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Farm Mechanization
THE NEW PARADIGM

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TOWARDS FARM MECHANIZATION..

Farm Mechanization will take a few more years to become an integral part of Indian agriculture. Currently the extent of mechanization hovers around 45-50% and most of it is focused in the initial stages or the harvest stages. There are varied and multiple reasons to this staggered and differential adoption of mechanization.

India is dominated by small and marginal land holdings, with farm areas less than 2 hectares. The small size severely restricts the scope of use of farm machines. Considering the economic potential of the farmers farming these small parcels of land, owning and operating farm machineries is a long shot. However, there are models that can help circumvent these limitations. Custom hiring has been widely accepted in many states, where an individual or a group of farmers can hire the machinery for rent and perform the necessary operations. This has come as a first-hand experience for farmers, who were struggling with labour shortages during peak agricultural operations.

The non-availability of labour and increased labour charges were decisive factors in pushing farmers towards mechanization. Also, the farm mechanization industry in India had also taken note of the conditions of Indian farms and are also designing machineries that suit our conditions. Migration of men to urban areas are creating women farmers. Having more women in field requires more machineries that can be used with ease by women farmers. So is the arrangement to get them trained for this challenge. We need more women friendly farm machines and training opportunities.

But most of all, the new farm machines and agro equipment should be environment friendly and cognizant of the fact to reduce emissions. Although currently India has no guidelines in place to make them so, in near future they will be set in motion. Electric tractors have already debuted on Indian soil. The industry can think about hybrid models, biofuels, CNGs and novel and efficient options.

India is yet to fully embrace farm mechanization. This can be considered an opportunity to experiment and bring out innovation in this field. India can become a leader in farms operating on farm machines that are women friendly, sustainable and economically feasible.



Anjana

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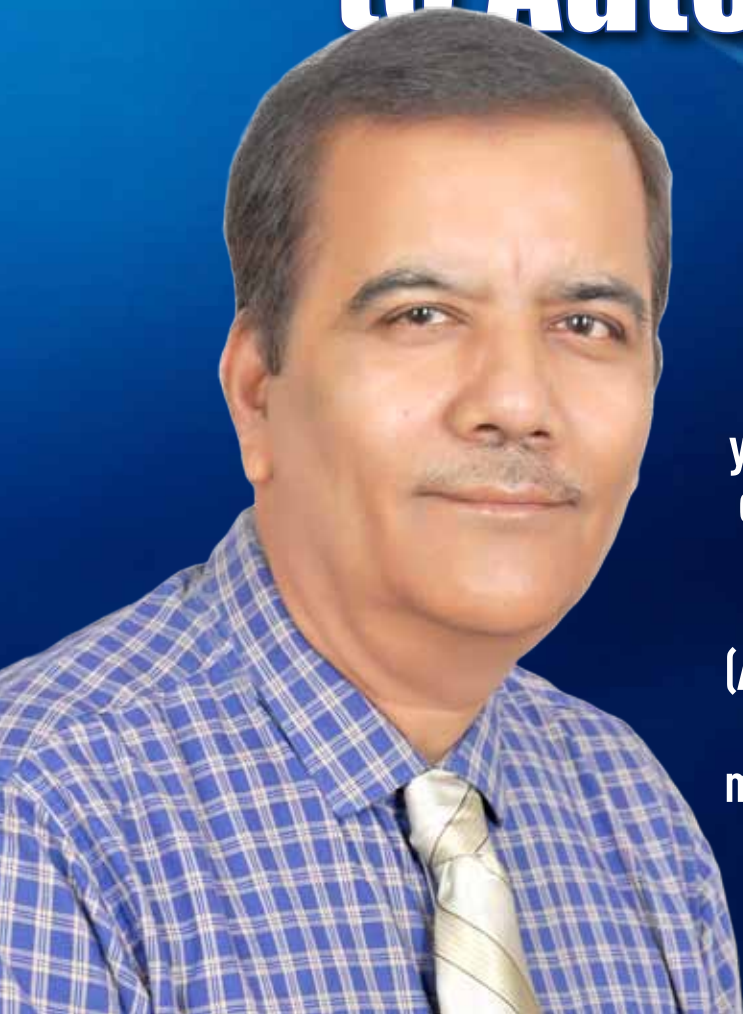
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IN CONVERSATION



From Mechanization to Automation



Mechanization in agriculture is undergoing tremendous transformation globally. India too is at the cusp of this transformation. However, the country faces multiple challenges and hence is yet to fully absorb the advancements and development in the field. In an interview with *Agriculture Today*, Dr SN Jha, Deputy Director General (Agriculture Engineering), ICAR discusses in detail the general scenario of farm mechanization in India and the challenges faced by the sector.

Mechanization has undergone a tremendous transformation worldwide. How has India lived up to it?

Yes, you are right. In India too, we now consider mechanization of agriculture as our compulsion. But the developed countries are going for full automation from field to fork. Still I feel that mechanization, here is not considered as priority. Most of the focus is on production and productivity. Presently, Indian agriculture is only 47 % mechanized, which needs to go to the level of 75 % by 2047. Power consumption per hectare in India is only about 2.54 kW, which need to go 7.5 kW per hectare by 2047. In addition, we also have to increase mechanization in post-harvest operations, processing and value addition of produces, which needs much attention than presently it is given. Agri-based rural industry using concept of the secondary agriculture needs prioritization to increase the income of farmers, salary-based income of rural youth and for grooming new entrepreneurs at their own localities. After all India is net surplus in farm machinery including tractor. We are the biggest exporter of tractors in the world.

What are the new trends in agri mechanization in India?

As said earlier, agriculture world-wide is going towards automation, use of artificial intelligence and robotics. Indian agriculture is however giving emphasis on digital agriculture and use of drones. Under digital agriculture, mostly engagements are for App development for broadcasting information to stakeholders/farmers. Those information in most cases are used for human based decision making, and then manual application. Accuracies of those information may need to be verified. A few universities and institutes are in the process of developing autonomous agricultural vehicles, robots for specific jobs, handheld devices for *in-situ* application and variable rate input applicators. In irrigation drainage, soil conservation, post-harvest



Mechanization in harvesting, transport, storage not only reduces post-harvest losses significantly, but also reduces time in those operations, and saves produce from inclement climate.

automation work is also in the process of development. The difference between developed countries and India is that, the developed countries are in the position of deployment of automation/robotics and sensor based technologies, while India is still in the initial stage of development phase for those technologies.

Climate change is another important challenge added to agriculture. How well is the agri mechanization sector coping with it?

Yes, you are right, climate change has

become a real threat now. In addition, other threats, which are not evident is the decreasing percentage of agricultural labourers. Our farmers are ageing. Majority of them in India are aged above 40. In 2016, the average age of an Indian farmer was 50.1 years, and the next generations of these farmers is not much interested in taking up this profession. The percentage of agricultural workers to total workers therefore declined from 59.0% in 1991 to 45.7 % in 2023, and is likely to be about 30 % by 2047, in which about 45 % were women in 2023, and the same is likely to be about 65 % by 2047. Indian climate change mitigation is mostly focused on development of climate resilient varieties, whereas engineering has not only solutions for adverse effect of harsh climate in production side, but also in post-harvest operations. storage, transportations, and self-life enhancement. Mechanization, which is an essential part of precision agriculture, saves 15 – 20 % seeds and fertilizers, 20-30 % time, increases germination by 7 - 25 %, reduces weeds 20-40 % and labour 20-30 %, enhances cropping intensity by 5-20 % and yield by 13 -23 %.

Mechanization in harvesting, transport, storage not only reduces post-harvest losses significantly, but also reduces time in those operations, and saves produce from inclement climate.



Imagine, if there were no wheat threshers and irrigation pumps during green revolution, and no combine harvesters during COVID-19 pandemic. These machines actually made green revolution success and saved grains by timely harvesting and filling Godowns when there were no labourers available during the pandemic in 2020. The most recent mechanized solution was for preventing crop residue/stubble burning in Northern parts of India. These examples show that mechanization is a sure shot solution to mitigate all challenges faced by agriculture, and also for reducing environmental pollution. Further, development of crop based SoPs for agricultural drones, robots, autonomous vehicle, promotion of automated greenhouse cultivation may save Indian Agriculture from climate change significantly.

What are the new guidelines to be adhered by the agri mechanization sector for reduced emissions?

As such I do not see much problem of CO₂ emission due to agricultural mechanization. But yes, trucks/cold van used for agricultural transportation should adhere to the latest Government emission norms. I however personally like to encourage kisan trains and similar transport system. Kisan Train is already operational for perishable products, but is very limited. Tractors and other vehicle as of now is not a threat from emission points of views. Research organizations, keeping future in view, are working on hydrogen energy from biomass, uses of renewable energy for various farm operations such as irrigation, storage, drying etc. and electric operated tractors, which will help in reducing carbon emission further in near future. Other greenhouse emission reduction at farm is also reported using zero-till-drill, and direct sowing rice machine.

What are the challenges of the farm mechanization sector?

Though farm mechanization is becoming compulsion, the biggest challenge for this sector is to get priority place



Farm mechanization is skill oriented work and a specialized discipline.

in the Indian Agriculture. There is a need of farm mechanization and post-harvest loss reduction policies in the country. Unavailability of proper qualified trainers for training farmers on farm machinery at their door step, improper agencies/staff at local level for implementing government schemes, small and fragmented land holding resulting in limitation of ownership of farm machinery, economy of scale to take up new mechanization technology to the farm, poor quality of non-tractor farm machinery being manufactured in cottage/small scale unorganized sector, lack of proper maintenance, repair and service centres at village level, mis-utilization of available farm powers, lack of proper manpower and specialized departments for monitoring and implementation of agricultural engineering oriented schemes and projects at centre and states level are some of the important limitations being faced by the sector.

What are your suggestions to improve the adoption of agri mechanization?

Farm mechanization is skill oriented work and a specialized discipline. We need several steps to take at state, centre and manufacturer levels. Some of them may be as below:

- Starting an independent scheme at Centre and state levels exclusively for mechanization including on-farm postharvest operations.
- Setting-up departments of Agricultural Engineering comprising, on-farm mechanization including on-farm post-harvest processing, value addition, farm irrigation and drainage (including micro-irrigation) at state and Centre levels.
- Deployment of Agricultural Engineers/diploma holders compulsorily at least one in each village, panchayat, block and districts level, besides one at each KVK to make link with field engineers/technicians for new technologies/machines
- Establishment of common repairs, maintenance and service centers at village level
- Starting of B. Tech. and diploma in Agricultural Engineering in all SAUs and IITs/NITs to have trained graduates to fulfil the vacancies.
- Establishment of at least one Farm Machinery and Post-harvest machinery testing centre in each state/district level.
- Incentive-linked scheme for localized manufacturing of quality machinery and equipment
- Organizing awareness programme on the benefit of proper utilization of proper machinery/equipment

AGRO EQUIPMENT

TRANSFORMING AGRICULTURE

Agriculture is the backbone of many economies, especially in developing countries. The productivity and income of farmers are critical to their livelihoods and to the overall economic health of these nations. One of the most significant ways to boost agricultural productivity and farmer incomes is through the adoption of modern agro equipments.

Efficiency and Speed

The introduction of modern agro equipment dramatically increases the efficiency and speed of agricultural operations. Traditional farming methods are often labor-intensive and

A man with a mustache and glasses, wearing a dark blue suit, white shirt, and a striped tie, is sitting at a desk. He is looking towards the camera. In front of him is a laptop. The desk is reflective. There are some papers and a folder on the desk to the right.

About the **AUTHOR**

Sanjay Kapoor,
CEO,
Lemken India



time-consuming, limiting the amount of land that can be cultivated and the variety of crops that can be grown. Modern machinery such as Tractors, Ploughs, Seed drills, and Combine harvesters streamline processes like ploughing, planting, and harvesting. This mechanization allows farmers to manage larger areas of land more effectively and to cultivate multiple crops in a single season, thereby increasing overall productivity.

For instance, a tractor with hydraulic reversible MB plough can plough several acres of land in a fraction of the time it would take a team of workers to do the same job manually. This efficiency not only saves time but also reduces the physical burden on farmers, allowing them to focus on other critical aspects of farm management.

Labour Savings

The automation of labour-intensive tasks through agro equipment also plays a crucial role in improving productivity and farmer's income. In many agricultural regions, labour shortages are a significant challenge. Modern machinery can mitigate these shortages by performing tasks that would otherwise require substantial human labor.

For instance, LEMKEN cultivator, such as Achat 70 models, are designed to perform secondary tillage operations,

including weed control and soil conditioning. These cultivators are highly effective in preparing a fine seedbed and managing crop residues. It performs three operations with a single equipment be it loosening of Soil, mixing and crumbling of soil.

By improving soil structure and controlling weeds, LEMKEN cultivators create an ideal environment for crop growth. This results in higher crop productivity and reduces the need for manual labor and herbicides, lowering overall production costs and increasing farmer incomes.

Sustainability

Sustainable farming practices are becoming increasingly important in the

face of environmental challenges such as climate change and soil degradation.

Modern agro equipment can contribute to sustainability by promoting practices that preserve natural resources and reduce environmental impact.

LEMKEN is committed to promote sustainable farming practices through its equipment. Their products are designed to minimize soil erosion, reduce water consumption, and decrease the environmental impact of farming.

For instance, LEMKEN's conservation tillage equipment reduces soil disturbance, preserving soil structure and moisture. Efficient irrigation systems, such as those integrated with LEMKEN machinery, conserve water and ensure optimal use. By adopting these sustainable practices, farmers can maintain long-term soil health and productivity, ensuring continued income generation.

By adopting sustainable practices, farmers can maintain the long-term health of their land, ensuring continued productivity and income generation for future generations.

Modern agro equipment can contribute to sustainability by promoting practices that preserve natural resources and reduce environmental impact.

Cost Savings and Long-term Investment

While the initial investment in agro

Policies that support the adoption of agro equipment through subsidies, loans, and grants can accelerate its uptake



equipment can be significant, the long-term cost savings are substantial. Reduced labor costs, lower input waste, and higher yields contribute to better profitability for farmers. Additionally, high-quality equipment has a long lifespan, providing ongoing value and reducing the need for frequent replacements.

For example, a well-maintained plough can serve a farmer for many

years, handling various tasks from plowing to hauling. The cost savings achieved through reduced labor and efficient resource use can quickly offset the initial purchase price of the equipment, leading to increased overall profitability. LEMKEN's durable and reliable equipment ensures consistent performance, reducing downtime and maintenance costs. The efficiency gained through mechanization and precision farming leads to higher yields and lower input costs, increasing overall profitability for farmers.

Government and Institutional Support

Policies that support the adoption of agro equipment through subsidies, loans, and grants can accelerate its uptake. Partnerships between governments, private sector, and agricultural institutions can

facilitate knowledge transfer and infrastructure development.

For example, government subsidies for purchasing agro equipment can make it more affordable for small-scale farmers. Agricultural extension services can provide training and technical assistance, helping farmers integrate new technologies into their operations. Collaborative efforts can also drive innovation and the development of locally appropriate solutions.

Training and Support

Alongside the provision of equipment, training farmers in the use and maintenance of modern machinery is also very crucial. Continuous support and access to spare parts and service centers ensure that equipment remains functional and effective over time.

LEMKEN provides comprehensive training and support to farmers, ensuring they can effectively use and maintain their equipment. This support includes user manuals, on-site training sessions, and access to technical assistance.

Proper training enables farmers to maximize the benefits of equipment's, ensuring optimal performance and longevity. Continuous support and access to spare parts and service centers minimize downtime, maintaining high productivity levels and income.

In conclusion, modern agro equipment holds immense potential to transform agriculture by enhancing productivity and increasing farmer incomes. Through increased efficiency, precision farming, labor savings, crop health monitoring, sustainable practices, cost reduction, improved market access, risk mitigation, training and support, and government and institutional backing, agro equipment can address many of the challenges faced by farmers today. Embracing these technologies is not only a pathway to higher productivity and profitability but also a means to ensure the long-term sustainability and resilience of the agricultural sector.



