators, and Start-ups

NEP-2020: Importance and Feasibility of Short Term and Certified Courses in Agricultural Universities (2022): NEP-2020 emphasizes the development of 'Higher-order skills' like creativity, critical thinking, and problem-solving, and promotes multidisciplinary learning across vocational and academic streams. It also advocates for stronger connections between agriculture education and related fields. Agricultural colleges must evolve into interdisciplinary institutions offering comprehensive education.

The 9th Regional Meeting of the Indian Agricultural Universities Association, held at Navsari Agricultural University, Gujarat, on 23-25 November 2022, focused on the importance and feasibility of short-term and certified courses in agricultural universities. Vice Chancellors and representatives from 30 universities shared experiences and discussed three sub-themes: 1) Conceptualization of Certified Courses for Technical and Vocational Skill Development, 2) Challenges and Opportunities for NEP in Short-Term Certified Courses, and 3) NEP-2020 and Future Skills Development. The meeting aimed to highlight the role of these courses in developing skilled human resources for an inclusive society.

National Education Policy 2020: Implementation in Agricultural Universities (2022): The convention, organized by UP Pandit

Shri Manoj Sinha, Lt. Governor of J&K, and dignitaries released a publication during the inaugural session of the 12th Brainstorming Session of IAUA at SKUAST, Srinagar

Dr R C Agrawal, DDG (Agril. Education), ICAR, Dr T Janaki Ram, VC, Dr YSRHU, VR Gudem, and Dr Z P Patel, VC, NAU, Navsari, co-chaired a technical session at the 12th Brainstorming Session

Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya (DUVASU), Mathura, in association with the Indian Agricultural Universities Association, took place on 26–27 December 2022, focusing on 'National Education Policy 2020: Implementation in Agricultural Universities'.

Discussions centered on transforming institutions into multidisciplinary, research-intensive bodies, revising curricula, modifying academic structures, introducing credit banking, and fostering partnerships with industry and other stakeholders. Key recommendations were made to guide the future implementation of NEP-2020 in agricultural universities.

Innovations in Sustainable Natural Resource Management: The 11th Brainstorming Session of IAUA on 'Innovation in Sustainable Natural Resource Management' was held at Rani Lakshmi Bai Central Agricultural University, Jhansi, on 7-8 April 2023. The event was attended by Vice Chancellors, ICAR Deputy Director Generals, and Deans/ Directors of research and academic institutions. Keynote speakers discussed issues and solutions in five technical sessions:

- Sustainable Management of Soil and Water Resources
- Sustainable Management of Animal and Fish Resources
- Sustainable Management of Plant Resources and Biodiversity
- Sustainable Climate Resilient Practices
- Innovations in AI, IoT, Blockchain, Agri-drone, and Blended Learning.

Redefining Agricultural Education to Leadership, Entrepreneurship, Employment and Discovery (2023): The 12th Brainstorming Session of IAUA on 'Redefining Agricultural Education to Leadership, Entrepreneurship, Employment, and Discovery (LEED)' was held at Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, on 24-25 August 2023. The session focused on developing a skilled workforce in agriculture, in line with NEP-2020, through improved curriculum design, teaching methods, and student assessment.

Experts discussed bridging the skill gap in agriculture, fostering entrepreneurship, and leveraging Agri-4 technologies (AI, ML, IoT, and Automation). The event offered networking opportunities and insights into the future of agricultural education and research, aimed at producing industry-ready graduates.

Strengthening National Agricultural Education System (2023): The evolution of

Dr R S Paroda Chairing the Brainstorming Session on 'Strengthening National Agricultural Education System' at NAAS, NASC Complex, New Delhi

agricultural education in India has led to the establishment of numerous colleges and universities that have been instrumental in addressing food scarcity and advancing agricultural practices. However, challenges in integrating teaching, research, and extension remain, necessitating a critical review of the system's history, achievements, concerns, and needed reforms. To achieve sustainable agricultural growth and address emerging challenges, reforms in research and education are essential. A reformed education system and skilled workforce are crucial to improving the livelihoods of smallholder farmers and making agriculture a more attractive profession.

To address these issues, a Brainstorming Session was organized by the Trust for Advancement of Agricultural Sciences (TAAS) and the Indian Agricultural Universities Association (IAUA) on 30 October 2023, at the NAAS, NASC Complex, New Delhi. Attended by Vice Chancellors, ICAR officials, and experts, the session focused on improving agricultural education, integrating teaching, research, and extension, fostering collaboration between ICAR, SAUs, and government departments, and devising strategies for the financial health and governance of the agricultural education system in India.

The Incremental Role Played by IAUA in Quality Agricultural Education, Research and Extension

The Indian Agricultural Universities Association (IAUA) has been focused on improving the quality of agricultural education, research, and extension. Its initiatives include enhancing student and faculty development, strengthening curriculum coordination, and addressing inbreeding of faculty in State Agricultural Universities (SAUs). IAUA is also promoting emerging fields like Nanotechnology, Artificial Intelligence, Robotics, Biofertilizers, and Botanicals. Notably, it has launched a network project on 'Nanotechnology in Agriculture' and other related projects.

IAUA has been organizing Vice Chancellors' Conventions, symposiums, and brainstorming sessions to address national priorities in agricultural education. Recent programs have focused on topics like 'Expectations from Agricultural Universities', 'Globalization of Agricultural Education', and 'Rethinking Under Graduate Agriculture Education'. Key presentations from these events include discussions on the National Education Policy (NEP) for Agricultural Education, strategies to improve agricultural higher education, and empowering faculty for entrepreneurship through innovation in agricultural universities.

IAUA works closely with the Agricultural Education Division of ICAR to implement NEP-2020. The roadmap for NEP-2020 developed by ICAR has involved active cooperation from agricultural universities and has been discussed at various IAUA platforms. Three IAUA Executive Committee members were part of the National Committee formed by ICAR to contribute to the development of NEP-2020 implementation strategies for agricultural education in the country. IAUA has also provided valuable input to ICAR, including a report on reducing faculty inbreeding in SAUs to improve

IAUA has been organizing Vice Chancellors' Conventions, symposiums, and brainstorming sessions to address national priorities in agricultural education.

the quality of education. These recommendations are being integrated into the implementation strategies for NEP-2020.

Looking ahead, IAUA will continue to strengthen coordination among SAUs, ICAR, and other stakeholders to improve agricultural research, education, and extension. Given the rapidly changing global landscape, agricultural universities must innovate, engage new partners, and rebuild trust with their stakeholders, all while focusing on the core pillars of research, education, and extension.

"Education should be so revolutionized as to answer the wants of the poorest villager, instead of answering those of an imperial exploiter"- Mahatma Gandhi

"Education is the most powerful weapon which you can use to change the world."

-Nelson Mandela

Executive Secretary
IAUA, G-5, A-Block, NASC Complex,
Pusa Campus, New Delhi 110 012

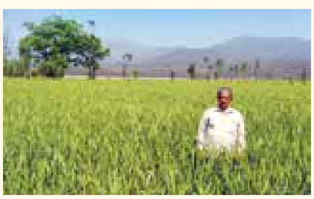
Improved Wheat-Production Technology

The challenge

The availability of quality wheat seed is a major concern for the farmers of Uttarakhand hills. Moreover, there is a need to demonstrate the yield potential of newly released varieties to popularize it among the farmer's community. VL *Gehun* 967 is a newly released and notified wheat cultivar having excellent agronomic characteristics which need to be popularized among farmers.