FARM MECHANIZATION IN INDIA

ADVANCEMENTS, CHALLENGES AND INSIGHTS

Farm mechanization today has a very broad meaning. This broad meaning includes production, distribution, and utilization of a variety of tools, machinery, and equipment for the development of agricultural land, planting, harvesting, and primary processing. Evidence suggests that mechanization has a major impact on the demand and supply of farm labour, agricultural profitability, and a change in the rural landscape. Mechanization trends vary globally and depend on several factors such as land sizes, availability of workforce in agriculture, availability of machines, government policies, and extension services. In many countries, agricultural mechanization is still in a

developing state, while others have advanced.

Mechanization in India

India's diverse agricultural landscape and large farming population have rapidly embraced both machinery and technology. Farmers across the country, regardless of the size of their landholdings, are utilizing these advancements to revolutionize their farming practices. This shift has been crucial in reducing labour-intensive tasks, boosting efficiency, and promoting sustainability. One of the most significant advancements in farm mechanization is the tractorisation.

In the 2022-23 annual report of the Indian Council of Agricultural Research (ICAR), there has been significant tractor-operated based diverse applications. Some of them are (1) Tractor-operated side trencher and FYM applicator for grape orchards, (2) Tractor-operated

raised-bed former-cum-planter for multiplier onions, (3) Unmanned rice transplanter, and many more. These led to an average saving in labour, time, and cost of operation by 98%, 80%, and 88% respectively, compared to the manual method. Secondly, drones have also made a significant impact, being used for crop monitoring, pest surveillance, and spraying pesticides and fertilizers. The Government of India has promoted the adoption of this technology through its *Kisan Drones* initiative, which has greatly reduced the need for manual labor while improving efficiency.

Additionally, the development of crop-specific machinery, particularly for crops like cotton and sugarcane, has made a major impact. These machines are designed to handle the specific requirements of different crops, leading to better efficiency and reduced wastage. Boom sprayers mounted on tractors, which are used to evenly distribute agrochemicals, have become especially popular in small farms across India.

Challenges

Despite these advancements, several challenges persist in the widespread adoption of farm mechanization. According to a 2022 report, 47% of agricultural operations in India are mechanized, which is lower compared to developing counterparts like China, with 60%, and Brazil, with 75% farm mechanization. One major issue is the high initial cost

In countries like India, where small landholdings dominate, the cost of high-tech equipment can be prohibitive without government subsidies or access to affordable financing.



About the AUTHOR

Rajat Vardhan
Founder & CEO, AgroNxt (ScaNxt Scientific Technologies Pvt Ltd)

of machinery. Smallholder farmers, who represent a significant portion of the global farming community, often struggle to afford modern machinery. In countries like India, where small landholdings dominate, the cost of high-tech equipment can be prohibitive without government subsidies or access to affordable financing.

Additionally, lack of awareness and technical know-how can be a barrier. While technologies like drones and automated machinery offer incredible benefits, farmers in remote or underserved areas may not be aware of these advancements or lack the training to operate them effectively. Another challenge lies in the diverse agro-climatic conditions in different regions, which necessitates the development of machinery that is adaptable to various environments. While tailored solutions are emerging, more research and innovation are needed to ensure that mechanization is viable across a wide range of conditions.

Collaboration between Public and Private Sector

The collaboration between the public and private sectors has been instrumental in driving farm mechanization. The Indian government has introduced policies to promote mechanization through subsidies, testing facilities, and the development of infrastructure to support the agricultural sector. For instance, various trade events bring together global leaders in agricultural machinery, providing a platform to showcase innovations and foster partnerships.

The private sector, on the other hand, is leading the charge in developing cutting-edge technologies that meet the evolving needs of farmers. Companies are investing heavily in research and development, producing machinery that not only increases productivity but also promotes sustainable farming practices. Through collaborations with governments and academic institutions, private companies are ensuring that farmers have access to the latest innovations in farm mechanization.

The Indian government has played a pivotal role in fostering farm mechanization through various initiatives and subsidies. One of the key programs is the Sub-Mission on Agricultural Mechanization (SMAM), which was launched in 2014. This scheme aims to make farm machinery more accessible to small and marginal farmers, minimize post-harvest losses, and improve overall productivity. Under SMAM, financial assistance is provided to farmers for purchasing farm equipment, while custom hiring centres (CHCs) have been established to make machinery available on a rental basis.

The use of battery-powered machinery like sprayers, weeders, and harvesters can bring down the long-term fuel costs, making mechanization more affordable, especially for smallholder farmers.

Way Forward

Looking ahead, India has immense potential for innovation in battery-operated mechanization, which holds the potential to reduce the recurring costs of operations. The use of battery-powered machinery like sprayers, weeders, and harvesters can bring down the long-term fuel costs, making mechanization more affordable, especially for smallholder farmers. Countries like China and Taiwan, which have similar small landholdings, have already introduced battery-operated equipment extensively. These machines not only cut down fuel dependency but also reduce emissions, making them a more sustainable choice. India has a strong opportunity to follow this path, adopting battery-operated tools to further promote cost-efficient, eco-friendly agricultural practices.

Secondly, India has immense global export potential in the mechanization sector, particularly in supplying farm equipment to regions like Africa and Southeast Asia, which have similar agricultural setups. Indian agricultural machinery could become a major export product, especially in the battery-

operated mechanization segment, as these countries face similar challenges regarding small landholdings and limited mechanization. This export potential presents an opportunity for India to position itself as a key player in the global mechanization market.

The future of farm mechanization in India will likely be dominated by further advances in automation, robotics, and AI. Automated tractors, robotic harvesters, and AI-powered systems for monitoring and managing crops are already beginning to make their mark. These technologies promise to further reduce labour costs, increase efficiency, and provide real-time data for decision-making. Additionally, developing machinery adaptable to specific regional conditions will be crucial in ensuring that all farmers, regardless of location or crop type, can benefit. Integration of sustainability-focused technologies, such as water-efficient irrigation systems and renewable energy-powered machinery, will also play a key role in promoting environmentally friendly farming practices.

India's vision for Atmanirbhar Bharat and Viksit Bharat for becoming a global production hub for agricultural machinery depends heavily on affordable R&D and innovations that support the mechanization of Indian farms. By investing in innovative mechanization and advancing research in cost-effective solutions, India can not only address its own agricultural challenges but also lead the way for other developing nations. Farm mechanization will continue to shape the future of agriculture in India and beyond, driving productivity, reducing labor dependency, and promoting sustainability.



Future of Farming

HOW ELECTRIC TRACTORS AND AUTONOMOUS TECHNOLOGY ARE CHANGING THE GAME

The agriculture industry is entering a period of rapid technological change, driven by increasing pressures to improve efficiency and sustainability. Innovation is becoming essential as farmers face challenges like labour shortages, rising production costs, and the need for environmentally responsible practices. Electric tractors and autonomous technology are two game-changing developments leading this transformation.

As electric vehicles become more popular in the automotive sector, the farming industry is beginning to see the value in transitioning to electric tractors.

The Need for Sustainable Farming Solutions

Sustainability has become a central focus in agriculture as concerns grow about the industry's environmental impact. Farming practices contribute significantly to greenhouse gas emissions, soil degradation, and water scarcity.

At the same time, global food demand is expected to rise with population growth, requiring farms to become more productive without further harming the environment.

Electric tractors and autonomous technology offer potential solutions to these challenges. They promise not only to reduce emissions but also to improve operational efficiency and address workforce shortages. These technologies can help farmers adopt more eco-friendly practices while maintaining or even increasing their output.

Electric Tractors: A Shift Toward Green Technology

Diesel-powered tractors have been the backbone of farming for decades, but they contribute to air pollution and climate change. As electric vehicles become more popular in the automotive sector, the farming industry is beginning to see the value in transitioning to electric tractors.

Environmental Advantages

One of the most significant benefits of electric tractors is their ability to operate without producing emissions. This means that farms using these machines can cut their carbon footprint substantially. Electric tractors also produce less noise, making them more suitable for farms near residential areas or in regions with noise regulations. Moreover, when powered by renewable energy sources like solar or wind, the environmental benefits are amplified, making electric tractors a key component of sustainable farming.

Increased Efficiency and Reduced Costs

Electric tractors offer a range of operational benefits beyond their environmental advantages. They provide instant torque, which translates into better performance during tasks such as plough-

Autonomous tractors can operate around the clock, performing tasks such as ploughing, planting, and spraying without the need for human operators.

ing and hauling. Additionally, electric motors are simpler than internal combustion engines, requiring less maintenance. With fewer parts to wear out or break down, farmers can save time and money on repairs and upkeep. Over the lifetime of the equipment, these savings can offset the higher upfront cost of electric tractors compared to traditional diesel models.

Adoption and Current Challenges

While electric tractors are still in the early stages of market adoption, several manufacturers are making strides in developing and introducing these machines. Companies like John Deere, AutoNxt, Fendt, and Monarch are leading the charge, creating models that are viable alternatives to diesel-powered tractors. However, there are hurdles to overcome, the most prominent being battery life. Current battery technology lacks the capacity to support long hours of operation, which can be a limitation for farmers who

need to run their tractors continuously during planting or harvesting seasons. Although Fast Charging options can solve this challenge.

The cost of electric tractors is another challenge. While prices are expected to drop as technology advances and production scales up, the initial investment can be prohibitive for smaller farms. Despite these barriers, the shift toward electric tractors is inevitable, particularly as governments and consumers demand more sustainable farming practices.

Autonomous Technology: Automating the Future of Farming

Automation is already reshaping industries around the world, and agriculture is no exception. Autonomous tractors, drones, and robots are becoming more common on farms, of-



About the AUTHOR

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Automation

fering new ways to increase productivity, reduce labor dependency, and improve precision in crop management.

Solving Labour Shortages

Farming is highly dependent on seasonal labor, and many farms struggle to find enough workers during peak periods like planting and harvesting. Autonomous technology can help fill this gap. Autonomous tractors can operate around the clock, performing tasks such as ploughing, planting, and spraying without the need for human operators. This not only solves the labor shortage problem but also increases farm efficiency by allowing continuous operation, even during nights or weekends.

Enhancing Precision Farming

Precision farming is the practice of using detailed data and advanced technology to manage crops and resources more effectively. Autonomous machines play a critical role in this approach. Drones equipped with sensors can monitor fields, collecting data on soil health, moisture levels, and plant growth. This data allows farmers to make informed decisions about where to apply water, fertilizers, or pesticides, optimizing resource use and reducing waste.

Autonomous tractors and robotic systems can also execute these tasks with pinpoint accuracy. For example, automated planters can place seeds at optimal depths and spacings, improving crop yields. Similarly, autonomous sprayers can target specific areas with precision, reducing the amount of chemicals used and minimizing their impact on the environment.

The Role of AI in Farming

Artificial intelligence (AI) is becoming an integral part of autonomous farming technology. AI systems can analyze data from various sources, such as drones, weather reports, and soil sensors, to provide real-time insights and recommendations for farm management. For instance, AI can predict the best time to plant or harvest crops based on weather



patterns and soil conditions. This allows farmers to maximize their yield and reduce the risk of crop loss due to adverse conditions. AI-powered systems can also help detect diseases or pests early, enabling farmers to take action before problems become widespread. By leveraging machine learning algorithms, these systems can become more accurate over time, continuously improving their ability to assist farmers.

Challenges of Autonomous Farming

Despite its potential, the widespread adoption of autonomous technology in farming faces several challenges. The cost of autonomous equipment is a significant barrier, particularly for small and mid-sized farms. The initial investment in these machines, along with the infrastructure required to support them, can be daunting.

Data privacy and cybersecurity are other concerns. Autonomous machines rely on internet connectivity, making them vulnerable to hacking or data breaches. As farms become more dependent on technology, protecting this data will become increasingly important.

Regulatory frameworks also need to catch up with the rapid development of autonomous farming technology. Governments will need to establish clear guidelines on the use of autonomous vehicles and robots in agriculture, particularly when it comes to safety and liability issues.

The future of farming will likely see

electric and autonomous technologies working together to create more efficient, sustainable operations. For instance, electric autonomous tractors could eliminate both emissions and the need for human intervention. These machines could operate independently, powered by renewable energy sources, further reducing the environmental impact of farming.

In this scenario, electric autonomous tractors could recharge themselves using solar power during downtime, ensuring continuous operation without human oversight. This combination of technologies has the potential to revolutionize farming, making it more sustainable and resilient in the face of environmental and economic challenges.

A New Era for Agriculture

The future of farming is poised for a dramatic transformation, with electric tractors and autonomous technology leading the way. These innovations promise to make agriculture more sustainable, efficient, and productive, while also addressing labor shortages and environmental concerns.

As these technologies continue to evolve, they will likely become more accessible and affordable, allowing farms of all sizes to benefit from the improvements they offer. In the coming years, we can expect to see a farming industry that is not only more environmentally responsible but also more capable of meeting the growing demand for food in a rapidly changing world.



2ND WORLD AGRICULTURE PRIZE AWARDED

TO MAHARASHTRA CHIEF MINISTER, EKNATH SHINDE

The World Agriculture Forum Board and its newly constituted Global Council announced the 2nd World Agriculture Prize. Maharashtra has made tremendous development in the field of sustainable agriculture development efforts and Chief Minister Eknath Shinde had played a pivotal role in the same. The event was organized on the occasion of World Bamboo Day. Chairman of Maharashtra Agricultural Value Commission Pasha Patel, President of 'World Agriculture Forum' Dr. Rudi Rabinge, Asia Region Vice President of the Forum. Prof. Williams Dar, Vice President of Africa Province. Dr. Lindway Simbada, Vice President of America Region. Kenneth Queen, Forum India Director and Indian Chamber of Food Agriculture (ICFA) President Dr MJ Khan, Maharashtra Pollution Control Board Chairman Siddesh Kadam, Environment and Climate

Change Department Principal Secretary Praveen Darade were present.

Speaking on the occasion, Chief Minister Shri. Shinde said that, he is dedicating the World Agriculture Prize given by the World Agriculture Forum to the hard working farmers of Maharashtra, assuring that efforts are being taken for making Maharashtra number one state in the entire nation in the agriculture sector. He reiterated that it is the need of the hour to maintain balance between environmental protection and agriculture in this era of Climate Change and global warming

William Dar, Vice President of World Agriculture Forum, gave information about the nature of the award and the selection process. M.J. Khan, National Director of the World Council of Agriculture, expressed his thanks.



DRONE-AS-A-SERVICE (DaaS)

As agriculture in India embraces new technologies, the growing adoption of drone technology has the potential to revolutionize farming practices nationwide. Agriculture drones offer contactless solutions for routine tasks such as spraying, spreading, and seeding, which is a game changer for the industry. But imagine adding a layer of convenience to using drones – **DaaS or Drone As a Service** removes the need for upfront payments for pilot training and drone acquisition and maintenance.

Drone As a Service

DaaS enables farmers to book a drone service slot to have their crops sprayed with pesticides, utilizing advanced agriculture drones. This service costs approximately Rs. 500 per acre, providing an affordable, efficient, and safe alternative to

traditional pesticide spraying methods. Instead of investing in expensive drone technology, which can cost up to Rs. 6.5 lakh, farmers can now access state-of-the-art solutions without the financial burden of ownership, thanks to DaaS.

Drone manufacturing companies are making significant strides in promoting Drone as a Service by collaborating with central and state governments, as well as farmer cooperatives. From providing access to drones and support services for farmers, Drone as a service is not



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only enhancing productivity but also unleashing a new wave of entrepreneurship in rural India. The focus on Daas is at the grassroots level of the drone ecosystem within the agriculture fraternity.

Generating Employment

Traditional forms of agriculture need an upgrade, and precision agriculture is the answer. Agriculture drones equipped with advanced sensors, can monitor crop health, assess soil conditions, and optimise irrigation patterns. With the provision of remote pilot certificate and agriculture spray courses for rural youth, the time is right to empower a new generation of 'dronepreneurs' who could harness the potential of drones.

The central government rolled out 'Namo Drone Didi' scheme, which was aimed at empowering women members of self-help groups (SHGs) by equipping them with drones at a subsidised rate. The plan entailed a subsidy of 80 percent of the drone cost or a maximum of Rs 8 lakh to women SHGs to purchase drones for commercial purposes and also included training women as pilots so that they could provide drone rental services to farmers for spraying pesticides or fertiliser. The scheme has not just empowered women socially but also financially, women drone pilots are running their venture of offering drones as a service for agricultural purposes and charging a fee per acre for spraying pesticides and fertiliser.

Addressing Labor Shortage

One of the key reasons for the rising demand of Drone as a Service in the Indian agriculture is to tackle the pressing issue of labor shortages in agri-centric states heavily reliant on migrant workers, such as Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, Telangana, Gujarat, Maharashtra, and Delhi-NCR.

Manual spraying is not only labor-intensive but also poses significant health risks to farm laborers due to direct exposure to harmful chemicals, which can lead to serious health conditions like cancer. While large scale farmers



Farmers who haven't secured a DGCA-certified license can steer clear of the financial, operational, and safety risks linked to drone operations, data capture, and analysis by opting for Drone-as-a-Service (DaaS). DaaS providers bring the necessary knowledge and experience to operate drones safely and efficiently across various conditions. Additionally, companies offering DaaS also provide technological expertise, ensuring farmers optimize drone usage and achieve the best possible outcomes.

DGCA-certified drone training is mandatory to ensure that operators are fully equipped to fly these drones, and thus generate demand for drone services through DaaS.

can manage to hire labors for pesticide spraying, it's the small-scale farmers who suffer the brunt of labor shortage. DaaS offers a safe, efficient alternative to manual spraying, addressing both the labor shortage and health risks. Drones like AG365 can cover 30 acres per day, compared to just 5 acres per day with manual spraying. Additionally, drone operators can earn up to Rs. 15,000 per day, far surpassing the Rs. 2,500 that manual sprayers typically earn.

Building an Ecosystem

Its key to understand that Indian drone companies need to build a robust ecosystem that fosters the growth of drone technology in India. DGCA-certified drone training is mandatory to ensure that operators are fully equipped to fly these drones, and thus generate demand for drone services through DaaS.

By sharing this demand with drone buyers, rural entrepreneurship can be created— especially by generating employment for unemployed youth who purchase the drones and provide services to local farmers.

This ecosystem approach ensures that the benefits of drone technology are accessible to more farmers and service providers across the country. Indian agriculture is also taking a technological leap, building dedicated platforms like DaaS apps for individual service providers, institutional service providers, and pilots can enable farmers in the near future to hire drones for pesticide spraying as easily as they book a cab through apps like Ola and Uber. Drone as a Service (DaaS) offers a cost-effective solution for farmers by eliminating the need for a significant upfront investment in drone technology. For a fee as low as Rs 300 per acre, farmers can access advanced drone services without purchasing the equipment themselves. This affordability makes it easier for farmers to adopt innovative practices that can greatly enhance crop productivity.

While Drone as a Service is enhancing crop productivity, it is also promoting sustainability and environmental stewardship. With the potential to transform farming practices and improve the livelihoods of rural entrepreneurs, DaaS is not just a service—it's a catalyst for change in India's agricultural landscape.



The cost of agricultural drone spraying can range from ₹8000 to ₹12000, depending on the model and specifications

ROI OF THE DRONE-BASED SPRAYING PROGRAM

The integration of drone technology in agriculture, particularly for spraying pesticides and fertilizers, has transformed farming practices. While the benefits of drone spraying are evident—such as increased efficiency, reduced labour costs, and improved crop health—farmers must also assess the return on investment (ROI) to ensure that this technology is financially viable. Measuring ROI involves evaluating both the costs and the benefits associated with drone spraying programs.

Understanding the Costs Involved

To accurately measure ROI, it is essential to first identify and quantify the costs associated with implementing a drone spraying program. These costs can be categorized into several key areas:

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Initial Investment Costs

The cost of agricultural drone spraying can range from \$8000 to \$12000, depending on the model and specifications. Higher-end drones may offer advanced features such as longer flight times and larger payload capacities. In addition to the drone itself, there is a need for specialized software that will help in flight planning and data analysis, as well as sensors for crop monitoring.

Operational Costs

Regular maintenance of drones is necessary to ensure optimal performance. This includes battery replacements, software updates, and repairs due to wear and tear. Training personnel to operate drones effectively is crucial. This may involve hiring experts or enrolling staff in training programs, which can incur additional expenses. While drone spraying reduces the need for manual labour, some labour costs may still be involved in operating the drones and monitoring their performance.

Evaluating the Benefits

Drones can cover large areas quickly—typically between 20 to 50 acres per day—compared to traditional methods. This efficiency translates into time savings, allowing farmers to respond rapidly to pest infestations or crop health issues. Drones apply pesticides and fertilizers more precisely, minimizing waste and reducing the overall amount of chemicals used. This not only lowers costs but also aligns with sustainable farming practices. Improved spraying techniques lead to better crop health and potentially higher yields. Drones can ensure even coverage, especially in hard-to-reach areas, which can significantly enhance productivity. The automation of spraying tasks reduces the need for manual labour, resulting in lower labour costs over time. Fewer workers are required for spraying, enabling farmers to allocate resources more efficiently. By reducing chemical runoff and soil compaction, drone spraying contributes to more sus-



Drones can cover large areas quickly—typically between 20 to 50 acres per day—compared to traditional methods

tainable agricultural practices.

Calculating ROI

$$\text{ROI} = \left(\frac{\text{Net Profit}}{\text{Total Investment}} \right) \times 100$$

In this scenario, the farmer would have a negative ROI for the first year. However, as the initial investment is amortized over subsequent years, the ROI may improve significantly in the following years as operational costs decrease and ben-

efits increase.

Long-Term Considerations

When measuring the ROI of a drone-based spraying program, it is crucial to consider long-term impacts. The initial costs may be high, but over time, the cumulative benefits can lead to a positive ROI.

Take Away

Measuring the ROI of a drone-based spraying program involves a comprehensive analysis of both costs and benefits. By understanding the financial implications and potential returns, farmers can make informed decisions about adopting drone technology in their agricultural practices. As the agricultural landscape continues to evolve, the integration of drones may not only enhance productivity but also contribute to more sustainable farming practices, ultimately leading to a more profitable future.

DRONE AS A SERVICE (DaaS): REVOLUTIONIZING INDIAN AGRICULTURE

India's agricultural landscape, dominated by traditional farming methods, is in dire need of innovation to tackle challenges like climate change, shrinking arable land, and a growing population. Drone as a Service (DaaS) is emerging as a transformative solution, offering enhanced productivity, cost reductions, and sustainable practices.

The Emergence of DaaS in Indian Agriculture

Drones, initially used for military and recreational purposes, are now making significant inroads into agriculture. DaaS provides farmers and agribusinesses with access to drone technology without the need for ownership. This is especially beneficial in India, where smallholder farmers, who manage 44% of cultivated land and contribute to 60% of food grain production, often lack the financial means to invest in expensive technology.

The DaaS model typically involves service providers offering aerial imaging, crop health monitoring, precision spraying, and data analytics on a pay-per-use or subscription basis. This democratizes access to advanced technology, enabling even small-scale farmers to benefit without significant capital investment.

Addressing the Skill Gap and Ease of Renting

One major factor driving the popularity of renting drone services in Indian agriculture is the lack of skilled manpower. Operating agricultural drones requires specialized training, which many farmers do not possess. DaaS bridges this gap by providing trained professionals who can operate drones and interpret

DaaS offers a cost-effective alternative by allowing farmers to rent drones as needed, reducing the financial burden and enabling access to cutting-edge technology.

the collected data, allowing farmers to leverage this expertise without extensive training.

While the cost of purchasing and operating drones can be prohibitive, several financing options are available, such as the Sub-Mission on Agricultural Mechanization (SMAM) scheme, which offers financial assistance and subsidies of 40-50% for drone purchases. Additionally, drone companies have established a network of drone hubs that provide village-level services, training, and sales support, making it easier for small farmers to access these technologies without buying a drone.

Challenges of Small Landholdings and High Asset Costs

Farm mechanization plays a crucial role in sustainable agricultural development,

but India's mechanization level lags behind industrialized economies. In India, about 84% of farms are under 1 hectare, making the individual ownership of agricultural machinery uneconomical and operationally unviable. Custom Hiring Centers of Agricultural Machineries, operated by cooperative societies, self-help groups, and private entrepreneurs, provide a viable alternative by offering easy access to technology and equipment.

Similarly, the high costs associated with owning a drone—including mainte-

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nance, repairs, and upgrades—pose a challenge. DaaS offers a cost-effective alternative by allowing farmers to rent drones as needed, reducing the financial burden and enabling access to cutting-edge technology.

The Rapid Pace of Drone Technology Innovation

Drone technology is evolving rapidly, with new models and features being introduced frequently. While these advancements improve efficiency and capabilities, they also present a challenge for farmers who own drones, as they may need costly upgrades or replacements to stay current. DaaS mitigates this issue by providing farmers with access to the latest technology without requiring them to invest in new equipment. Service providers regularly update their fleets, ensuring that farmers always have access to the most advanced drones, reducing their financial risk, and keeping them competitive.

Overcoming the Complexities of Acquiring Drones

While government subsidies are available to help farmers purchase drones, the process can be lengthy and cumbersome. The bureaucratic procedures involved can lead to significant delays, with farmers sometimes receiving their drones after the growing season has ended. Renting drone services through DaaS eliminates these delays, providing farmers with immediate access to the technology they need. This flexibility is crucial in agriculture, where timing is essential for maximizing productivity and yields.

Legal Ownership and After-Sales Service

Owning a drone comes with challenges, particularly in the event of malfunctions or damage. Drones require regular maintenance and repairs, and the after-sales service sector is still developing. Farmers may struggle to access reliable support, and the responsibility for re-



Drone as a Service (DaaS) provides a transformative opportunity to establish a large-scale, widely accessible network in Indian agriculture.

pairs falls on the owner, leading to additional costs and time. DaaS alleviates these concerns by shifting the responsibility for maintenance and repairs to the service provider, reducing the burden on farmers and allowing them to focus on farming.

Moreover, as the drone sector continues to evolve, many startups are working to establish a robust after-sales and support network. Currently, most drone Original Equipment Manufacturers (OEMs) have a centralized manufacturing base with limited regional support, but this is expected to improve as the industry matures.

Opportunity for Accessible

Network:

Drone as a Service (DaaS) provides a transformative opportunity to establish a large-scale, widely accessible network in Indian agriculture. By leveraging DaaS, farmers, agribusinesses, and government agencies can access a unified platform that connects various stakeholders across vast geographical areas. Additionally, the widespread availability of drones through this service model reduces the cost barrier, allowing smaller farms to harness the power of drones for crop health assessment, field mapping, and yield optimization, thereby revolutionizing agricultural practices nationwide.

Drone as a Service is revolutionizing Indian agriculture by offering a practical, cost-effective, and flexible solution to many challenges faced by farmers. By addressing issues such as the lack of skilled manpower, the high cost of ownership, the rapid pace of technological innovation, and the complexities of legal ownership, DaaS is making advanced drone technology accessible to farmers across India. This innovation has the potential to transform the agricultural landscape, ensuring sustainability and productivity in the face of future challenges.

TECHNOLOGY AND TRADITION: BLENDING DRONES WITH CONVENTIONAL FARMING METHODS

Imagine standing in a vast, open field, with the sun caressing back as we admire the crops that served our family's sustenance for generations. We comprehend this land well—how the soil smells after the first rain and the subtle variations in colour that signify a crop's health. Now, let's think about introducing another dimension to this experience: the buzz of a



With the support of government programs like the Production-Linked Incentive (PLI), India hopes to overtake all other countries in the world's drone production by 2030.

drone flying overhead, its camera capturing intricate images of our fields from high above. Within a few seconds, we have data at our fingertips that can indicate which region require additional irrigation, where pests are congregating and how our crops are legitimately flourishing.

In agriculture, drones are far more than flying cameras; they have grown to be increasingly vital tools for farmers to oversee large swaths of land effectively and responsibly. From offering a bird's view of crop health to providing precise information, the advantages of drone technology over conven-

tional farming methods are profound.

Evolution of Traditional Farming: Indian Context

According to the India Brand Equity Foundation (IBEF), 55 per cent of the country's population relies on agriculture for their livelihood. Moreover, India has grown to become one of the greatest players in the global agriculture industry. Presently, the Indian agriculture industry is undergoing a paradigm change, stepping into a period of technological advancement wherein the sky is becoming the new ground. At the forefront of this transformational wave is the introduction of drone technology, an indicator of development that represents the country's trajectory towards ascending to the possibilities of tomorrow.

With the support of government programs like the Production-Linked Incentive (PLI), India hopes to overtake all other countries in the world's drone production by 2030. Drones in agriculture can transform conventional farming practices by providing producers access to real-time updates on crop health, water management and soil texture. Recently, the Director General of Civil Aviation (DGCA) has approved the launch of India's first agriculture drone called "Agribot," the only legally compliant drone to be used in farming practices. Considering such a pivotal step and its

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benefits, Frost and Sullivan have projected that drone utilisation in India's agriculture business is expected to reach USD 121.43 million by 2030.

Benefits of Agricultural Drones

Here's a look at some of the promising perks of drones in agriculture:

Precision Agriculture

One of the primary advantages of agricultural drones is their capability to facilitate precision agriculture. These drones, outfitted with excellent-quality cameras, GPS and sensors, capture precise pictures of the farm. The collected information is then analysed to evaluate crop health, detect pests and evaluate soil conditions. Farmers can leverage this information to make more educated decisions about water, fertiliser and pesticides.

For example, a drone survey can detect particular zones of an agricultural field that require more irrigation or indicate areas with nutritional deficits. This tailored technique maximises the utilisation of resources while also reducing environmental impact.

Data-Focused Insights

Considering the possibility that unpredictable weather can cause damage to crops, timely data collection is imperative. Agriculture drones deliver real-time information on weather patterns and possible crop risks, making them an effective choice. This, in turn, helps farmers take preventive measures to mitigate the impact of adverse weather on agricultural output. They can also effectively manage their cultivation and harvesting schedules. Furthermore, producers who comprehend their crops' growth phases



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can maximise the timing of these operations, resulting in enhanced agricultural yields and revenues.

Cost Savings

The deployment of drones in agriculture causes a change in cost-cutting tactics. From precise material application and irrigation to improved decision-making and time efficiency, drones effectively enhance economic efficiency in agriculture. As technology progresses, the economic benefits of drones are likely to grow, providing farmers with long-term, financially viable answers to the challenges they face in the modern agricultural landscape.

Sustainable Farming

Agriculture drones not only boost productivity and efficiency but also encourage sustainable farming methods. They allow for more accurate input application, which decreases the adverse



environmental impact of farming activities. With reduced water, fertiliser and pesticide usage, agriculture's ecological footprint is substantially decreased. Additionally, drones also assist in monitoring deforestation, illicit logging, and land degradation. They have become key conservation tools since they give an aerial view of large regions, preserving biodiversity and natural resources.

Combating Locust Swarm

Locust swarms are reported for devouring crops, trees and other vegetation. This feeding process can damage crops, resulting in deprivation and challenges in cultures that rely primarily on these foods for existence. These swarms have recently invaded numerous parts of India, particularly Rajasthan. Consequently, some states have used drones to carry out the spraying efficiently. This is because drones can spread insecticides across 2.5 acres in 15 minutes. In this way, they have proven to be an effective, secure and practical way to combat locust swarms.