The solution

In order to enhance the quality seed availability to the farmers and to demonstrate the yield superiority of the newly released wheat variety, VL Gehun 967 was included in the on-going farmer participatory seed production (FPSP)-cum-varietal demonstration programme of the institute in the Tharu tribal villages, Jhankat (N 28°949056°, E 79°791728°) and Nakulia (N 28°58.832', E 79°42.876') of Sitarganj (district Udham Singh Nagar, Uttarakhand). The farmers of these villages showed their keen willingness for the FPSP of VL *Gehun* 967 due to the associated monetary benefits and potential performance of the variety.



Farmers' Participatory Seed Production (FPSP) of Wheat Variety VL *Gehun* 967

The application

The farmers involved in the participatory seed production were regularly given institutional support in the form of quality seed of the variety, regular monitoring of their fields by the scientific team for a range of seed production activities like weed management, insect and disease management, roughing activities and other on-field training-cum-demonstration activities. Besides, farmers were also trained at the institute to gain technical know-how regarding good agricultural practices as well as for quality seed production. In the process, the new variety is also being disseminated and popularized to the nearby region farmers.

The impact

From the last 3 years, tribal farmers of the Sitarganj area have been cultivating the variety and producing truthfully labelled (TL) seeds of the wheat variety VL *Gehun* 967. The details of the seed procured from the farmers are asfollows:

Year	Procurement (q)	Remittance to farmers (₹)
2019–20	41.38	91,036
2020–21	142.00	3,40,800
2021–22	134.57	3,22,968
Total	317.95	7,54,804

The income received by seed-producing farmers by direct procurement of seed by the institute was ₹7.54 lakhs. Apart from the monetary benefits, the technology was received by the farmers at an accelerated rate and the variety demonstrated a yield advantage of 5–7% over the local cultivars.

Source: ICAR Annual Report 2023-24, p.187

H G Ashoka

Digital Agriculture in College of Agricultural Engineering, UAS, Bangalore: Way Forward

The migration of rural youth from agricultural occupations continues to drain rural India. Although the country has achieved substantial progress in food production, it remains a challenge to keep pace with future demands. In this context, digital agriculture offers hope for the future, providing a way to attract rural youth to stay in the agricultural profession. The development and deployment of such technologies is crucial. In this direction, University of Agricultural Sciences, Bangalore (UAS, B) has made concerted efforts through the College of Agricultural Engineering, GKVK, and has made significant progress in bringing digital agriculture to farms. Faculty, students from various institutions, and rural youth are involved in these efforts.

Digital Agriculture Technologies at the College of Agricultural Engineering

In 2023, the university established the Center for Innovation and Development in Smart Agriculture (CIDSA), supported by the Government of Karnataka, to advance farm equipment design, agricultural automation, and precision agriculture. The central hub features five specialized laboratories, including those for farm machinery design, agri automation, and agriculture drone labs, all equipped with 29 licensed software tools. CIDSA provides training for students, farmers, entrepreneurs, and engineers while hosting events, industry activities, and training programs. It promotes smart precision agriculture using Hexagon Agron systems for end-to-end monitoring of operations and introduces drone technology for land management, vegetation mapping, disease detection, spraying, and crop insurance.

CIDSA provides training for students, farmers, entrepreneurs, and engineers while hosting events, industry activities, and training programs.

Digital Image Processing System: The Digital Image Processing System for detection of maturity indices and postharvest defects in mango fruits is a low-cost, non-destructive sensing technology capable of sorting fruits based on colour, maturity, external damage, and black spots. It replaces the drudgery, inconsistency, and time-consuming nature of manual fruit sorting. An image processing system measuring 2.0 × 0.5 × 1.0 m was designed and fabricated for detecting maturity indices (peel colour and lenticels) and postharvest defects (black spots and external damages) in mangoes. An algorithm was developed using various operations from OpenCV and NumPy in Python for detecting these maturity indices and postharvest defects. The machine provides a cost-effective solution, ensuring high productivity, reduced time consumption, quality sorting with minimal damage to fruits,

Digital image processing system

Solar bird scarer in operation

and high accuracy. It meets grading standards required for export purposes. The target audience for this technology includes farmers, mango boards, pack houses, the Department of Horticulture, traders, exporters, and quarantine systems. This machine at the farm level helps reduce postharvest losses, improving fruit quality and shelf life. The machine capacity ranges from 600-800 kg/hr.

Solar-operated bird scarer

Solar-operated bird scarer has been developed to scare and frighten birds in crops such as sunflower and maize. Bird scarer emits three different types of sounds at 15 second intervals like a plate sound, a siren sound, and a recorded human voice. The system is powered by a solar panel, equipped with a charge controller and a battery.

3D Printed Honeycomb Structure

The 3D Printed Honeycomb Structure technology has been developed at the college. The 3D printed honeycomb model helps reduce beeswax production, thereby increasing honey yield and other comb products. This allows bees to concentrate on their primary job of pollination. The 3D printed honeycomb made from polymer is not attacked by moths, increasing its lifespan. The mechanical properties of the 3D printed honeycomb model are significantly higher compared to the mechanical properties of natural honeycomb. The honeycomb model, coated with beeswax prior to field installation, ensures acceptance of the comb by honeybees.

The 3D printed honeycomb model helps reduce beeswax production, thereby increasing honey yield and other comb products.

Quality Testing of Micro-Irrigation Components Laboratory

A Laboratory for Quality Testing of Micro-Irrigation Components has been established to test micro-irrigation components, facilitating farmers and government agencies in selecting quality components under subsidy programs. It also tests polyhouse structural components to facilitate improvements in the protected cultivation ecosystem.

REWARD Project

Also, the college is operating the world Bank assisted GoK Project on Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD). Under this project various latest art of the technologies are established in the laboratories as well installed in the farmers field. Some of them are:

Automatic weather sensor: Automatic weather sensor (AWS) incorporates the sensor used for collecting weather parameter like Atmospheric Temperature, Relative Humidity, Wind speed, Wind

3D printed Honeycomb structure bee colony

Field Station

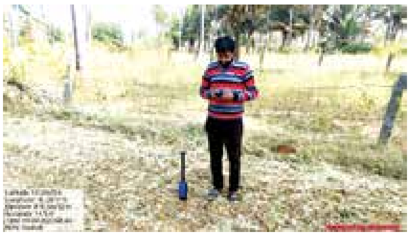
The college is operating the world Bank assisted GoK Project on Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD).

Direction, Atmospheric pressure, Solar Radiation and Rainfall (Rain guage).

Stevens Hydra Probe: Automatic profile soil moisture sensor (APSMS), the Stevens Hydra Probe is simultaneously measuring the moisture content, salinity, and temperature of a soil. The moisture content and salinity are determined from the dielectric constant and the conductivity of the soil, and temperature measured thermistor. Soil moisture data collected automatically at interval of 15 min continuous data through website and this data is used for quantifying soil moisture storage in a given period for deriving water balance of model micro-watersheds and assessing moisture stress in the soil.

Hydra Go surface soil moisture meter: Hydra Go surface soil moisture meter is the Stevens Hydra-GO portable digital soil moisture meter measures surface soil moisture at sampling spot quick and easy. It instantly measures

Sensor placed at different depth of crop rooting zone



soil moisture, electrical conductivity and temperature and data can easily access the data with mobile app.

LAI: Leaf area index meter (LAI 200) calculates Leaf Area Index (LAI) and other canopy attributes from light measurements made with a "fish-eye" optical sensor (148° field-of-view). Measurements made above and below the canopy are used to calculate canopy light interception at five zenith angles, from which LAI is computed using a model of radiative transfer in vegetative canopies. The data has been used to determine crop evapotranspiration.

Current meter: Current meter is a device that measures the speed and direction of

Field observation of the crop

water flow in the stream.

Both Post Graduate as well as undergraduate Agricultural Engineering students are

Runoff velocity measuremnt in the stream

utilizing the art of all these advanced digital technologies

Both Post Graduate as well as undergraduate Agricultural Engineering students are utilizing the art of all these advanced digital technologies for their studies and research activities.

for their studies and research activities.

Special Officer, College of Agricultural Engineering, UAS, GKVK, Bangalore.

Chief Scientific Officer
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Seema Jaggi, R C Agrawal and S R Sharma

The Rise of Female Enrolment in Agricultural Higher Education: ICAR National Level Entrance Exam

Agricultural education in India is undertaken through the partnership and efforts of the Indian Council of Agricultural Research (ICAR) and the Agricultural Universities (AUs) System, comprising 65 State Agricultural Universities (SAUs), 4 Research Institutes with Deemed-to-be-University (DU) status, 3 Central Agricultural Universities (CAUs), and 4 Central Universities (CUs) with agricultural faculties. These institutions impart education in agriculture and allied sciences and are working diligently to provide quality education to students.

To meet the demand for a talented pool in the field of agriculture and allied science disciplines, the Agricultural Education Division of ICAR annually conducts a national-level entrance examination, starting from 1996-97, for centralized admission to 20% (15% before 2022-23) of undergraduate (UG) seats across 12 disciplines and 30% (25% before 2022-23) of postgraduate (PG) programs (Masters and Doctorates) in about 80 agriculture and allied science subjects in AUs under the ICAR-AU system.

The basic objective of these examinations is to reduce academic inbreeding in agricultural education by promoting national integration through student mobility, infusing merit, encouraging talent, and establishing uniform examination standards across universities. This process leads to an overall improvement in the quality of higher agricultural education in the country.

To meet the demand for a talented pool in the field of agriculture and allied science disciplines, the Agricultural Education Division of ICAR annually conducts a national-level entrance examination, starting from 1996-97

Since 2019-20, ICAR has been conducting the entrance examination through the National Testing Agency (NTA) in Computer-Based Test (CBT) mode. From 2023-24, ICAR has joined the Common University Entrance Test (CUET) conducted by NTA for UG admissions in agriculture and allied sciences.

Key Insights

The overall proportion of female enrolment in

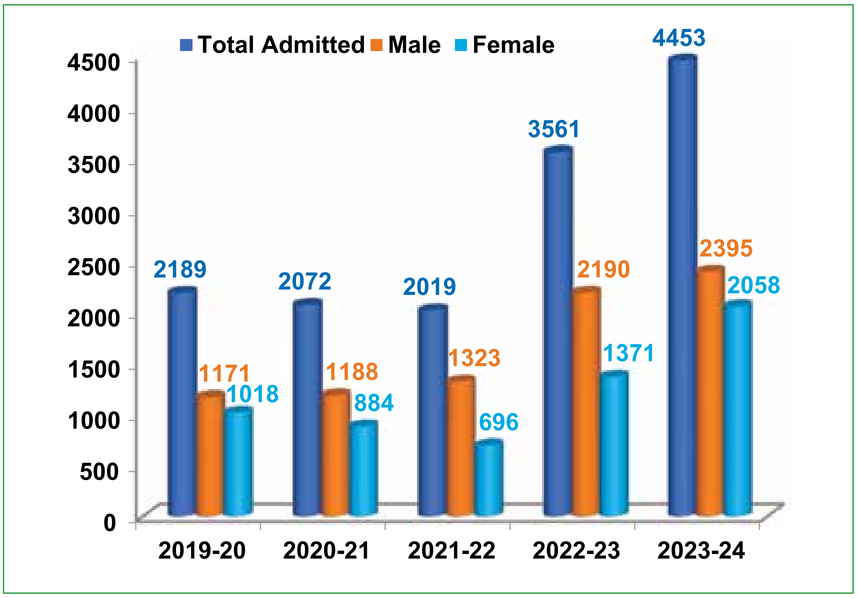

Fig. 1: Gender-wise distribution of number of students admitted in Bachelor programmes over years

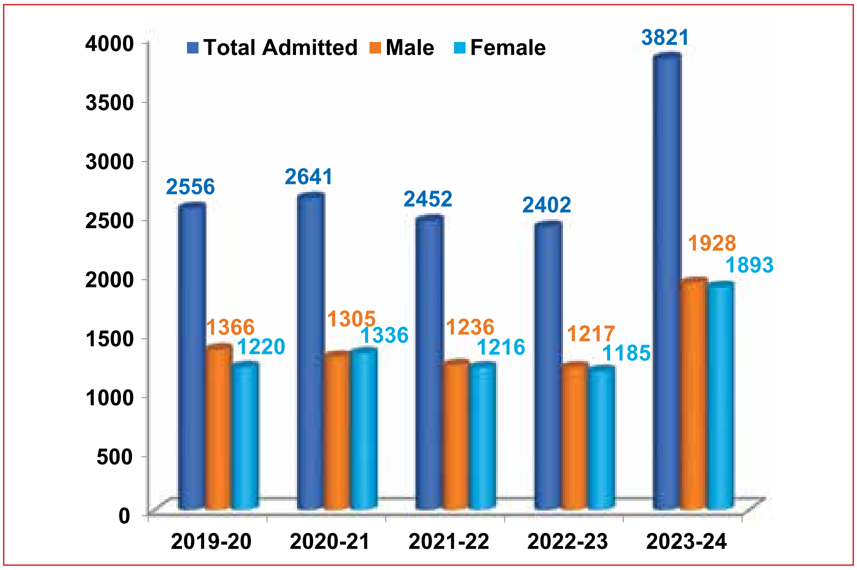

Fig. 2: Gender-wise distribution of number of students admitted in Masters programmes over years

professional higher agricultural education (UG) is 46% in 2023-24 which has increased over years (Fig. 1).

In case of Masters programmes, the proportion of female enrolment is 49.5% in 2023-24 which has increased over the years reflecting an increase in the interest of girls towards higher agricultural education in the country (Fig. 2).

In case of PhD admissions, the girls have outnumbered the boys as compared to earlier years with 53.4% enrolment in 2023-24 (Fig. 3).

In all the programmes combined (UG, PG and PhD), the enrolment of female has increased to 48.6% in 2023-24 thereby reducing the gap between the male and female enrolment over the years.

The education of females transforms communities, strengthens countries, boosts economies, and reduces inequality. Females in higher education make a significant contribution to sustainable development through the generation and dissemination of knowledge. It is evident that the enrollment of females in higher education is increasing. The Ministry of Education, in its All India Survey on Higher

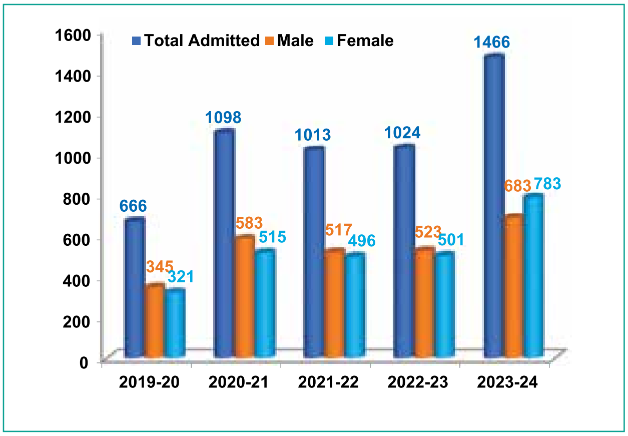

Fig. 3: Gender-wise distribution of number of students admitted in Doctorate programmes over years