Wrapping Up

The Indian agriculture landscape is evolving tremendously with the emergence of drone technology, revolutionising numerous facets of farming. Ranging from crop monitoring to aerial photography, agricultural drones have covered it all. This blend of innovation and tradition is more than just a technological invention. It is a way to advance agricultural practices while preserving the region's rich cultural past. Embracing these developments can redefine our approach to agriculture, making it more informed, effective and sustainable for future generations.



PROGRESSIVE TRANSFORMATION OF AGRICULTURE INFRASTRUCTURE LANDSCAPE IN INDIA

The recent approval of the progressive expansion of Agriculture Infrastructure Fund (AIF) by cabinet chaired by Hon'ble Prime Minister reaffirms the commitment of the Government of India to strengthen the agriculture infrastructure in our country, much needed for enhancing farm productivity and reducing costs and ultimately contribute to the overall economic growth of the agricultural sector.

Agriculture Infrastructure Fund (AIF)

Launched in July 2020 under Aatmanirbhar Bharat package, the flagship scheme of Agriculture Infrastructure Fund (AIF) aims to develop agriculture infrastructure at farm-gate level for reducing post-harvest losses of farm produce and to promote the use of modern technologies in Indian agriculture. AIF is a medium - long term debt financing facility for investment in viable projects for post-harvest management infrastructure and community farming assets through interest subvention and credit guarantee support. The Fund of Rs. 1 lakh crore under the scheme will be disbursed from FY 2020-21 to FY 2025-26 and the support under the scheme will be provided for the duration of FY2020-21 to FY2032-33. Under the scheme, Rs. 1 Lakh Crore will be provided by banks and financial institutions as loans with interest

Notably, 54% of the approved projects are associated with farmers, cooperatives, farmer producer organizations, and self-help groups, highlighting strong farmer participation in building farm-level infrastructure.



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subvention of 3% per annum and credit guarantee coverage under CGTMSE for loans up to Rs. 2 Crores for period of 7 years including moratorium period of upto 2 years. Further, each entity is eligible to get the benefit of the scheme for up to 25 projects located in different LGD codes.

Since its launch, Agriculture Infrastructure Fund (AIF) has played a crucial role in transforming the agricultural and rural landscape by catalysing private investments in key sectors, effectively addressing existing deficiencies in infrastructure, particularly in conventional storage capacity. Post-harvest losses of agricultural produce are a significant issue globally and in India, necessitating the development of infrastructure across various components of the value chain, such as storage (both dry and cold) and transportation.

AIF in Numbers

As on date, the sanctioned amount under the scheme has exceeded Rs. 48,400 crores. The scheme has mobilised more than Rs 80,000 crore of investments in the Agri sector. Notably, 54% of the approved projects are associated with farmers, cooperatives, farmer producer organizations, and self-help groups, highlighting strong farmer participation in building farm-level infrastructure. The remaining projects, led by agri-entrepreneurs and start-ups, are bringing essential agricultural infrastruc-

ture closer to the farming community, enhancing farmers' access to these resources.

As of now, 74,695 agriculture infrastructure-related projects have been approved under the scheme across the length and breadth of the country, including 18,508 custom hiring centers, 16,238 primary processing centers, 13,702 warehouses, 3,095 sorting and grading units, 1,901 cold stores, and 21,251 other types of agricultural infrastructure like precision Agriculture projects, Solar pumps, Biogas plants, Bio-stimulant units etc. Besides infrastructure development, AIF has fostered entrepreneurship among youth and farmers, resulting in the establishment of approximately 50,000 new enterprises. This infrastructure and entrepreneurship development has collectively created over 830,000 job opportunities in the farm sector

AIF scheme is critical for developing necessary processing and cold storage infrastructure especially for horticulture crops. India has approximately 4.419 million metric tons of cold chain storage capacity, which is only 15.72% of the country's fruit and vegetable production. Completed projects under AIF have increased storage capacity in the sector by approximately 5 million metric tons, leading to the preservation of 1.86 million metric tons of food grains annually, resulting in savings of around Rs. 5,700 crores. Additionally, proper cold storage could reduce post-harvest losses of horticultural produce by 10%, preventing the loss of 350,000 metric tons of produce each year, which translates to savings of about Rs. 1,250 crores.

Expansion of AIF

In a significant move, the Government of India on 28.08.24 has approved the progressive expansion of the ambitious Agriculture Infrastructure Fund (AIF) scheme, making it even more impactful and inclusive. Currently, some technology driven projects such as hydroponic farming, mushroom cultivation, vertical farming, aeroponic farming, poly-houses and greenhouses are reserved for farmer



Entrepreneurship among youth and farmers, resulting in the establishment of approximately 50,000 new enterprises.

groups and collectives only. However with the expansion of its scope, these ventures can now be approved under AIF for individual farmers and entrepreneurs also.

Similarly, post-harvest management activities were previously limited to primary processing. Now, by expanding the scope, integrated processing projects which includes both primary and secondary processing are eligible under AIF, thereby increasing project viability and helping farmers achieve better price realization. This also helps in holistic post-harvest value chain development of Agri- Horti crops.

Additionally, Component A of the PM KUSUM scheme, which facilitates the establishment of solar power plants of up to 2 megawatts on barren, fallow, cultivable, pasture, or marshy land, has now been integrated with AIF scheme. This strategic convergence will empower both individual

farmers and groups, elevating their role from being food producers to energy providers (Annadaata to urjadaata), while also promoting the development of reliable clean energy infrastructure in rural areas.

A dedicated credit guarantee cover window through NABsanrakshan specifically for Farmer Producer Organizations (FPOs) under NABARD will remain open for AIF beneficiaries, where the guarantee fee will be eligible for reimbursement.

The progressive expansion of AIF will certainly enhance processing capabilities, diversify food production, and improve the quality of yields. They will extend shelf life, boost transportation capacity, and connect rural supply with urban demand. These changes are poised to generate much needed rural employment opportunities, reduce input costs, increase yields, and enhance efficiency in agriculture activities contributing to substantial rural development. By addressing the root causes of post-harvest losses, the Agriculture Infrastructure Fund (AIF) provides a sustainable solution that promises to progressively transform the agricultural infrastructure landscape and ensure a brighter future for Indian farmers. With improved infrastructure, the AIF is fostering a more resilient and prosperous agricultural economy.

PROJECT UNNATI APPLE

ENHANCING INDIA'S FRUIT PRODUCTION SUSTAINABLY

As the world's second-largest producer of fruits and vegetables, India yields over 300 million metric tons annually. The fruit circular economy is increasingly appealing to Indian farmers due to its promises of higher yields, better rates, and greater profitability through sustainable and organic practices. Initiatives like Project Unnati by Coca-Cola India Private Limited (CCIPL) align with the government's goal of developing high-yielding, climate-resilient, and biofortified crops. The project promotes advanced agricultural practices, helping farmers produce more, reduce costs, and boost earnings while enhancing overall sustainability and productivity.

Project Unnati

Launched in 2011 with a focus on mangoes, Project Unnati expanded by 2017 to include a variety of crops within the Fruit Circular Economy. It aims to uplift small-scale and marginal fruit growers by increasing productivity, improving marketing, and enhancing livelihoods. The program demonstrates the success of sustainable cultivation and circular methods, offering farmers training, resources, and access to markets and networks.

For over a decade now, Project Unnati, a national project, has helped fruit farmers across the country including Maharashtra, Madhya Pradesh, Tamil Nadu, Bihar, Uttarakhand, Himachal Pradesh and Jammu & Kashmir. Fo-

cused on several horticulture crops like mango, apple, orange, grapes, litchi, coffee, and sugarcane, the program has helped in building agriculture production capacities and propelling the horticulture supply chain across the country.

Project Unnati Apple – a Fructuous Journey

Under the same umbrella, Project Unnati Apple is a case in point. Targeting the apple-growing communities in India, its success sets an outstanding precedent for the effectiveness of the UHDP method of apple cultivation. This project has enabled competency development in research and knowledge around sustainable agriculture. It has also led to deeper community and partner interactions that



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Launched in 2011 with a focus on mangoes, Project Unnati expanded by 2017 to include a variety of crops within the Fruit Circular Economy.

facilitate open and honest dialogue with various agri-ecosystem participants.

Launched in 2018 and implemented in two phases so far, Project Unnati Apple focuses on apple cultivation in Uttarakhand, Himachal Pradesh, and Jammu & Kashmir, regions where apple production is largely prevalent. Despite the fact that these regions enjoy climates conducive to apple cultivation and land is available for greenfield development of orchards, the productivity has been low, forcing India to become a net importer of apples and apple juice concentrate.

Proof of Success Model

Partnering with select farmers, a demo farm is established to showcase the benefits of sustainable practices and build word-of-mouth credibility. Each demo farm is equipped with a single-point access and all necessary infrastructure to enhance productivity, demonstrating the success of these sustainable methods. High-yielding planting materials best suited to the Indian agro-climate are provided, and beneficiary farmers receive subsidies on infrastructure to make it

more affordable.

In the case of apples, five demo farms were created across various altitudes to evaluate the performance of different varieties in distinct climates. The varieties that excelled in these specific conditions were then promoted. Additionally, key agricultural institutes were involved as technical partners to ensure the selection of the most suitable varieties. By witnessing the success of these practices firsthand, farmers are more inclined to experiment with these new techniques on their own farms.

Advanced Agricultural Techniques

Global agricultural best practices were introduced with a focus on ultra-high-density plantation (UHDP). This approach has resulted in a 10-12 times increase in plant population per acre. We (CCIPL) worked with Indo Dutch Horticulture Technologies Pvt. Ltd. (IDHT) as an Implementation Partner for this project.

Under the UHDP cultivation method, the apple plant is supported with a trellis system to help it grow as a creeper. Hail nets are placed to protect the plants from being damaged in case of hailstones. The project provides farmers with access to cutting-edge technology, including high-density planting and advanced pruning methods. Drip irrigation is advocated to save water. These techniques help achieve a substantial increase in quality, productivity, and profitability per unit of land, directly elevating the incomes of the farming community.

Comprehensive Training Programmes

The training programs are crafted to bridge the gap between traditional farming knowledge and modern agricultural advancements. Farmers receive village-level training, comprehensive explanations, and hands-on support throughout their apple cultivation journey, including personalized one-on-one interactions for maximum impact. In addition to these training programs, field supervisors regularly visit farmers' fields to identify gaps



and issues, offering practical advice and corrective measures as needed.

Enhanced Market Linkages

Many Indian farmers struggle to access profitable markets, but Project Unnati Apple addresses this issue by creating strong market linkages that connect farmers directly with buyers. By eliminating intermediaries, the project ensures that farmers receive better prices for their produce. Direct market access not only boosts farmers' income but also fosters transparency and promotes fair trade opportunities.

A Sustainable Approach to Irrigation

The project introduced several initiatives that focus on using water efficiently. By encouraging practices such as rainwater harvesting, micro-irrigation, and water conservation, the project ensures a sustainable water supply for agricultural activities. This sustainable approach of-

fers a strong foundation for long-term productivity and maintaining the environmental balance.

Scaling Work

Project Unnati Apple is committed to inclusive development, evident in its focus on small-hold farmers and women farmers. Extending support to farmers with limited landholdings brings the benefits of advanced agricultural techniques to the grassroots. This inclusive approach promotes equity and social justice, fostering a more resilient and self-sufficient farming community.

High-Profile Partnerships

The success of Project Unnati Apple is enhanced through strategic partnerships with key implementation partners and other valuable contributors. These include technology providers, forward market linkages, and prestigious scientific agricultural institutes. Together, these collaborations offer essential resources, technical expertise, and innovative solutions, significantly amplifying the project's reach and impact.

We worked closely with the governments of Uttarakhand, Himachal Pradesh and local bodies in Jammu & Kashmir. Forming the Apple Federation and helping the government design the project proved instrumental. Additionally, a cooperative for apple farmers was formed to enhance community involvement and liaison for government-backed schemes.

Next Steps

The larger objective of Project Unnati Apple is to serve as a catalyst in India's efforts to become self-sufficient in apple production. Doing so would make apple cultivation a lucrative means of livelihood with a reduced payback period of around four years.

More than 10,000 hectares of virgin land is available in Uttarakhand that can be utilised for apple cultivation in the future. Spurred by our success so far, we aim to extend the reach and coverage of Project Unnati Apple even further.

BAYER FORWARD FARMING TAILORED SOLUTIONS FOR REGENERATIVE FARMING

Bayer recently launched its global initiative, 'Bayer ForwardFarming', in India, the newest of the 29 ForwardFarms worldwide. Each ForwardFarm serves as a beacon of sustainable agricultural practices, providing a platform for farmers, researchers, and stakeholders to collaborate and share knowledge. The Bayer ForwardFarm in India will demonstrate innovative farming techniques tailored to the needs of 150 million smallholder farmers in the country, with a particular focus on sustainable rice cultivation, thus promoting the transition towards regenerative agriculture. In an exclusive interaction with Agriculture Today, Ms. Natasha Santos, Head of Sustainability & Strategic Engagements at Bayer, elaborated on the vision of the movement and how it will be crucial to India. Excerpts from the interview.



What is the concept behind Bayer's Forward Farm? What is the vision behind this?

This is an initiative that we have thought about many years ago. It is based on the concept of 'Seeing is Believing'. If we cannot bring stakeholders to see for themselves how the practices are done and what are the results and what is the methodology, behind it, they would not believe it. We need to do it in the field. Secondly, we wanted something that would be driven by a real farmer. So, we are supporting the farmer to have the best outcome and to be most successful as possible with our technology and agronomic knowledge. We wanted to have a real farm in real conditions so that we could be credible to the farmer and to the stakeholders.

Our scale model for buyer-forward farming, is how we can connect with the farmers around the world. Bayer's initiative is active in many countries and the farmers talk to each other. Farmers mainly believe in farmers. So by building this network of knowledge exchange between farmers, we can enhance our offering, while they can really learn more and scale and adopt those practices to their activities. These are the three steps for us to invest, and that's why this is a global flagship.

How does it align with Bayer's sustainable agriculture goals?

For us now, we are meeting those activities with our regenerative agriculture framework and objectives. Our vision is to produce more restored nature and scale regenerative agriculture. It's how we see the future of farming.

We are trying to foster six main outcomes. Yields, profitability of farmers, water optimization, reductions of GHG emissions and climate adaptation as well. We are also striving for restoration and protection of biodiversity, and water optimization. So, those are the outcomes that under certain principles, with certain practices, we can integrate into the life of farmers. This will unlock potential of new revenues. So, the Bayer Forward farm under this network is a place where we can test those concepts with a real farm and a real farmer. So, if the farmer starts in a small plot here and he sees that it really works, and successful, they will scale this into their land holding and hopefully that will be a model for other farmers. This platform for us is so important because it helps us to test and showcase the solutions that we believe are right, and the farmers can decide.

Bayer has also collaborated with many tech companies in this initiative. Why are these partnerships important?

We are a company that produces seeds, traits, crop protection chemicals and biologicals. So, we don't have all the offerings. We don't have machinery. Customized mechanization is needed here for smallholder farmers.

Similarly, we are investing in certain areas of crop nutrition, but we don't have fertilizers to offer. So, for us to live upto our farmers' expectation, we want farmers to be successful and we want to look at them not only from a product point of view. Anywhere in the world, especially in India smallholder markets are so complex. We need to bring more offerings together with ours to really address all the pain points. We cannot talk about



soil health without addressing fertilizer usage. But then we need to bring that technology as well to the farmers so we can have a complete package.

A lot of startups that partner with us, bring specific sensors to help us scale the drones application. So, we are obsessed with partnerships, because otherwise we cannot make the farmers successful in the long-term.

India is a place where majority of the farmers are with small landholdings. What are the initiatives that Bayer has planned for them?