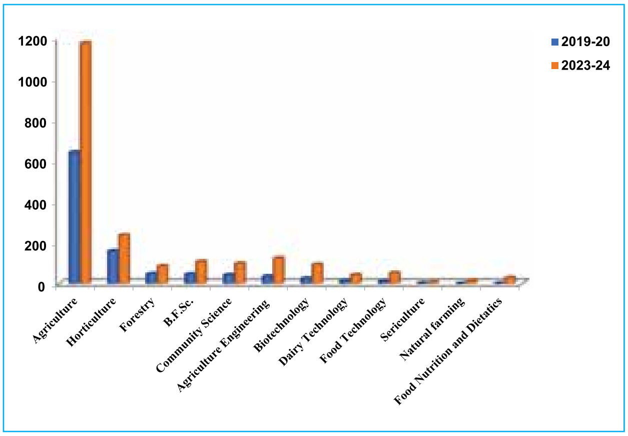

Fig. 4: Discipline-wise distribution of female students admitted in Bachelor programmes

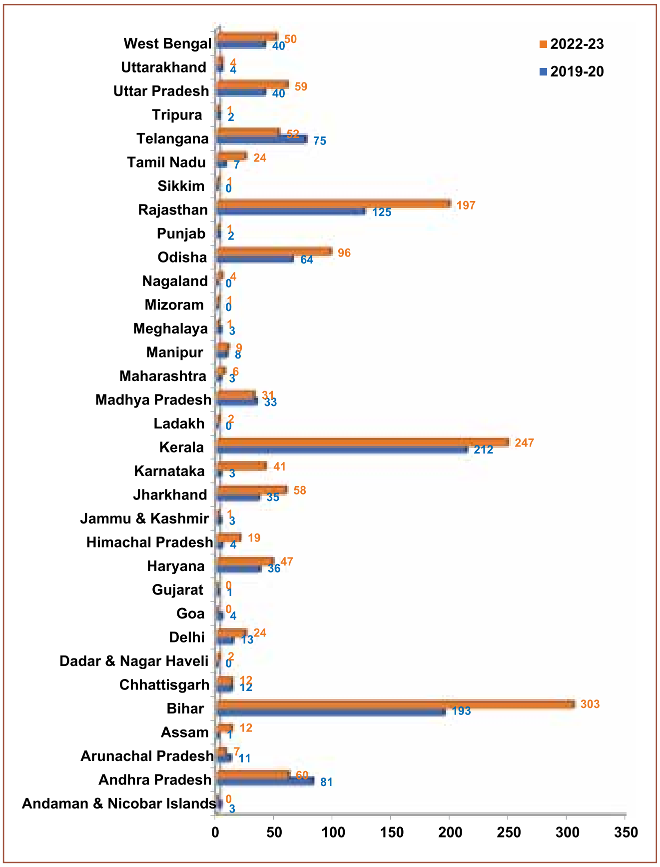

Fig. 5: State-wise distribution of female students admitted in Bachelor programmes (2019-20 and 2022-23)

Education (AISHE) 2021-2022, reported a 32% increase in female enrollment in higher education since 2014-15.

Agricultural higher education is an integral part of our education system and has a profound role to play in shaping the future of sustainable agriculture. Here some facts and figures obtained from the ICAR National Level Entrance Examinations being conducted in last five years (2019-20 to 2023-24) have been presented focussing on the female enrolment in higher agricultural education.

Key Insights

A major proportion of female enrollment is in the discipline of Agriculture (63% in 2019-20 and 57% in 2023-24), followed by Horticulture (16% in 2019-20 and 11% in 2023-24) (Fig. 4). The states of Bihar (22% in 2022-23 and 19% in 2019-20), Kerala (18% in 2022-23 and 21% in 2019-20), and Rajasthan (14% in 2022-23 and 12% in 2019-20) together contribute more than 50% of female students in higher agricultural education (UG) (Fig. 5). ICAR awards the National Talent Scholarship (NTS) to UG students based on qualifying ICAR's All India Entrance Examination and subsequent admission to an Agricultural University/Institute outside the state of domicile of the candidate. The scholarship amount is ₹3,000 per student for a period of four years. This support has fostered cultural exchange, promoted healthy competition, enhanced national integration and diversity, and led to improvements in overall academic excellence. In 2023-24, out of a total of 2,058 female students admitted, 1,654 (80%) have been awarded NTS. This demonstrates a significant change in terms of the mobility of girls for their higher education.

Agricultural Education Division
Indian Council of Agricultural Research (ICAR), New Delhi
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Success Stories from ICAR & WSU Dual Degree PhD Program

In a groundbreaking move in 2019, Western Sydney University (WSU) partnered with India's ICAR-accredited agricultural universities to establish a dual-degree PhD and master's program. This initiative aimed to cultivate global research excellence and collaboration. The program's inaugural cohort of five Indian PhD students recently concluded their studies, achieving significant academic milestones and securing promising career paths.

This article showcase the success stories of students from the ICAR and WS exchange study program.

Km Sindhu Sheoran, from CCS Haryana Agricultural University, Hisar, exemplifies the program's success. Now a Senior Research Program Coordinator at Western Sydney University, her journey highlights the program's transformative impact. Her exceptional academic achievements include being the first Indian to win the Hawkesbury Institute for the Environment's prestigious 3 Minute Thesis award. She represented HIE at Western Sydney University in 2022, where she was again the people's choice. Her name proudly adorns the Honour Board of the Hawkesbury Institute for the Environment. In 2023, Km. Shearan further demonstrated her exceptional skills by winning the Jann Conroy Award, establishing herself as a great speaker and presenter.

Km Sheoran's PhD research centered on the influence of floral diversity on pollinators. Her studies spanned diverse environments, from Indian open fields to Australian glasshouse settings, where she focused on native stingless bees and strawberries. This comparative research, conducted in Western Sydney University's advanced smart glasshouse facilities, yielded valuable insights into pollinator behaviour and crop health.

In a groundbreaking move in 2019, Western Sydney University partnered with India's ICAR-accredited agricultural universities to establish a dual-degree PhD and master's program.

Reflecting on her journey, Km Sindhu shared, *"The dual-degree program was transformative. It broadened my academic horizons and offered invaluable international exposure. Being selected for the dual PhD program and then having the chance to work in the vibrant environment and labs at WSU was a pivotal moment in my academic career. The facilities and research support at WSU were outstanding. Working with Prof. Sally Power and Dr Amy-Marie Gilpin, who were incredible supervisors, allowed me to participate in numerous events and win multiple awards in just two years. It was truly a dream come true."*

Shri Sanjay Kumar Pradhan, another standout student from the dual-degree program, has excelled as a

researcher in Professor Markus Reigler's laboratory, focusing on innovative Queensland fruit fly management strategies. With a stellar academic record, including an All India Rank 1 in the ICAR-SRF exam, Pradhan commenced his PhD in Agricultural Entomology at the University of Agricultural Sciences, Bangalore, in 2019. Selected for the dual PhD program in his first year, he conducted part of his research at UAS, Bangalore, collaborating with the ICAR Indian Institute of Horticultural Research. In 2022, he transitioned to Western Sydney University, successfully completing his dual PhD in February 2024. Shri Pradhan's exceptional research has garnered significant recognition. He was awarded a $15,000 student research grant from the Genetic Society of Australasia for his groundbreaking work on Illumina sequencing and virus discovery in Queensland fruit flies. Additionally, he received the prestigious Ted Taylor Award from the Entomological Society of Australia and was voted the People's Choice at the HIE 3-minute thesis competition.