First of all, we are trying to be tailor-made and address the micro ecosystem of the farmers, even the smallholder farmers.

We are trying to support the government, which is trying to collectivize farmers through cooperatives like the FPOs, or some government incentives. We can give the farmers better access to certain technologies. In India, we are partnering with governments in certain regions, so we can address a bigger group of farm-

ers.

We don't have our own program in terms of collectivization. But we are partnering with local governments to be able to address, in terms of extension services and other opportunities, a larger pool of farmers, particularly farmers who are neighbours, especially with a transformation like DSR. We are committed to bring return of investment for the farmers. We need to address some basic needs, which are the technology and the knowledge that they need.

For example, with DSR, we need effective weed management tools, good crop nutrition plans, and mechanization. Otherwise, it's not going to be successful. It doesn't matter if I have all the best products in the world.

So, in the short term, we really need to address that, so farmers believe and can see that this is increasing their yields and eventually profitability. Parallely, we are trying to explore market linkage opportunities. Is there a different premium payment, a differentiation? But most importantly here we are partnering with governments, so we can develop several interventions like carbon credits, specific insurance, or develop specific risk management plans for farmers that can help them to change or adopt things that might be risky, particularly if you're a smallholder farmer. So, I believe the future is bright.

What makes India an exciting country to work with?

In India, the amount of innovation and innovative thinking is incredible. All those startups, the scale of India, millions of farmers. It's really exciting, particularly for a company like us, it's a global footprint. And we really believe that DSR is the future because of all the environmental elements that we mentioned.

So, we, I believe this will position agriculture in India differently as well for the new generations that have additional concerns. Sustainable practices and regenerative agriculture will be an anchor for farming in the country will play a crucial role to position India in a new way.

TOWARDS REGENERATIVE AGRICULTURE

Bayer has launched its global initiative, 'Bayer ForwardFarming', in India. This is the newest of 29 ForwardFarms worldwide that serves as a beacon of sustainable agricultural practices, providing a platform for farmers, researchers, and stakeholders to collaborate and share knowledge. The Bayer ForwardFarm in India will demonstrate innovative farming techniques tailored to the needs of 150~ million smallholder farmers in the country, with a particular focus on sustainable rice cultivation, thus promoting the transition towards regenerative agriculture.

For Bayer, regenerative agriculture is an outcome-based crop production model with improving soil health at its core. Strengthening resilience is a key objective, alongside mitigating climate change, maintaining or restoring biodiversity, conserving water, and increasing yields. Ultimately, the combination of regenerative practices aims to improve the economic and social well-being of farmers and their communities.

Bayer's DSR

The potential of regenerative agriculture in India is particularly high in rice cultivation given its role as the world's second largest producer of rice. The need to shape an economically viable and sustainable rice cultivation system has never been more pressing. Rice production is not only impacted by climate change but also contributes to it. Bayer's **Direct Seeded Rice (DSR)** system is the most comprehensive and tangible example of regenerative agriculture in action.



Launch of the ForwardFarming initiative in Panipat, Haryana



Simon Wiebusch, Malu Nachreiner and Natasha Santos inaugurate the Bayer ForwardFarm

DSR touches on almost every outcome of regenerative agriculture that Bayer is focusing on, including improving soil health, reducing water usage, and enhancing resilience to climate change.

Moving from transplanted puddled rice cultivation to DSR can help farmers to reduce water use by up to 30-40 per-

cent, greenhouse gas emissions (GHG) by up to 45 percent and reduce farmers' dependence on scarce and costly manual labor by up to 40-50 percent. For India alone this could add up to a potential reduction of GHG emission by up to 82 million mt CO² per year and water consumption by up to 167 billion m³ by



2040. The introduction of the DSR system is fully in line with Bayer's approach to regenerative agriculture which will enable farmers to produce more while restoring more.

Through Bayer's **DirectAcres flagship project**, Bayer is providing farmers with a tailored crop system that includes best-in-class seed, crop protection, digital tools, mechanization services, and agronomic solutions. These efforts are driven by public-private partnerships, ensuring that farmers can harvest a profitable rice crop with a regenerative focus.

Last year, 5,000 Indian farmers have successfully planted Direct Seeded Rice across 8,600 hectares through the DirectAcres program. Bayer would endeavor to support over 1 million smallholder farmers in India through its DirectAcres program by 2030. There are also plans to introduce DirectAcres in other rice growing countries in Asia, starting with the Philippines.

Tailored Solutions for Indian Agriculture

Ved Prakash Saini, the first Bayer ForwardFarm partner in India, expressed his optimism about the partnership: "I am hopeful that the regenerative agricultural practices introduced through Bayer ForwardFarming will lead to significant improvements in my yield and livelihood while making farming more sustainable. Techniques like Direct Seeded Rice and advanced technologies have the potential to enhance crop health, reduce

Spread over 18 hectares, the Bayer ForwardFarm in India is unique as it introduces a convergence of innovative technologies and sustainable interventions specifically designed for smallholder farmers.

water usage, and increase efficiency. I look forward to witnessing these benefits firsthand as we work together to build a resilient and prosperous future for farming."

Spread over 18 hectares, the Bayer ForwardFarm in India is unique as it introduces a convergence of innovative technologies and sustainable interventions specifically designed for smallholder farmers. The farm integrates the following practices:

- **Direct Seeded Rice (DSR) Cropping System:** A sustainable alternative to traditional rice cultivation that minimizes soil disturbance, reduces water consumption, and enhances soil health.
- **Innovative Weed Management:** Advanced weed control strategies that reduce reliance on chemical herbicides while maintaining crop health.

- **Customized Agronomy Systems:** Tailored solutions for diverse climatic conditions and soil types, enhancing crop yields and soil health.
- **Carbon Farming:** Practices aimed at capturing and storing carbon in the soil, contributing to climate change mitigation and soil fertility improvement.
- **Nutrition and Water Management:** Advanced techniques to optimize nutrient use and water efficiency, boosting farm productivity while reducing environmental impact.
- **Vermicompost and IoT:** Use of vermicompost to enhance soil health, coupled with IoT technologies for precise monitoring and management of agricultural processes.
- **Irrigation and Drone Technology:** Innovative irrigation techniques and drone technology for optimized water use and precise crop management.

Simon Wiebusch, President, Bayer South Asia mentioned, "At Bayer, we envision a regenerative farming future that restores and enhances the environment. The launch of Bayer ForwardFarming in India is a part of it. By providing farmers with tailored solutions, modern tools and practices, proactive stewardship measures, and strategic partnerships, we aim to boost productivity, improve quality and yields, all while preserving the environment. We are dedicated to empowering farmers to adopt sustainable practices that build a resilient and thriving agricultural sector in India."

RESILIENT CATALYSTS

Can Regenerative Agriculture Revolutionize Rice Farming for Smallholders in Asia?

Regenerative agriculture boosts food security and water conservation for Asia's smallholder farmers

Rice has been cultivated for millennia. Today, it sustains billions of people all over the world. But as the planet grapples with population growth, water scarcity, and climate change, the environmental cost of rice farming has become impossible to ignore.

Consuming 43% of the world's irrigation water and contributing 12% of global methane emissions, rice production stands at the intersection of food security and environmental challenges.

Rice is resource heavy, and continuing with current practices is no longer an option; the time for change is now and regenerative agricultural practices can drive the change.

The Reality of Farming: Livelihood Protection Vs Climate Change Mitigation

These global challenges are not just concepts and numbers; they are daily realities for smallholder farmers who depend on farming for their livelihoods and food for their families.

One such farmer is Shanti Lata Basiwal. As a smallholder rice farmer in the state of Odisha, India, her north star has always been to take care of the needs of her family. Letting go of her business in the town to manage a few acres inherited from her father, she labours to continue the legacy of this land but it is not without challenges.

She experienced firsthand the chal-

The adoption of DSR is not just about improving individual farming practices and reducing environmental impact. It's about addressing a larger global challenge—food security.

lenge of hiring sufficient labour to transplant rice from the nursery patch to the field—a crucial step in the crop's early phase. For every acre of land growing rice, farmers need no less than 10 laborers to carefully transfer rice seedlings, one at a time, into a flooded paddy.

Urban migration and an aging farming population are contributing to the labour shortage in rural India, which poses a significant problem for Shanti and the millions of farmers who engage in this time-sensitive activity.

Transplanting delays can stunt the growth of rice plants, resulting in reduced tillering and ultimately, lower grain yields. This, in turn, diminishes the income smallholder farmers rely on to sustain their families.

Aside from labour shortage, Shanti's dependence on water to flood the rice paddies puts her field at the mercy of the weather, with climate change increasing erratic rainfall patterns and drought. This is a stark reality for millions of smallholder farmers who are most vulnerable to these conditions.



About the AUTHOR

Malu Nachreiner,
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The need to shape a more economically viable and sustainable rice cultivation system has never been so pressing.

Sowing the Seeds of Regenerative Agriculture: Direct-Seeded Rice

Shanti was introduced to direct-seeded rice 2 years ago.

Instead of recruiting a large labour base to carry out transplanting work, in the absence of standing water, DSR allows machinery to enter the paddy including sowing machines. This saves time and ensures each plot is optimized with the right spacing and depth to boost the chances of crop success.

Digital technologies, namely Farm-Rise and the Chatbot Deena, allow farmers to contact machinery providers and obtain specialized hybrid seed and crop protection solutions as well as advice on how best to manage these new practices.

With the right formula—seeds, crop protection and digital support—Shanti is confident in her decision to evolve the way she, her father, and earlier generations have been cultivating the land to produce the grain that sustains both her community and the world export market.

The Way Forward: Focusing on Water Conservation and Soil Health

Yet, the benefits of DSR go beyond the farm gate.

4,000 to 5,000 liters of water are needed to produce one kilogram of grain using the traditional method of rice cultivation. DSR eliminates the need for flooding fields, cutting water usage by up to 40%.

DSR also plays a critical role in reducing greenhouse gas emissions. Without the flooded conditions and thus the methane creating bacteria that thrive in water, DSR fields can reduce emissions by up to 45%, contributing to global climate change mitigation efforts.

DSR can also improve soil nutrition and help avoid erosion. Healthier soil not only supports current crops, but also enhances long-term productivity, allowing



DSR can also improve soil nutrition and help avoid erosion

farmers to pass on the land to generations to come.

With 150 million smallholder farmers worldwide, DSR has the potential to change agriculture.

The Bigger Picture: Striking A Balance Between Food Security and Sustainable Farming

The adoption of DSR is not just about improving individual farming practices and reducing environmental impact. It's about addressing a larger global challenge—food security.

With the global population expected to reach nearly 10 billion by 2050, the demand for rice will rise. The FAO estimates that agriculture will need to produce 50% more food to feed the growing world population. Meeting this demand will require not just increasing production, but doing so in a way that is both sustainable for the planet and resilient to the impact of climate change. DSR has the potential to play a key role in this effort.

The benefits of DSR are already being experienced in countries including India, Indonesia and the Philippines. Indeed, in India - where innovative farmers like Shanti are adopting the practice and harvesting its rewards - it's expected that DSR adoption will grow by about 10% year on year.

What Next? Shifting Towards Regenerative Agriculture

The history of rice farming is one of adaptation and resilience, with each generation building on the knowledge and practices of those who came before. Modern technologies have already increased farmer productivity exponentially, reduced world hunger and lowered farming's impact on the environment. But as an industry, we must continue to do more.

Today, as we face new and complex challenges, a transformation of the rice system at scale is going to be hugely challenging. But I believe it is achievable if all stakeholders work together and embrace this transformation towards a more regenerative way to cultivate rice, a way that improves the livelihoods of farmers, has the potential to produce enough food for more people while contributing to a healthier planet for future generations.

'R & D IS VITAL'

In conversation with Agriculture Today, Mr. Vimal Kumar, Managing Director, Best Agrolife Ltd. Explains the relevance of R&D in Crop Protection. He also discusses about the importance of farmer awareness, environment protection and climate change.

How much important is Research and Development in the field of crop protection?

Research and Development (R&D) plays a critical role in the field of crop protection, driving the innovation needed to address modern agricultural challenges. As the world grapples with the effects of climate change, increasing food demand, and the growing resistance of pests to conventional treatments, R&D becomes essential to keep pace with these evolving threats. It is through continuous research that new and more effective crop protection solutions are developed, ensuring farmers have the tools they need to safeguard their crops while also minimizing environmental impact.

One of the most pressing concerns in agriculture is pest resistance. R&D is crucial in developing new active ingredients and multi-action formulations that target resistant pest populations. In addition to pest resistance, R&D is also focused on improving the environmental safety of crop protection products. Research in this area aims to develop products that meet strict regulatory standards while minimizing harm to ecosystems.

R&D is vital in helping agriculture adapt to the challenges posed by climate change. Research in climate-resilient products ensures that farmers can continue to protect their crops regardless of changing environmental factors. Additionally, advancements in precision application technologies and low-resi-



One of the most pressing concerns in agriculture is pest resistance



due pesticides contribute to enhanced crop productivity and sustainable farming practices. R&D not only addresses immediate challenges but also lays the foundation for future agricultural success, ensuring food security and environmental sustainability.

What are the new products launched by Best Agrolife and how is it superior to other products in the market?

Best Agrolife has recently introduced a range of innovative patented products that are set to transform crop protection in India. These new products—**Defender, Nemagen, Ronfen, Tricolor, Orisulam, and Warden Extra**—are the result of extensive research and development, designed to tackle multiple challenges faced by farmers in crop protection. What differentiates these products from others in the market is their

use of ternary combinations, blending three active ingredients to offer a broader-spectrum control over pests and diseases. This is a significant improvement over traditional methods that typically rely on separate pesticides for specific issues, providing a more comprehensive and efficient solution.

The superiority of these products lies in their ability to address complex pest infestations and diseases in a single application. This not only simplifies the pest management process for farmers but also reduces the overall cost by eliminating the need for multiple products. Moreover, these new offerings promote healthier crop growth by reducing the stress caused by excessive use or mixing of different chemical treatments. This leads to improved crop quality, higher yields, and ultimately greater profitability for farmers. In addition, the formulations are designed to be environmentally friendly, minimizing chemical residues

and reducing the risk of pest resistance, which has become a growing concern in modern agriculture.

How do you inculcate environment and farmer friendly ideals in to your products?

We believe that agricultural success should not come at the expense of the environment, and we work to create solutions that benefit both farmers and the ecosystem. We prioritize eco-friendly, newer and safer formulations designed to minimize environmental impact. Our products are specifically created to target pests while remaining safe for beneficial insects, soil health, and surrounding ecosystems. We also integrate our solutions into Integrated Pest Management (IPM) systems, which combine chemical, biological, and cultural pest control methods. By encouraging farmers to use our products as part of a balanced pest management approach, we reduce the reliance on chemicals and foster long-term sustainability. Our Research and Development (R&D) teams are constantly innovating, creating crop protection solutions that meet global environmental standards. This includes the development of new, more efficient molecules that ensure our products are safe and effective for future use.

Beyond product innovation, we are committed to farmer education, ensuring that farmers understand the appropriate dosage, timing, and application methods to prevent overuse and reduce environmental contamination. In addition, our products are formulated to protect water and soil health by minimizing runoff and leaching, safeguarding vital natural resources essential to farming. Finally, we collaborate with regulatory bodies to ensure compliance with the latest environmental safety standards, particularly around residue levels, which ensures our products remain safe throughout the food chain and support long-term agricultural sustainability.

Safe and judicious use of pesticides to some extent are



One major trend we foresee is the rise of smart and precision agriculture, where digital technologies like drones, sensors, and AI will allow farmers to monitor crop health in real-time.

a very significant aspect in application of crop protection products. How does Best Agrolife ensure that farmers are aware of the safety protocols. Do you have any farmer outreach programs?