Shri Sanjay said, "*The dual-degree program was a pivotal experience in my academic journey. The opportunity to work with esteemed researchers and utilise advanced facilities at Western Sydney University greatly enhanced my research capabilities. This program not only broadened my expertise in molecular entomology and bioinformatics but also provided a platform to present my work at prestigious conferences, which has been incredibly rewarding.*"

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The dual-degree program has yielded impressive results, shaping the careers of students like Km. Swathy from Kerala Agricultural University. Having

successfully defended her PhD thesis, Km. Swathy is now a tech specialist at a leading Sydney-based vertical farming company. Under the guidance of Professor Oula Ghannoum at Western Sydney University, Km. Swathy's research delved into sorghum's resilience to water and heat stress. Her findings have the potential to revolutionize breeding programs and agricultural practices, ensuring food security in the face of climate change. This program not only fosters global research collaboration but also equips

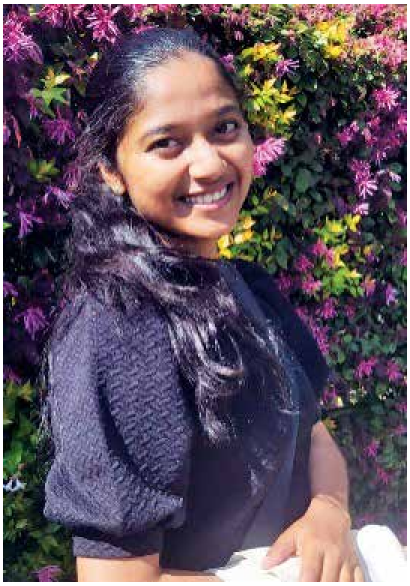
students with the expertise to drive innovation in the agricultural sector, both in Australia and India.

Km Swathy said, "*This opportunity has been incredibly rewarding, allowing me to immerse myself in advanced research, utilize lab facilities, and collaborate with various research groups. Attending the Australian Society of Plant Scientists International Conference in beautiful Tasmania was another highlight. It provided a fantastic platform to discuss my research with esteemed researchers worldwide. Working with the agricultural industry during my research has equipped me with* *valuable career skills. I look forward to joining a project at the Hawkesbury Institute for the Environment (HIE) as a research assistant soon."*

Shri Charan Singh is journey as a dual PhD candidate exposed him to diverse academic cultures and environments. He is eager to apply the knowledge and skills acquired abroad to contribute to agricultural advancement in India.

Having completed his dual PhD program, Shri Charan Singh has returned to his alma mater, CCS HAU, Hisar, as an Assistant Professor in the Department of Soil Science. His experience at Western Sydney University, where he conducted research under the guidance of Associate Professor Uffe Nielsen, focused on harnessing bacterial isolates to improve plant drought resilience. Shri Charan's journey as a dual PhD candidate exposed him to diverse academic cultures and environments. He is eager to apply the knowledge and skills acquired abroad to contribute to agricultural advancement in India.

Km Mantavya Bishnoi, hailing from the Department of Food and Nutrition, has successfully completed her dual PhD at Western Sydney University. Under the mentorship of Professor Vijay Jayasena, she delved into the characterization of stingless bee honey across various Australian regions. Km Bishnoi's academic journey continues as a research academy at Western Sydney University. The successful thesis submissions of all mentioned candidates to both their home



institutions and Western Sydney University underscore

This pioneering collaboration between Western Sydney University, ICAR, and 26 State Agricultural Universities has proven to be a catalyst for global research excellence.

the program's effectiveness. This pioneering collaboration between Western Sydney University, ICAR, and 26 State Agricultural Universities has proven to be a catalyst for global research excellence. The following candidates are currently conducting their research at WSU and reflect on notable highlights from their journey.

"Hello, I am **Dharini S V** *from Tirupur, Tamil Nadu. I am pursuing a Dual PhD from Tamil Nadu Agricultural University, India and WSU, Australia on a project titled 'Mango pollination in Tamil Nadu, India and the significance of cross-pollination in improving the yield and quality of Australian*

mangoes.' The journey so far has been great, and WSU has given me memorable experiences and paved new learning pathways. As a dual PhD student, I had the opportunity to learn the orchard management strategies for mango cultivation in India as well as Australia. My project involved immense field work in the mango orchards and the surrounding National Parks in Northern Territory, Australia. I took up the task of managing field studies, including designing the experiments, drafting methodologies, and developing adaptation measures suited to the field conditions. I had the opportunity to experience the wildlife of Australia and also learned the procedures for collecting biological samples in the wild. I was given a chance to present my research work at an international conference held in Darwin, Australia. This journey has also helped me to hone my data analytical and interpretation skills. On a personal note, after coming to WSU, I have managed to handle my personal expenses, which boosted my confidence to lead a financially independent life."

"I am **Arindam Deb,** *a dual degree student pursuing a Doctoral*

degree with Kerala Agricultural University and Western Sydney University. The overarching aim of my research is to assess the effects of climate change on biotic (weeds) and abiotic (heatwaves) stresses on rice production and design appropriate management strategies. Getting this opportunity was a dream come true for me, and presently I am learning many skills and techniques in my research area at WSU."

In addition to the above-mentioned candidates conducting or having completed their PhD at WSU, applications from more PhD candidates are currently being processed. Over the next few months, we are expecting another batch of 21 students to start the program with us. Some students who initially enrolled in dual master's programs with WSU have successfully progressed to PhD candidacy at the university. Shri Bhavesh, one of these dual master's students, highlights that participating in this program has afforded him the invaluable opportunity to conduct research under the mentorship of distinguished Professor Brajesh Singh, a globally recognized scientist in microbiology.

"This dual-degree program not only enriches my academic journey but also offers unparalleled exposure to diverse perspectives in microbiology research. Collaborating with Professor Brajesh Singh at WSU provides me with a unique opportunity to deepen my understanding and skills in the field, preparing me to make significant contributions to research and innovation in microbiology upon completing my master's degree," said Shri Bhavesh.

The ICAR & WSU dual-degree PhD program stands as a testament to the transformative impact of academic partnerships, shaping both careers and the future of global agriculture. As it continues to cultivate a new generation of researchers,

Following Shri Bhavesh, additional students have enrolled in the dual master's program, including Aditya, Kanti, Sanju, Shimi, and Manjeet, who are from various state agricultural universities across India. The India-Australia dual degree program offers unparalleled research, teaching, and learning opportunities for aspiring professionals. The success of its initial cohort underscores the power of international collaboration in fostering individual growth and cross-cultural innovation.

With over 20 students currently enrolled, this program is at the forefront of cutting-edge research, pushing the boundaries of knowledge across disciplines. The ICAR & WSU dual-degree PhD program stands as a testament to the transformative impact of academic partnerships, shaping both careers and the future of global agriculture. As it continues to cultivate a new generation of researchers, this initiative promises to deliver groundbreaking advancements and inspire a brighter future for all.

Bio-engineering measures for the stabilization of ravine slopes and its productive utilization in Western India

The conservation measures such as (a) Bench terracing + Sapota (Bt); (b) Bench terracing + Sapota with crop cultivation (BtCr); (c) Continuous slope + Sapota (Sl) and (d) Continuous slope + Sapota with trenches (SlTr) were evaluated for stabilization of ravines slopes. Bench terracing and trenching brought in significant decrease in runoff (34% and 16%, respectively) and soil erosion (25% and 15%, respectively), and enhanced tree growth, biomass and carbon stock. The results indicated that bench terracing is the best conservation measure for the stabilization of slopes in ravine lands followed by trenching. These conservation measures could also be important strategies for climate change mitigation and adaptation for such highly degraded ravine lands.

Stabilization of ravine slopes

Source: ICAR Annual Report 2023-24, p.126

P S Pandey

An Institute of National Importance:

Dr Rajendra Prasad Central Agricultural University, Pusa, Samastipur

Birth place of Indian Agriculture

The history of Pusa is deeply rooted in the Darbhanga Raj of the Tirhut Estate. During the 18th century, following the victories of the British East India Company in the Battle of Plassey (1757) and the Battle of Buxar (1764), and the subsequent Treaty of Allahabad (1765), the imperial government acquired the U-shaped land of Pusa near the right bank of the Burhi Gandak River in 1796. Later, the East India Company established

During the 18th century, following the victories of the British East India Company in the Battle of Plassey (1757) and the Battle of Buxar (1764), and the subsequent Treaty of Allahabad (1765), the imperial government acquired the U-shaped land of Pusa near the right bank of the Burhi Gandak River in 1796.

a stud farm at Poosah (Pusa), under the supervision of Lieutenant Major Frazer (Superintendent, 1793–1808), to breed cavalry horses. This endeavor continued until 1874 but was discontinued due to an epidemic of glanders disease.

Imperial Agricultural Research Institute, Pusa (Bihar)

The Bengal government owned a sprawling estate at Pusa, where it had previously operated a model farm from 1875 to 1876. Subsequently, the estate was leased to British tobacco firms for experiments on tobacco cultivation from 1877 to 1897 to meet the requirements of UK cigarette factories.

Pusa is a revered place for agricultural researchers and academicians in India, as it

Scientists at work in laboratory at the Agricultural Research Institute, Pusa Bihar marks the origin of organized agricultural research and education in pre-independence India. On 1 April 1905, it was established as the Imperial Agricultural Research Institute (IARI). The foundation began with the construction of the Phipps Laboratory, funded by a generous donation of £30,000 in 1903 by Mr Henry Phipps, an American philanthropist. Additionally, a grant of £110,000 from the colonial government facilitated the development of various infrastructural facilities, including the Navlakha Building.

In 1911, the Agricultural Research Institute (ARI) was renamed the Imperial Institute of Agricultural Research, and in 1919, it was further renamed the Imperial Agricultural Research Institute (IARI). However, a devastating earthquake on 15 January 1934, led to the institute's relocation to Delhi on 29 July 1936. After India's independence in 1947, it was renamed the Indian Agricultural Research Institute (IARI). Since then, the institute has continuously served India, achieving numerous milestones in agriculture, transforming the country into a food-surplus and nutritionally secure nation.

Hence, IARI, Pusa, Samastipur (Bihar) is the birthplace of agricultural research and education in India. In 1923, the first postgraduate program in agricultural education was initiated here, and today marks the centenary year of that prestigious and groundbreaking initiative.

Hence, IARI, Pusa, Samastipur (Bihar) is the birthplace of agricultural research and education in India.

Since 1794, Pusa has been the epicenter of agriculture and animal husbandry-related economic activities in various forms, as documented in numerous historical records of that period. Therefore, it can be conclusively stated that the name "Pusa" is not derived from the name of the philanthropist Mr Henry Phipps from the United States of America (USA), as is commonly believed. This perception is incorrect.

In fact, historically Pusa was existing long before the generous contribution made by the Henry Phipps of USA and can be found into the '*Rigvedas* 10th sloka devoted to deity *Pooshan*'

पूषागाअवतुनःपूषारक्षितारिवतः।
पूषावाजंसनोतुनः।"

Sukt 6.54.5. and also in the 16th sloka of '*Eshavaashopnishad*' which is one of the reputed embodiment of holy knowledge book.

About RPCAU

Dr Rajendra Prasad Central Agricultural University (RPCAU), an Institution of National Importance established on 7 October 2016, traces its legacy to Rajendra Agricultural University, Pusa (1970), and the Agricultural Research Institute, Pusa (1905). The latter is regarded as the mother of organized agricultural research and education in India, where higher agricultural education at the postgraduate diploma level was initiated in four disciplines: Botany, Agricultural Chemistry, Mycology, and Entomology.

The jurisdiction and responsibility of RPCAU, Pusa, encompass teaching, research, and extension education across the entire country, with a special focus on the state of Bihar.

Vision

Advancing professional competency to pursue excellence in agriculture and allied fields through education, research, and entrepreneurship, guided by ethical values. This mission aims to meet regional, national, and global needs while providing specialized services to farmers for achieving a decent livelihood, building resilience, and reducing pressure on agricultural land through higher productivity.

Mission

Promote a high-quality

learning environment and foster an integrated approach that cultivates an appreciation and understanding of the environmental and socio-economic significance of the soil-plant-animal-people interface.

Empower agricultural stakeholders to adopt self-sustaining modes of operation through innovative education, cutting-edge research, entrepreneurship/start-up skill development, and the dissemination of appropriate agricultural technologies.

Address national and global needs for sustainable food production and safety by mitigating pressure on agricultural land through advanced research and development interventions.

To streamline academic processes, RPCAU has implemented the Integrated University Management System (IUMS) and e-Office, significantly enhancing academic management efficiency.

Academic Programs and Students Welfare Activities

Excellence in education is reflected in the academic structure of the university, comprising eight colleges: Tirhut College of Agriculture, PG College of Agriculture, College of Agricultural Engineering and Technology, College of Community Science, College of Basic Sciences and Humanities, College of Fisheries, Pt. Deen Dayal Upadhyay College of Horticulture and Forestry, and the School of Agri-Business and Rural Management.

The university offers undergraduate (UG) programs in 10 disciplines, including Agriculture, Horticulture, Agricultural Engineering, Community Science, Fisheries, Biotechnology, Food Technology, Forestry, Natural Farming, and Food Nutrition and Dietetics. Additionally, it provides Master's programs in 28 subjects and PhD programs in 16 subjects.

To streamline academic processes, RPCAU has implemented the Integrated University Management System (IUMS) and e-Office, significantly enhancing academic management efficiency. The university not only produces qualified and technically competent human resources but also introduces innovative programs to nurture inherent talent and foster the holistic development of students, creating responsible citizens for society and the nation. Initiatives such as *Diksharambh* (a foundation course), programs to enhance the happiness index of students and faculty, and career counseling for students are integral to this mission.

These efforts have resulted in outstanding student's performance at both national and international levels, as

evidenced by student selections for higher studies at prestigious institutions such as IISc, IISERs, IITs, IARI, CIFA, and achieving top ranks in national entrance examinations like GATE and AIEEA.

Recent milestones include launching certificate and postgraduate diploma programs for school dropouts to graduates, aimed at generating skilled human resources at the base and supervisory levels for industry and society. Other significant achievements include the revival of the Placement Unit, the upgrading and automation of library facilities, and the training of more than 1.3 lakh members of the farming community, reflecting the university's dynamic progress.

Educational Programs

RPCAU comprises eight colleges located across Pusa, Dholi, and Piprakothi, offering 67 academic programs, including 10 undergraduate, 28 postgraduate, 16 PhD, 3 postgraduate diploma, and 10 certificate courses. The university has an intake capacity of 1,080 students, with a current enrollment of 2,000 students and a high retention rate of 92%. Its diverse community includes students from 27 states and faculty from 17 states, fostering a rich and inclusive academic environment.

Research Achievements

With two research institutes, four regional research stations, and eight centers of excellence, RPCAU has made significant contributions to agricultural research. Key achievements include the development of 23 crop varieties, 28 innovative technologies, 12 patents, and 1 Geographical Indication (GI) tag.

The university has undertaken 185 research projects, with 107 ongoing and 78 successfully completed, demonstrating its commitment to addressing critical agricultural challenges. RPCAU's research output includes 1,458 publications and five policy papers, which have significantly influenced agricultural policy and practices. This robust research productivity underscores the university's role as a leader in agricultural innovation and development.