One of our primary initiatives is farmer training programs, where we conduct regular sessions at the grassroots level. Our experts engage directly with farmers, demonstrating proper pesticide application techniques, the use of personal protective equipment (PPE), and the importance of adhering to recommended dosages. These training sessions are designed to help farmers minimize their exposure to pesticides while ensuring that they apply products in a way that reduces the risk of environmental damage.

We also utilize demonstration fields as a hands-on approach to teaching. These field trials allow farmers to see the practical application of our products while observing essential safety protocols in action. By showing them the correct methods and timing for applying pesticides, we ensure that they can achieve optimal results without compromising on safety.

Additionally, we run awareness campaigns in partnership with agricultural extension workers and local influencers. These campaigns focus on best practices for storing, handling, and disposing of pesticides, further promoting safety

throughout the product's life cycle. To reach a broader audience, we leverage digital platforms and SMS alerts, sending farmers educational materials in regional languages and offering real-time guidance during critical crop stages.

Finally, we ensure that our products come with clear labelling and packaging that meets the highest safety standards. The labels provide easy-to-understand instructions on safe usage and proper precautions, available in multiple languages to ensure accessibility for all farmers.

What according to you will be the future crop protection products?

As agriculture evolves, the need for safer, more efficient, and environmentally responsible solutions will grow significantly. One major trend we foresee is the rise of smart and precision agriculture, where digital technologies like drones, sensors, and AI will allow farmers to monitor crop health in real-time. Multi-action and patented formulations will also become increasingly important. These products will offer broader-spectrum control and help combat pest resistance, enabling farmers to achieve effective results with fewer applications. Furthermore, the demand for low-residue and environmentally safe formulations will intensify as global regulations tighten. Future products will need to break down quickly in the environment, leaving minimal residues in the soil and water. Nanotechnology is poised to revolutionize crop protection by enabling more targeted delivery systems. Additionally, the need for climate-resilient solutions will become increasingly important.

To conclude, we foresee a greater integration of crop protection products with sustainable farming practices, such as regenerative agriculture, organic farming, and Integrated Pest Management (IPM). Our goal is to provide next-generation solutions that align with these practices, reducing reliance on chemical inputs and promoting long-term crop health and productivity.

CIRCULAR ECONOMY THE GLOBAL NEED

The recent report published by the UNEP 2024 on the Global waste management outlook shows that the world generates 2.01 billion tonnes of municipal solid waste annually. By 2050, it is expected to grow to 3.40 billion tonnes. It has been observed that those nations that generate high income produce more waste compared to low-income groups of nations. In the current situation if we look at waste disposal methods in most countries more than half of waste is openly dumped, and the trajectories of waste growth are creating vast adverse implications on the environment, health, and prosperity, thus requiring urgent action to prevent.

The circular economy is an emerging model where materials never become waste and nature regenerates. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting. The concept of circular economy has been considered a promising alternative



The recent report published by the UNEP 2024 on the Global waste management outlook shows that the world generates 2.01 billion tonnes of municipal solid waste annually

to the prevailing linear economy which is dependent on the continuous use of available resources without replacement leading to an imbalance in the resource cycle extraction, utilization, and disposal. However, in the circular economy, there is a need to invent Indigenous and affordable technologies to convert waste resources into useful products and materials, and further after their full utilization, the disposed waste needs to be recycled continuously on the zero-waste concept.

Circulate Products and Materials

After their use, materials must be recycled using appropriate technology so that no part of the product will be wasted. Material cycles must be designed for the proper length of time for human use and the natural cycle to which they are connected. Materials while manufacturing should not be mixed in ways that prevent separation and recovery unless they can continue to cycle infinitely at high value in their mixed form. Materials must be used only when necessary and there is an inherent preference for dematerialization of products and services. While developing a circular

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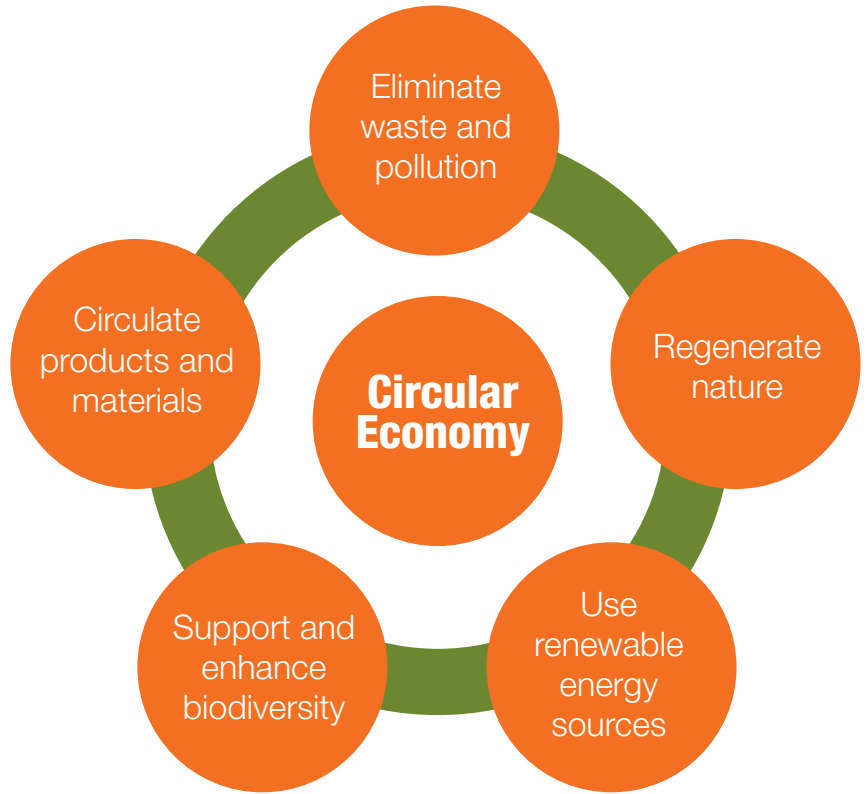
economy we should remember that materials are one of the major resources where all flows are connected and influence one another. Therefore, developing a system or protocol that will help us fully recover the entire materials through the intensive recycling process is necessary.

Use Renewable Energy Resources

To meet increasing demand for the energy use of natural resources is not sufficient. Therefore, there is a need to focus on renewable energy technology with the highest efficiency from each resource. We should be able to store the surplus energy generated from renewable energy properly for future use when it is required. The materials used in generating renewable energy need to be recovered and again recycled into the system. The quantity of energy consumption is matched to the quantity of energy availability to avoid structural energetic losses in transport. The system is designed for maximum energy efficiency without compromising performance and service output. Ultimately, in a circular economy, all energy should be supplied from renewable or otherwise sustainable forms.

Support and Enhance Biodiversity

Today, more than 90% of biodiversity loss is due to the extraction and processing of natural resources. To halt and reverse biodiversity loss, we need to fundamentally transform the way we produce, use, and consume our products and food. Conservation and restoration efforts are needed on war foot.



The circular economy is an emerging model where materials never become waste and nature regenerates

The circular economy offers a framework and guidelines for such a transformation. If we eliminate waste and pollution, circulate products and materials, and regenerate nature, biodiversity can thrive. To support and enhance biodiversity policymakers, businesses, and citizens have a very vital role in making circular economy action plans more beneficial to nature. Policymakers, businesses, and citizens can all play a role in making circular economy actions more beneficial for nature. Policymakers must design policies that ensure a strong integration between circular economy actions and biodiversity aspects over the entire life cycle of goods and services. Businesses must develop and upscale innovations, paying attention to product life spans pollution, and materials sourcing. Consumers can support these actions by reducing overall consumption and demanding more biodiversity-friendly choices.

Regenerate Nature

We should move to a regenerative model so that we begin to emulate natural systems. In a circular economy, we shift the





In the circular economy, the principle of regenerating nature involves

- Moving from a take-make-waste to support natural processes and leave more room for nature to survive.
- Avoiding the use of non-renewable resources and preserving or enhancing renewable ones.
- Returning valuable nutrients to the soil to support regeneration.
- Using renewable energy instead of relying on fossil fuels.

focus from extraction to regeneration. Instead of continuously degrading nature, we build natural capital. We employ farming practices that allow nature to rebuild soils, increase biodiversity, and return biological materials to the earth. In a linear economy, most of these materials are lost after use and the land used to grow them is getting depleted of nutrients. In a circular economy, nothing is wasted, and all wastes are used for rebuilding natural resources.

Policy Framework to Promote Circular Economy

Promoting a circular economy involves creating a policy framework that encourages sustainable practices and reduces waste. Here are some key policy goals and measures that can help achieve this transition:

1. Stimulate Design for the Circular Economy:
 - Encourage the design of durable,

reusable, repairable, and recyclable products.

- Implement product labels and digital passports to track materials and promote transparency
2. Manage Resources to Preserve Value:
 - Develop business models that keep products and materials in use for as long as possible.
 - Implement tax incentives and procurement policies that support repair, sharing, and remanufacturing
 3. Make the Economics Work:
 - Adjust economic policies to support circular practices, such as reducing taxes on recycled materials and increasing taxes on virgin materials.
 - practices.
 4. Invest in Innovation, Infrastructure, and Skills:
 - Fund research and development in circular technologies and pro-

cesses.

- Build infrastructure that supports recycling and resource recovery.
 - economy.
5. Collaborate for System Change:
 - Foster collaboration between governments, businesses, and communities to create a cohesive approach.
 - Align policies at national and international levels to reduce friction and lower costs

Future Directions

The principles and guidelines given in the circular economy need to be strictly followed on a priority basis. The strategies related to the concept of zero waste must be implemented to protect future generations' human rights. All stakeholders—public, private, and civil society—must work together to reduce waste and its complexity, and the leakage of pollutants into the environment. Materials need to be kept in use for as long as possible and at their highest possible value. Recyclability and accountability need to increase. The waste crime must fall.

Finally, the safety and quality of the livelihoods of people who work with waste need to be prioritized to ensure a just transition with social and environmental justice at its core. There can be several driving forces that can decide the future development of a circular economy. However, some key driving forces mentioned below will have a greater impact on the growth of a circular economy.

- Regulatory framework to promote circular economy
- Development of innovative environmental technologies
- Adoption of circular business models
- Investments in the transition to a circular economy
- Adoption of carbon pricing
- Climate Awareness
- Scarcity of resources

These driving factors may evolve in years to come and interact with each other and create a significant impact on the development of a circular economy.

CREATING A BETTER FUTURE BEYOND OUR CORE BUSINESS

PARIJAT INDUSTRIES INDIA PVT.LTD.

As a socially responsible corporate citizen, Parijat extends its goodwill through various community projects, reflecting a commitment to impact communities positively. Parijat's CSR vision actively contributes to social, cultural, and economic development by providing sustainable solutions.

Parijat Urja Chakra

Established in 2014, this community development institution houses numerous initiatives in education, environment, health, sanitation, sports, agriculture, rural development, livelihood, and cultural heritage.

8 Core Areas of CSR Initiatives

Education & Livelihood: Tuition classes promote education among underprivileged children, helping them integrate into the formal education system and develop holistically. Vocational training in cutting/tailoring empowers women to become financially independent by teaching embroidery, designing clothes, and stitching.

Environment: Parijat supports Plantology, aiming to plant 50,000 trees per year with the help of Army and Paramilitary forces. This initiative promotes environmental sustainability.

Rural Development: Parijat strengthens rural schools in Ambala, Haryana, by providing sanitation facilities, clean water, proper lighting, and essential amenities. Anganwadi centers have been revamped and equipped with toys, furniture, and utensils. LED lights have been installed in villages, enhancing safety and energy efficiency. Water

"CSR is not just an obligation but an opportunity to create a lasting positive change in the communities we serve"

**– NATASHA RASHID
CSR HEAD**



Navigating agriculture through climate change



"Sustainability and environmental stewardship cannot be an extra-curricular activity that we do over and above our regular business. The real change will come when the way run businesses integrates a climate lens into its fundamental style of working"

- UDAY RAJ ANAND, DIRECTOR & CEO – DOMESTIC BUSINESS

coolers and RO systems have been installed in government schools.

Health & Sanitation: Parijat provides preventive healthcare in neighbouring villages through regular health awareness programs, check-ups, and camps. Audio-visual media is used to enhance understanding, especially during monsoons.

Sports: Parijat sponsors a rural football team in Ambala, promoting sports as a constructive activity against drug and alcohol issues. The sponsorship includes developing a football field and providing kits to team members.

Agriculture: Pan-India farmer safety training in collaboration with Krishi Vigyan Kendra's promotes the safe use of pesticides, with materials available in 11 languages.

EMPOWERING FARMERS THROUGH INNOVATION AND EDUCATION

This program is dedicated to enhancing the efficiency, productivity, sustainability, and profitability of agricultural practices. By integrating innovative technologies, training farmers in best practices, promoting sustainable farming methods, and providing financial support, the program strives to empower farmers, improve food security, and contribute to economic development in rural areas.

Intangible Cultural Heritage: In collaboration with the Anand Foundation, Parijat offers internships focusing on performing and visual arts, natural heritage, crafts, community, linguistics, and sciences, allowing students to document and experience cultural diversity.

From Vision to Reality

THE ROLE OF SOLAR ENERGY IN SHAPING THE FUTURE OF AGRICULTURE

Solar Energy for Sustainable Agriculture

The agricultural sector is undergoing a remarkable transformation, driven by the urgent necessity for sustainable practices. At the forefront of this revolution is solar energy, a technology once seen as futuristic, now playing a crucial role in agriculture's future. Agriculture, beyond its central role in global food production, also significantly influences socio-economic dynamics, especially in countries like India, where nearly 65 crore people depend on farming and allied activities for their livelihood. Given its critical importance, agriculture must evolve to become sustainable—not only economically, but also socially and ecologically—to meet the increasing demands of a growing global population.

The Solar Shift: Moving Away from Fossil Fuels

Traditional farming methods are heavily reliant on fossil fuels and are often energy-intensive, contributing substantially to global warming and its harmful effects. In contrast, solar energy offers a renewable, eco-friendly solution that meets the energy demands of modern agriculture while reducing its carbon footprint. The adoption of solar technologies, such as photovoltaic (PV) panels and concentrated solar power (CSP), is helping farmers transition from fossil fuels, lowering emissions and promoting environmental sustainability.

One of the most impactful applica-

Indian market for solar water pumps is growing rapidly with significant thrust from the government and is poised to become world's largest market for Solar Agri pumps.

tions of solar energy in agriculture is irrigation. Solar-powered irrigation systems (SPIS) are becoming increasingly popular, especially in regions with limited access to conventional electricity. These systems use photovoltaic panels to drive water pumps, providing a reliable and sustainable water supply for crops. A 2023 report by the International Renewable Energy Agency (IRENA) indicates that these solar irrigation systems can reduce water usage by up to 40% compared to traditional methods.

Economic and Ecological Benefits

While solar installations involve significant initial costs, the long-term savings

make them more economical than traditional energy sources. For instance, solar irrigation pumps eliminate the need for expensive diesel or grid electricity, leading to substantial savings for farmers. Besides, solar energy systems can generate additional revenue by selling surplus electricity back to the grid through net metering programs.

The investment in solar technology often pays off within a few years, depending on the system's size and local electricity tariffs. After this payback peri-

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od, the energy generated is virtually free, given the minimal maintenance required for solar panels. This ensures farmers have access to consistent, reliable, and inexpensive energy over the typical 25-30 years lifespan of a solar installation.

Beyond Irrigation: Cold Storage and Environmental Conservation

Solar energy extends its benefits beyond irrigation. Solar-powered cold storage facilities, for example, significantly reduce post-harvest losses. The Indian Agricultural Research Institute (IARI) estimates that nearly 30-40% of vegetables and fruits, and about 10% of India's total agricultural produce, perish due to inadequate refrigeration. Solar-powered cold storage units, like the IARI-designed 'Sun Fridge,' allow farmers to store their produce for longer periods, ensuring they can sell at better market prices.