RPCAU Extension and Outreach Services

RPCAU's extension services, delivered through its 16 Krishi Vigyan Kendras (KVKs), have directly benefited approximately 50,000 farmers through nine *Kisan Melas* and various training programs. Additionally, over 3 lakh farmers, rural youth, and extension workers have gained from the diverse activities of the KVKs. The university has conducted 1,916 frontline demonstrations, 23,267 farmer activities, and 160 technology trials while establishing 80 Extension Knowledge Kiosks and 64 virtual e-*Kisan Choupals*, significantly enhancing outreach and knowledge dissemination.

Awards and Recognitions

The university has received multiple prestigious accolades:

- Ranked 7th in IIRF 2024, 29th in NIRF 2024, and 9th among the top important government universities in the *India Today-MDRA Survey 2024*.
- Its Sukhet Model was prominently featured in the *Mann Ki Baat* program, earning national recognition.
- Awarded a 5G Lab at RPCAU, Pusa, by the Prime Minister in 2023.
- Established a DGCA-approved Drone Pilot Training Center, which provides licenses to aspiring drone pilots, further advancing digital technology and modern agricultural education.
- RPCAU's commitment to

excellence has also been recognized through the following awards:

- The 'University of the Year Award' from FICCI in 2021.
- Green Campus Excellence and Green University Awards for the Asia-Pacific region in 2020.
- Prestigious awards for its KVKs, including the *Pandit Deendayal Upadhyay Krishi Vigyan Protshahan Puraskar* in 2020 and the *Jagjivan Ram Abhinav Kisan Puraskar*.

These achievements reflect RPCAU's significant contributions to agricultural education, research, and extension services.

Students Achievements

Students have excelled in various fields, earning medals at the All-India ICAR Sports Meet 2022–23, securing AIR-1 in GATE, and achieving 3rd place in Asia's largest business conclave at IIT Mumbai. The university's E-Cell recently secured 2nd place in the All-India E-Summit Contest, held as part of the National Entrepreneurship Challenge at IIT Mumbai from 2-4 February 2024. Additionally, students from the Agri-Business and Rural Management program achieved 100% placement for both the 2022–23 and 2023–24 academic years.

New Initiatives and Flagship Programme

RPCAU, Pusa has launched two important flagship programs: Climate Resilient Agriculture, covering 13 districts of Bihar, and Natural Farming, which includes introducing a UG program and developing packages and practices in Natural Farming. The university has taken a leading role in implementing the National Education Policy (NEP) 2020 and adopting the recommendations of the 6th Dean's Committee. Additionally, the university is actively working towards achieving the target of *Vikshit Bharat@2047* through various programs and strategies.

Students from the Agri-Business and Rural Management program achieved 100% placement for both the 2022–23 and 2023–24 academic years.

University Headquarter

Colleges under the University

Vice Chancellor
Dr Rajendra Prasad Central Agricultural University
Pusa, Samastipur
Email: vc@rpcau.ac.in

Annual Conference of ICAR Directors, Vice Chancellors and Industries

A two-day Annual Conference of Vice-Chancellors of Agricultural Universities and Directors of ICAR Institutes was organized at the Bharat Ratna Dr C Subramaniam Auditorium, NASC Complex, New Delhi, on 26-27 February 2024. The main focus of the conference was enhancing the quality of higher agricultural education in the country. Several issues related to the mutual benefits of Agricultural Universities and ICAR were discussed, along with a roadmap for the successful implementation of the National Education Policy (NEP) 2020 in Agricultural Universities.

In his inaugural address, Dr Himanshu Pathak, Secretary, DARE & Director General, ICAR, emphasized the importance of the annual conference for discussing common agenda items of ICAR and Agricultural Universities and how all stakeholders can work together for research, education, and

A two-day Annual Conference of Vice-Chancellors of Agricultural Universities and Directors of ICAR Institutes was organized at the Bharat Ratna Dr C Subramaniam Auditorium, NASC Complex, New Delhi, on 26-27 February 2024.

the extension of technologies. Speaking about the Prime Minister's vision to transform the country into a developed nation, Dr Pathak said that unless India's agriculture sector is transformed into a developed one, the country cannot be transformed into a developed nation. He further added that agriculture has made significant progress in recent years, particularly in the production of agricultural and horticultural crops, due to the substantial contribution of the National Agricultural Research and Education System (NARES).

Dr Sanjay Kumar, Chairman of ASRB, presented insights into the genesis of ASRB, its evolution over the years, and the streamlined recruitment process for research management positions, as well as for scientific, administrative, and technical staff in the ICAR system. Shri Sanjay Garg, Additional Secretary, DARE & Secretary, ICAR, emphasized focusing on employee-friendly,

research-based administration to reduce time and costs, and how efficiently ICT tools could be used to address administrative issues. He further stressed using the e-HRMS portal to minimize the time taken for administrative processes. Smt. Alka Arora, Additional Secretary & Financial Advisor (DARE/ICAR), apprised the attendees about budget allotments to DARE, ICAR, KVKs, AICRPs, international organizations, fellowships, etc., and emphasized the need to generate budgets using external resources and to use the budget more effectively and efficiently.

Dr Satyendra Arya, CEO of the Agriculture Skill Council of India, highlighted the integration of quality vocational education, training, and skilling into higher education, with emphasis on practical hands-on training, skilling, and employability skills. Dr Manoj K Trivedi, Chartered Accountant (T & B), spoke about CSR funding opportunities. He further added that health care, environment, education, livelihood

promotion, rural development, women empowerment, and skill development are the CSR priority areas for funding. Dr N S Kalsi, Chairperson of the National Council for Vocational Education and Training, MSDE, discussed the National Credit Framework for implementing the mandate and intent of NEP-2020. He emphasized the need for mechanization, automation, and smart agriculture using the latest ICT tools. Dr R C Agrawal, DDG (Agricultural Education), highlighted the importance of initiating diploma courses in Agricultural Universities. Presentations were also made by other DDGs and ADGs on important topics. Several publications on agriculture, as well as products and technologies developed by ICAR institutes, were also released by the dignitaries on the occasion.

A Breakout Session for Vice-Chancellors of CAUs, SAUs, and Deemed Universities was held under the chairmanship of Dr Himanshu Pathak, Secretary, DARE & DG, ICAR. A number of issues related to agricultural education were discussed, including: implementing NEP-2020 in NARES, the Deans' Committee report, vocational/ polytechnic diploma courses in agriculture, agriculture in school education as per NEP-2020, IT initiatives in agricultural education, issues related to private agricultural universities/colleges, and the inclusion of agriculture courses under the Prime Minister's Special Scholarship Scheme for the UTs of Jammu and Kashmir and Ladakh. An open session on sharing experiences for good governance by Vice-Chancellors and Directors was also organized.

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Development of Nano Sensor and its application through Cloud-Based Network for real time irrigation to soil and plant

A process technology was developed for coating of outer surface using PANI (Polyaniline) nano particles and other chemical concentration to modify soil moisture sensors to give maximum range and sensitivity. A set-up was developed for surface modification of MP 406 soil moisture sensor using nano particles of PANI material. A prototype "MEGH" (Measuring Essential Good Hydration) was developed for field deployment and estimation of the moisture from soil in a non-contact manner. The device calculates the relative humidity of the soil which is in equilibrium with the soil moisture. The device also acquires the temperature, humidity of the air and the soil moisture and stores the data in a library. The self-developed, IoT-enabled software uploads all data to cloud for future big-data analysis and thus make them available for prompt intervention. If required the proposed device MEGH is preloaded with an indigenously developed Arduino-based Interface for data acquisition and analysis. The acquired data were analysed by an intuitive algorithm which converts the spectroscopic information into the relative humidity based on the calibration equation fed to the software. The software is entirely developed in Arduino platform for automated data acquisition and output result generation.

Source: ICAR Annual Report 2023-24, p.156

NEXT ISSUE THEME **INNOVATIONS IN SOIL SCIENCE**

LIST OF AGRICULTURAL UNIVERSITIES IN INDIA

S.N.	State Agricultural Universities	University Link
1	Acharya NG Ranga Agricultural University, Guntur, AP	https://angrau.ac.in
2	Dr YSR Horticultural University, Venkataramannagudem, AP	https://drysrhu.ap.gov.in
3	Sri Venkateswara Veterinary University, Tirupati, AP	http://svvu.edu.in
4	Assam Agricultural University, Jorhat, Assam	http://www.aau.ac.in
5	Bihar Agricultural University, Sabour, Bhagalpur, Bihar	https://bausabour.ac.in
6	Bihar Animal Sciences University, Patna, Bihar	https://basu.org.in
7	Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh	https://igkv.ac.in
8	DAU Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Anjora, Durg, Chhattisgarh	https://cgkv.ac.in
9	Sardar Krushinagar Dantiwada Agricultural University, Dantiwada, Gujarat	http://sdau.edu.in
10	Anand Agricultural University, Anand, Gujarat	http://www.aau.in
11	Navsari Agricultural University, Navsari, Gujarat	https://nau.in
12	Junagarh Agricultural University, Junagarh, Gujarat	http://www.jau.in
13	Kamdhenu University, Amreli, Gujarat	https://www.kamdhenuuni.edu.in
14	Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana	http://hau.ac.in
15	Lala Lajpat Rai University of Veterinary & Animal Sciences, Hisar, Haryana	http://www.luvas.edu.in
16	Maharana Pratap University of Horticulture, Anjanthali, Karnal, Haryana	http://www.mhu.ac.in
17	Ch. Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur, Himachal Pradesh	http://www.hillagric.ac.in
18	Dr. Yaswant Singh Parmar University of Horticulture & Forestry, Solan, Himachal Pradesh	http://www.yspuniversity.ac.in
19	Birsa Agricultural University, Ranchi, Jharkhand	http://www.bauranchi.org
20	Sher-e-Kashmir University of Agricultural Sciences & Technology, Srinagar, Jammu & Kashmir	http://www.skuastkashmir.ac.in
21	Sher-e-Kashmir University of Agricultural Sciences & Technology, Jammu, Jammu & Kashmir	http://www.skuast.org
22	University of Agricultural Sciences, Bangalore, Karnataka	http://www.uasbangalore.edu.in
23	Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka	http://kvafsu.edu.in
24	University of Agricultural Sciences, Raichur, Karnataka	http://www.uasraichur.edu.in
25	University of Agricultural Sciences, Dharwad, Karnataka	http://www.uasd.edu.in
26	University of Horticulture Science, Bagalkot, Karnataka	http://www.uhsbagalkot.edu.in
27	Keladi Shivappa Nayaka University of Agriculture & Horticulture Sciences, Shivamogga, Karnataka	http://uahs.edu.in
28	Kerala Agricultural University, Thrissur, Kerala	http://www.kau.in
29	Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala	http://www.kufos.ac.in
30	Kerala Veterinary and Animal Sciences University, Pookode, Wayanand, Kerala	http://www.kvasu.ac.in
31	Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior, Madhya Pradesh	http://www.rvskvv.net
32	Nanaji Deshmukh Pashu Chikitsa Vishwavidyalaya, Jabalpur, Madhya Pradesh	http://www.ndvsu.org
33	Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh	http://www.jnkvv.org
34	Dr. Balasaheb Sawant Kokan Krishi Vidyapeeth, Dapoli, Maharashtra	http://www.dbskkv.org
35	Maharashtra Animal & Fisheries Sciences University, Nagpur, Maharashtra	http://www.mafsu.in
36	Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra	http://www.vnmkv.ac.in
37	Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra	http://mpkv.ac.in
38	Dr. Punjabrao Deshmukh Krishi Vishwa Vidyapeeth, Akola, Maharashtra	https://www.pdkv.ac.in

S.N.	State Agricultural Universities	University Link
39	Orissa University of Agricultural & Technology, Bhubaneswar, Orissa	http://www.ouat.ac.in
40	Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab	http://www.gadvasu.in
41	Punjab Agricultural University, Ludhiana, Punjab	http://web.pau.edu
42	Maharana Pratap University of Agriculture & Technology, Udaipur, Rajasthan	https://www.mpuat.ac.in
43	Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan	http:// www.raubikaner.org
44	Rajasthan University of Veterinary & Animal Sciences, Bikaner, Rajasthan	http://rajuvas.org
45	Sri Karan Narendra Agriculture University, Jobner, Rajasthan	http://www.sknau.ac.in
46	Agriculture University, Kota, Rajasthan	http://aukota.org
47	Agriculture University, Jodhpur, Rajasthan	http://aujodhpur.ac.in
48	Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu	http://www.tnau.ac.in
49	Tamil Nadu Veterinary & Animal Sciences University, Chennai, Tamil Nadu	http://www.tanuvas.ac.in
50	Tamil Nadu Dr J Jayalalithaa Fisheries University, Nagapattinam, Tamil Nadu	http://www.tnjfu.ac.in
51	Sri Konda Laxman Telangana State Horticultural University, Hyderabad, Telangana	http://skltshu.ac.in
52	Sri PV Narsimha Rao Telangana Veterinary University, Hyderabad, Telangana	http://tsvu.nic.in
53	Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana	http://www.pjtsau.ac.in
54	Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand	http://www.gbpuat.ac.in
55	VCSG Uttarakhand University of Horticulture & Forestry, Bharsar, Uttarakhand	http://www.uuhf.ac.in
56	Chandra Shekhar Azad University of Agricultural & Technology, Kanpur, Uttar Pradesh	http://csauk.ac.in
57	Acharya Narendra Deva University of Agriculture & Technology, Faizabad, Uttar Pradesh	http://www.nduat.org
58	Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh	http://www.svbpmeerut.ac.in
59	U.P. Pt. Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidhyalaya Evem Go Anusandhan Sansthan, Mathura, Uttar Pradesh	http://www.upvetuniv.edu.in
60	Banda University of Agricultural and Technology, Banda, Uttar Pradesh	http://buat.edu.in
61	Bidhan Chandra Krishi Vishwavidhyalaya, Mohanpur, West Bengal	http://www.bckv.edu.in
62	West Bengal University of Animal & Fishery Sciences, Kolkata, West Bengal	http://wbuafscl.ac.in
63	Uttar Banga Krishi Vishwavidhyalaya, Cooch Behar, West Bengal	http://www.ubkv.ac.in
	Central Agricultural Universities	
64	Central Agricultural University, Imphal, Manipur	http://www.cau.ac.in
65	Rani Laxami Bai Central Agricultural University, Jhansi, Uttar Pradesh	https://collegedunia.com
66	Dr. R P Central Agricultural University, Pusa, Samastipur, Bihar	https://www.rpcau.ac.in
	Deemed Universities	
67	Indian Agricultural Research Institute, New Delhi	https://www.iari.res.in
68	Central Institute of Fisheries Education, Mumbai, Maharashtra	http://www.cife.edu.in
69	Indian Veterinary Research Institute, Bareilly, Uttar Pradesh	http://www.ivri.nic.in
70	National Dairy Research Institute, Karnal, Haryana	http://www.ndri.res.in
	Central Universities with Agricultural Faculty	
71	Aligarh Muslim University, Aligarh, Uttar Pradesh	https://www.amu.ac.in
72	Nagaland University, Medziphema, Nagaland	http://nagalanduniversity.ac.in
73	Banaras Hindu University, Varanasi, Uttar Pradesh	http://www.bhu.ac.in
74	Visva Bharti (Pali Siksha Bhavana) P.O. Santiniketan, Bolpur, West Bengal	http://www.visvabharati.ac.in

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