The environmental benefits of solar energy are immense. It produces no greenhouse gases or pollutants, reducing the carbon footprint of farms and contributing to ecological conservation. Additionally, solar-powered systems can reclaim previously unusable lands. In regions with saline or infertile soils, solar-powered desalination units can transform brackish water into suitable irrigation water, turning unproductive land into arable farmland.

Achieving Energy Independence

Solar energy also promotes energy independence for farmers. With captive solar panels, farmers can generate their own electricity, reducing dependence on grid power or costly fuels. This is particularly crucial in remote and rural areas where reliable electricity is often scarce.

The 'Suryashakti Kisan Yojana' (SKY) initiative by the Gujarat state government is a compelling example of how solar energy programs can foster energy independence. This program incentivizes farmers to install solar panels on their farmland by offering credit for initial installation costs. Farmers use the electricity generated for their needs and can



Small-scale farmers can reap numerous advantages from solar water pumps, including financial savings, environmental preservation, practical benefits, and socioeconomic empowerment.

sell any surplus back to the grid. This initiative empowers farmers with a sustainable energy source while providing an additional income stream.

The Future of Solar-Powered Agriculture

In India, Government is actively promoting solar installations on farms through various schemes. The PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) scheme is a notable example. It aims to solarize agricultural pumps and reduce dependence on diesel for irrigation by providing subsidies of 30-50% to farmers for installing solar irrigation pumps. The target of installing 3.5 million solar pumps by 2025 under this scheme is a major step toward sustainable energy in agriculture, with the potential to save 27 billion kWh of electricity annually.

([https://www.india.gov.in/spotlight/pm-kusum-pradhan-mantri-kisan-urja-](https://www.india.gov.in/spotlight/pm-kusum-pradhan-mantri-kisan-urja-suraksha-evam-utthaan-mahabhiyan-scheme)

[suraksha-evam-utthaan-mahabhiyan-scheme](https://www.india.gov.in/spotlight/pm-kusum-pradhan-mantri-kisan-urja-suraksha-evam-utthaan-mahabhiyan-scheme))

In addition to policy support, ongoing advancements in solar energy technology are poised to greatly benefit farmers. Cutting-edge innovations such as PERC, TOPCon, and IBC are also poised at enhancing the efficiency and performance of solar panels. These improvements are likely to enable farmers to optimize the use of their limited land resources, resulting in higher energy output and improved returns on investment.

Agrivoltaic systems, which integrate solar panels into cropland, pastures, or grazing areas, enable farms to simultaneously generate electricity and cultivate land, thereby maximizing land use. These systems offer multiple benefits, including shade provision, water conservation, soil protection, and improved crop yields. Innovations in solar farming are extending to combine energy production with complementary agricultural practices, such as agroforestry, aquaculture, and beekeeping, further optimizing resource utilization on farms.

A Vision for a Sustainable Future

The integration of solar energy in agriculture is not just about reducing costs or improving efficiency. It is a step towards building a sustainable future where farmers are energy-independent, operational costs are reduced, and environmental impact is minimized. Solar energy is paving the way for a cleaner world and fostering a self-sufficient farming community.

THE FUTURE OF THE READY-TO-EAT PULSES INDUSTRY: A NUTRITIONAL REVOLUTION

The global food industry is undergoing a transformative shift, with consumers increasingly prioritizing health, convenience, and sustainability. In this evolving landscape, the ready-to-eat (RTE) pulses segment has emerged as a promising market, providing not only convenience but also essential nutritional benefits. Pulses—such as lentils, chickpeas, beans, and peas—are known for their high protein content, dietary fiber, vitamins, and minerals, making them an attractive option for health-conscious individuals. As plant-based diets gain momentum globally, the future of the RTE pulses industry is poised for substantial growth.

Why Ready-to-Eat Pulses are Needed

The growing demand for plant-based proteins is primarily fueled by health concerns, environmental sustainability, and the rising popularity of vegan and flexitarian diets. Pulses have long been recognized as an excellent source of plant-based protein, offering a nutrient-dense alternative to animal-based proteins. In a world where chronic diseases like obesity, diabetes, and cardiovascular conditions are on the rise, the consumption of pulses, which are low in fat and cholesterol, is a critical solution to promoting better health outcomes.

Furthermore, pulses contribute significantly to food security in both developed and developing regions. As global populations continue to grow, the pressure on food production systems is intensifying. The ready-to-eat format

offers a convenient solution for busy consumers who seek quick, nutritious meals without compromising on health. Additionally, pulses are affordable and widely available, making them a practical choice for consumers from various socio-economic backgrounds.

Environmental Impact

The environmental benefits of pulses cannot be overstated. According to the Food and Agriculture Organization (FAO), pulses have a lower environmental footprint compared to other protein sources, such as meat and dairy. Livestock production accounts for approximately 14.5% of global greenhouse gas emissions, largely due to methane emis-

sions from ruminant animals like cattle. In contrast, pulses are nitrogen-fixing crops, which means they enrich the soil by converting atmospheric nitrogen into nutrients, reducing the need for synthetic fertilizers. This not only improves soil health but also minimizes greenhouse gas emissions.

Additionally, pulses require significantly less water than animal-based proteins. For example, producing one kilogram of beef requires approximately 15,000 liters of water, whereas one kilogram of lentils requires only 1,250 liters. This makes pulses an environmentally sustainable choice for a world facing increasing water scarcity.

Taste and Health Benefits

One of the primary concerns consumers have regarding plant-based foods is

Pulses have long been recognized as an excellent source of plant-based protein, offering a nutrient-dense alternative to animal-based proteins.

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taste. Traditionally, pulses were associated with bland, home-cooked meals. However, innovations in the RTE sector have transformed how pulses are perceived. Food manufacturers are now offering a diverse range of pulse-based meals, with global flavors such as Mediterranean hummus, Indian dal, and Mexican bean chili becoming mainstream options. The addition of spices, herbs, and modern cooking techniques has made these products more appealing to a broader consumer base.

From a health perspective, pulses are packed with essential nutrients. They are rich in protein, fiber, vitamins (such as folate), and minerals (such as iron, magnesium, and potassium), which are critical for maintaining overall health. Studies have shown that regular consumption of pulses can reduce the risk of chronic diseases, including heart disease, type 2 diabetes, and certain cancers. Moreover, they support digestive health due to their high fiber content, which promotes gut regularity and helps in weight management.

Increasing Acceptance of Plant-Based Foods

Although the health and environmental benefits of pulses are well-documented, increasing their acceptance among a broader consumer base requires concerted efforts from both manufacturers and marketers. One effective strategy is consumer education. Many people are still unaware of the nutritional advantages of pulses or how to incorporate them into their diets. Public health campaigns, nutrition education in schools, and partnerships with healthcare professionals can help raise awareness.

Flavor innovation also plays a crucial role in boosting acceptance. As food manufacturers experiment with new flavors and product formats, pulses are becoming more versatile and exciting. For instance, snacks such as roasted chickpeas and lentil chips have gained popularity in Western markets, offering a healthy alternative to traditional processed snacks. By introducing pulses

Although the health and environmental benefits of pulses are well-documented, increasing their acceptance among a broader consumer base requires concerted efforts from both manufacturers and marketers.

in snackable, easy-to-consume formats, brands can appeal to younger consumers, athletes, and busy professionals seeking convenient yet nutritious food options.

Price parity with animal-based proteins is another factor that can influence consumer choices. As the production of RTE pulses scales up, economies of scale will help bring down prices, making them more competitive in the marketplace. Governments and policymakers can also play a role by offering subsidies and incentives for plant-based food production, helping to level the playing field with traditional animal agriculture.

Sustainable and Ethical Sourcing

Sustainability is now a key concern for consumers, with many seeking out brands that prioritize ethical sourcing practices. The RTE pulses industry is well-positioned to meet this demand. Many companies are adopting sustainable agricultural methods, such as crop rotation and organic farming, to ensure that pulses are grown in a way that supports biodiversity and soil health. Additionally, fair trade practices are becoming more common, ensuring that farmers are paid fairly for their labor and that supply chains are transparent and equitable.

In the future, traceability and accountability in food production will play an increasingly significant role in shaping consumer preferences. Brands that can guarantee the ethical and sustain-

able sourcing of their pulses will likely attract more environmentally and socially conscious consumers.

Challenges and Opportunities

Despite the promising outlook, the RTE pulses industry faces certain challenges. For one, consumer education remains a hurdle in regions where pulses are not traditionally consumed. Misconceptions about pulses being bland or difficult to digest must be addressed through innovative product development and marketing efforts. Additionally, some consumers may still associate RTE foods with being overly processed or lacking in nutritional value. However, ongoing advancements in food processing techniques, such as sprouting and fermenting, can improve the digestibility and nutritional profile of pulses, making them more appealing to a broader audience.

On the flip side, these challenges present opportunities. Brands that can effectively communicate the benefits of pulses and offer flavorful, convenient, and digestible products will be well-positioned to capture market share. Investment in research and development (R&D) to improve pulse processing methods will also unlock new product possibilities and expand consumer acceptance.

The Future is Plant-Based

The ready-to-eat pulses industry is on the cusp of a nutritional revolution. As consumers continue to prioritize health, sustainability, and convenience, pulses offer an eco-friendly, nutrient-dense solution that meets the demands of modern living. With innovations in packaging, flavor development, and ethical sourcing, the RTE pulses sector is set for significant growth in the coming years.

The future of food is undoubtedly plant-based, and pulses are leading the charge. Whether as a quick meal solution, a nutritious snack, or a sustainable protein source, pulses are poised to become a staple in diets worldwide, reshaping how we think about food and nutrition.

RESIDUE-TO-ENERGY: HARNESSING AGRICULTURAL WASTE FOR ENVIRONMENTAL SUSTAINABILITY



Rice is grown in diverse growing places during different seasons. It is the world's most significant food crop, cultivated in 112 nations on every continent and feeding more than half of the world's population by delivering 35 to 60% of their daily calories. Fibre, protein, vitamin B, iron, and manganese are all present in reasonable levels. As a result, rice is a significant component of the Government of India's Food Security Mission, as it helps to combat malnutrition in the country.

Rice farmers, on the other hand, confront significant problems such as low income, deterioration of natural resource bases, and climate change-related amplification of both biotic and abiotic pressures, all of which take all of science's ingenuity to overcome. After harvesting or processing the economic components of cultivated crops, such as leaves, stalks, and roots, residual plant material or biomass is left behind. Proper management techniques, such as incorporation or mulching, mitigate

A conservative technique to managing crop residue *in-situ* that saves energy and the environment is to leave the residue on the soil surface.

environmental impacts like greenhouse gas emissions and soil degradation. India produces an estimated 178 Mt of surplus crop residues annually, of which 87 Mt are burnt. Implementing effective residue management practices contributes to sustainable rice production and environmental preservation.

Why Residue Management?

"Crop residues should be seen not as wastes but as providers of essential

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environmental services, assuring the perpetuation of productive agro ecosystems”.

Crop residue and its management challenges have significantly increased

1. Since high yielding varieties of crops were used in modern crop production. Crop residue burning has become a common practice, particularly in developing nations like India, due to factors such as the critical window period between two crops, which is crucial for wheat sowing after rice and sugarcane harvest, and the unsuitability of certain crop residues for animal feed.
2. As mechanization has increased, with the use of combine harvesters increasing from 2000 in 1986 to 10000 in 2010.
3. Due to a lack of traditionally competing uses for crop residues such as animal feed, fodder, fuel, roof thatching, packaging and composting.

Generation of cereal crop residues is highest in the states of Uttar Pradesh (72 Mt) followed by Punjab (45.6 Mt), West Bengal (37.3 Mt), Andhra Pradesh (33 Mt) and Haryana (24.7 Mt).

How to manage Rice residue?

On farm residue management

Residue retention: A conservative technique to managing crop residue in-situ that saves energy and the environment is to leave the residue on the soil surface. Recent advancements in agricultural technology enable the direct sowing of crops in soil conditions coated with residue by widening the tiny openings for the insertion of seeds and fertilizer, while maintaining the integrity of the remaining soil surface. Crop tolerance against terminal heat stress is increased, soil erosion is decreased, and soil carbon is sequestered when crop residue is kept on the soil's surface.

Residue Incorporation: The residue of various cereal and pulses crops can either be mixed with soil using active i.e.



Consequences of crop residue burning on crop productivity, profitability and natural resource (Source: Kumar et al., 2023)

Crop residue can serve as second generation feedstock for the production of various fuels.

PTO (power take-off) driven implements or buried into soil using passive type implements. However, each implement provides different soil pulverization, stubble cutting, and crop residue burial efficiency with their relative advantages and disadvantages

Straw mulched-Zero Tillage: Used for seeding the crops in an untilled field with/without anchored residue.

Happy seeder: It can be used for seeding the crops in untilled field with anchored and loose residue.

Strengthen Industrial Utilization

Rakes and balers for residue removal:

Balers play a pivotal role in stubble compression, acting as hydraulic presses to compact crop residues into dense, manageable packages. These compressed stubbles are securely bound using twine, wire, or strapping.

Industrial Utilization Options

Power generation from straw

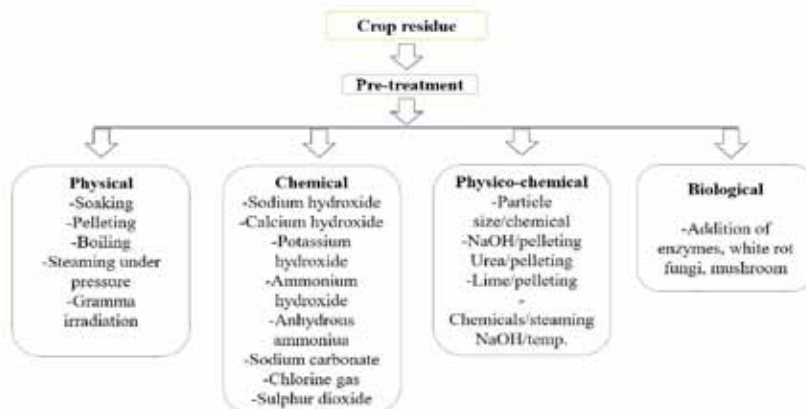
A 12 MW rice-straw power plant typically needs 120,000 tonnes of stubble, which can be collected from about 15,000 farmers. Power industry pay Rs 900 a tonne for non-basmati rice straw and Rs 1,500 for basmati rice straw

Straw as a raw material for ethanol production

Crop residue can serve as second generation feedstock for the production of various fuels. In production of liquid fuel through pyrolysis, dried and pre-treated biomass is exposed to high temperature (300–600 °C) in the absence of oxygen, which decomposes it into solid (charcoal, biochar), liquid (pyrolysis oil) and gaseous (H₂, CO, CH₄, C_xH_y, CO₂ and



a. Use of rice straw as animal feed with proper treatment



N) components.

Value Addition

Plant biomass is composed of cellulose, hemicellulose, lignin, lipids, proteins, starch, carbon, water, hydrocarbon and other compounds such as nitrogen, phosphorus, potassium, sulphur, etc., depending upon plant species and growing conditions. Rice residue, a lignocellulosic biomass, contains about 38% cellulose, 25% hemicellulose and 12% lignin

- Straw as a fuel in brick kilns and boilers
- **Straw for paper/ board making:** Similarly, in addition to paper industry, sugarcane bagasse is conventionally used in sugar mills for providing the fuel to boilers where its hemicellulose and lignin components are underutilized due to their

limited contribution in total heating value

- Straw as a packing material
- Straw for mushroom cultivation

It is recommended that governments employ a blend of punitive and compensatory strategies to discourage farmers from incinerating crop residue. Crop residue has the ability to partially replace traditional feedstock in the processes of composting, growing mushrooms, and using biogas in rural regions. There is surplus agricultural residue (about 180 Mt) available in India that can be used as feedstock for second generation bio-fuels. For example, it has the capacity to produce 60 billion litres of bioethanol per year. Before being applied to gasification and thermal power plants, low heating value components with value additions must be extracted from crop residue. This will allow by products from one business to be systematically used as feedstock in other industries. Moreover, additional by products produced during the manufacture of biofuel, such as biochar, biomass ash, and biogas slurry, have excellent uses in the construction industry as a partial replacement for Portland cement and as a way to improve soil quality. Crop residue has enormous potential for use in the paper industry, the synthesis of multifunctional carbon materials, and cutting-edge sectors including pharmaceuticals and cosmetics in addition to the biofuel program.

BIOPESTICIDES: BRIDGING THE GAPS IN THE UK HORTICULTURAL MARKET



The UK horticultural market is facing significant challenges related to the over-reliance on synthetic agrochemicals.

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As the UK horticultural sector continues to evolve post-Brexit, the need for sustainable crop protection solutions has never been more critical. Rising concerns over synthetic agrochemicals' environmental and health impacts are driving the agricultural industry to transition to greener alternatives. Despite this urgency, regulatory bottlenecks and market resistance have hindered the widespread adoption of biopesticides in the UK. However, biopesticides offer an alternative that protects crops and aligns with the UK's environmental and sustainability goals.

The UK Horticultural Market: Current Challenges

The UK horticultural market is facing significant challenges related to the over-reliance on synthetic agrochemicals. While these chemicals have boosted



yields for decades, their long-term impact on soil health, water quality, biodiversity, and pest resistance is concerning. The widespread use of certain pesticides has led to pest and disease resistance, rendering these chemicals less effective. Growers now find themselves in a precarious position, needing to apply increasingly toxic chemicals or risk substantial crop losses.

Among the critical crops affected by pest and disease resistance are:

- **Strawberries and soft fruits:** Common pests such as aphids and spider mites have resisted pyrethroid insecticides, forcing growers to rely on more harmful chemicals like neonicotinoids.
- **Brassicas:** Cabbage stem flea beetles have become resistant to several insecticides, including organophosphates, leaving growers limited options.
- **Potatoes:** Potato blight remains a significant issue, with resistance



Derived from natural sources, such as microorganisms, plants, and minerals, biopesticides present lower risks to human health and the environment than traditional synthetic chemicals.

emerging against widely used fungicides like metalaxyl.

The growing resistance of pests and diseases to synthetic chemicals has increased interest in **Integrated Pest Management (IPM)**, where biopesticides can play a critical role. However, the UK market for biopesticides remains underdeveloped, mainly due to a regulatory framework that has been slow to adapt post-Brexit.

Post-Brexit Regulatory Landscape: A Barrier to Biopesticides?

The UK regulatory environment for pesticides, including biopesticides, remains primarily based on the EU's regulatory framework. Post-Brexit has created delays in approving new biopesticide products as the UK continues to follow a complex and lengthy registration process inherited from the EU. The result is that UK growers are being denied access to innovative biopesticide solutions that could help mitigate pest and

disease resistance in critical horticultural crops.

For example, several microbial and biochemical biopesticides that have proven effective in other regions, such as the EU and North America, are still awaiting approval in the UK. These include:

- **Trichoderma-based products:** Widely used in other regions to combat soil-borne diseases, these products remain unavailable to UK growers due to the slow approval process.
- **Beauveria bassiana:** This fungal biopesticide, effective against pests like whiteflies and aphids, is still not registered in the UK despite extensive use across Europe and Latin America.
- **Spinosad:** While registered for limited use, this natural insecticide is not yet fully available for the range of horticultural crops that could benefit from its application.

The UK's post-Brexit regulatory system has introduced additional complexities. The country must now navigate its internal processes while still contending with the legacy of the EU's regulatory framework. Despite the UK government's promises to streamline the biopesticide approval process, progress has been slow, leaving many growers reliant on synthetic chemicals that no longer provide effective pest control.

The Role of Biopesticides in Filling the Gaps

Biopesticides offer a viable solution to many challenges in the UK horticultural

market. Derived from natural sources, such as microorganisms, plants, and minerals, biopesticides present lower risks to human health and the environment than traditional synthetic chemicals. They can target specific pests and diseases without harming beneficial organisms, making them ideal for use in IPM strategies.

Several biopesticide products have the potential to address key pest and disease challenges in the UK:

- **Bacillus thuringiensis (Bt):** A microbial insecticide that targets caterpillars, including those affecting brassica crops. Bt is widely used in organic farming and effectively manages resistant pests.
- **Azadirachtin (Neem):** A plant-based insecticide offering broad-spectrum pest control. Widely used in organic farming systems globally, it could help address the growing issue of aphid resistance in the UK's fruit and vegetable sectors.
- **Metarhizium anisopliae:** Effective against soil-dwelling pests like vine weevils, this fungal bioinsecticide is particularly useful for ornamental plants and certain horticultural crops.

The Future of Biopesticides in the UK

To fully realise the potential of biopesticides in the UK horticultural market, several key steps must be taken:

- **Regulatory Reform:** The UK must avoid the slow, EU-based regulatory processes hindering biopesticide registration. Faster, more efficient

approval pathways can help bring innovative biopesticide products to market sooner, supporting growers in transitioning to sustainable crop protection methods.

- **Increased Investment:** As global investment in biopesticide research and development grows, the UK must also increase its investment in this sector. Public and private partnerships can help drive innovation, bringing new products to market that address specific pest and disease challenges in UK horticulture.
- **Farmer Education and Support:** Many UK growers are unfamiliar with the benefits of biopesticides or are hesitant to switch from synthetic chemicals due to concerns over efficacy and cost. The government can help build grower confidence in these products by increasing field demonstrations and offering financial incentives for adopting biopesticides.
- **Market Access:** Improved access to the UK market for biopesticide products developed in other regions would allow UK growers to benefit from advances in biocontrol technologies. Greater alignment with international regulatory frameworks and faster approval processes are crucial.

A Sustainable Future for UK Horticulture

Biopesticides can potentially fill the gaps left by synthetic agrochemicals in the UK horticultural market, addressing the growing pest and disease resistance issue while promoting sustainable farming practices. However, the UK's regulatory system must evolve to allow for the faster approval of these products, and significant investment is needed to support the development and adoption of biopesticides. With the right regulatory reforms, increased market access, and more significant investment in education and infrastructure, biopesticides can be crucial in ensuring the future sustainability and productivity of the UK horticultural sector.



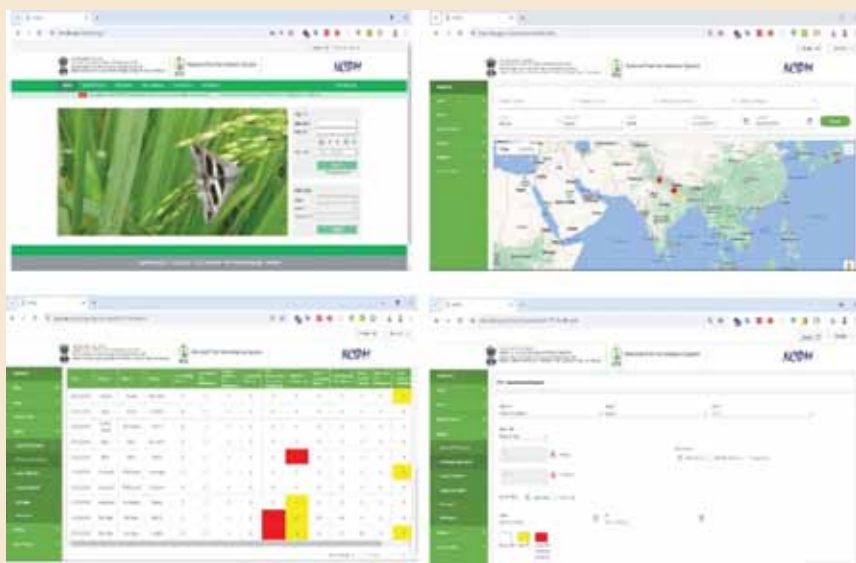
AI-BASED PEST IDENTIFICATION AND SURVEILLANCE SYSTEM FOR FARMERS

India is a vast country with diverse agro-climatic conditions, numerous varieties of crops and cropping systems. Agriculture production is prone to several challenges. One of the challenges is pest attack which causes losses of up to 20% in food production. Expectedly, crops face diverse kind of pest and disease attacks. Thus, it is imperative for different central and state agencies to correctly identify, record and monitor the pest population so as to advise the farmers for effective and timely pest mitigation measures. Regular wide-area pest surveillance/monitoring is the cornerstone of Integrated Pest Management (IPM), through which epidemic situations can be avoided by detecting damage prior to being established into a higher pest population. For effective pest management, farmers need timely access to expert support on pest identification or pest surveillance based expert decisions as advice. However, in the absence of knowledge and expertise, farmers are over dependent on pesticide dealers for pest management decision-support in the country, which results in excessive, injudicious, and irrational use of chemicals for the pest control.

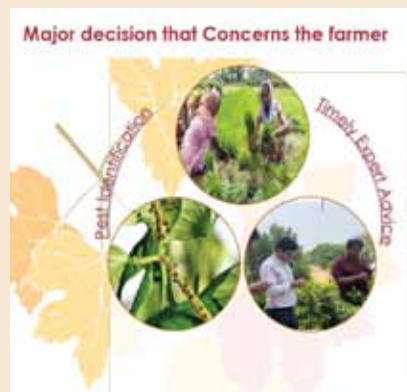
Timely availability of expert support on pest identification and pest surveillance based expert decisions as advice can either result in saving crop worth several crores of rupees or in non-application of pesticides saving cost involved and the environment. Through regular and systematic pest surveillance, epidemic situations can be avoided by detecting damage before endemic establishment of a pest in any area.

Modern Technologies

Application of modern technologies such



The National Pest Surveillance System (NPSS) is a crucial step towards safeguarding crop yields and farmers' incomes through proactive pest management.

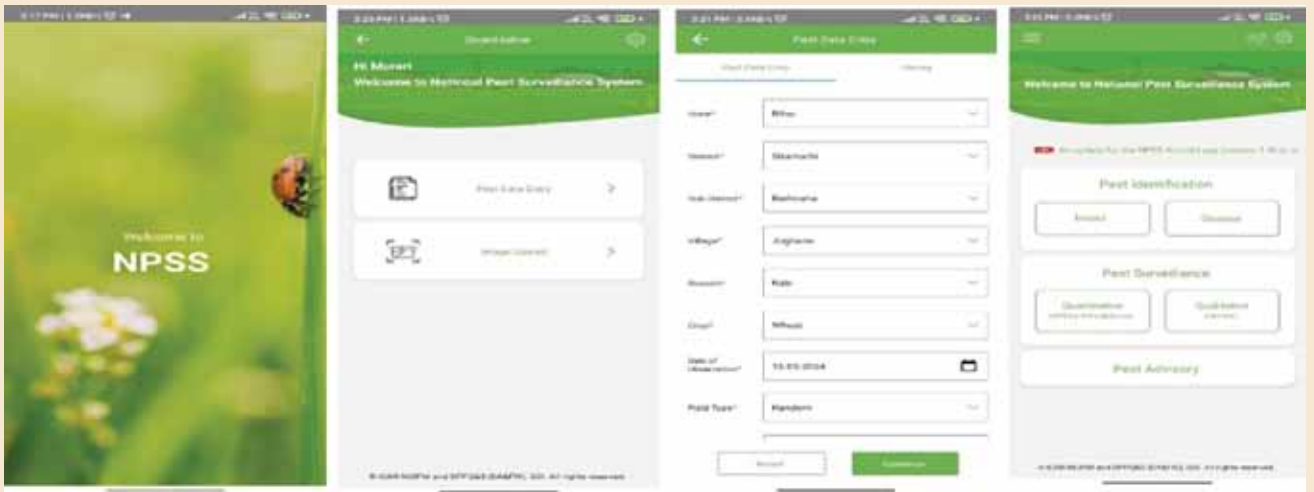


as Artificial Intelligence (AI) and Information and Communication Technology (ICT) can automate and speed up the process of regular and systematic wide-area pest surveillance. Hence, ICAR-NCIPM in collaboration of DPPQ&S (DA&FW), ICAR-IASRI, Plantix and AI-Wadhvani developed National Pest Surveillance System (NPSS) leveraging digital technologies such as Artificial Intelligence (AI), smart phones and web-based tools.

NPSS, an Artificial Intelligence (AI)-

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based platform aims to connect the farmers with the agricultural researchers to reduce the crop losses and enhance the production and productivity at the farmer's field. This initiative is part of a broader strategy to reduce farmers' reliance on pesticide retailers and promote a scientific approach in the management of Insect-pests.

Aspects of NPSS

The system uses AI to correctly identify the pest problem and thus provides pest management information. The system has functionality for quantitative and qualitative pest surveillance of farmers' fields so as to advice appropriate pest management advice, on the basis of pest situation of the farmers' field.

NPSS comprises of Mobile app and Web portal

Mobile app has pest identification as well as pest surveillance capability to provide correct pest management advice to the farmers.

Web portal consists of a dashboard and pest reporting in different formats.

Utility of the System for Farmers

The National Pest Surveillance System (NPSS) is a crucial step towards safeguarding crop yields and farmers' incomes through proactive pest management. It is a game-changer for the



plant protection in the country. This comprehensive system provides easy and timely access to expert support for pest identification and surveillance-based pest management advice to farmers across the nation. By offering accurate pest identification and timely management recommendations, the NPSS app greatly enhances productivity and efficiency in the agricultural field. The NPSS system will assist in avoiding pest epidemics and minimizing crop loss due to pests by leveraging real-time data submission from government agencies, resources, and lead farmers. Furthermore, it maintains a repository of the national pest scenario, which is accessible to various public agencies

working in the field of plant protection. This repository helps in identifying pest hotspots and formulating effective plant protection policies. With its intuitive interface and comprehensive features, the NPSS app is beneficial for farmers and agricultural professionals looking to stay ahead in plant protection, ultimately revolutionizing how pests and diseases in major crops are managed.

Presently, NPSS is enabled for providing pest identification for 61 crops and pest surveillance services for selected 15 crops in Hindi and English languages. The NPSS mobile app is available on the Google and Apple play stores for download whereas the web portal is available at <https://npss.dac.gov.in>.

NANO DAP: FUTURE OF EFFICIENT NUTRIENT MANAGEMENT IN AGRICULTURE

Fertilizers play a crucial role in enhancing soil fertility and boosting crop yields. Among the various types of fertilizers, Diammonium Phosphate (DAP) is widely used due to its high phosphorus content, which is essential for plant growth.

However, traditional DAP fertilizers often face challenges related to nutrient efficiency and environmental impact, such as nutrient losses through leaching, volatilization, and runoff. The development of Nano DAP fertilizers, leveraging nanotechnology to improve nutrient delivery and uptake, has emerged as a promising solution to these challenges. IFFCO Nano DAP, for example, contains nitrogen (8.0% N w/v) and phosphorus (16.0% P₂O₅ w/v) in a formulation with particles smaller than 100 nanometers (nm). This nano-scale particle size enhances the surface area to volume ratio, facilitating better penetration through the seed surface, stomata, and other plant openings. Additionally, biopolymers and excipients improve the stability and dispersal of nitrogen and phosphorus nano-clusters within the plant system, resulting in increased seed vigor, chlorophyll content, photosynthetic efficiency, improved quality, and higher yields.

Unique Properties of Nano DAP Fertilizer

Nano DAP fertilizers are characterized by their Nano scale particle size, typically ranging from 1 to 100 nanometers. This reduction in particle size allows for several advantageous properties:

- **Increased nutrient uptake:** The nanoscale particles provide a larger surface area, enhancing the dissolution and absorption of phosphorus and ammonia in the soil, leading

Nano DAP fertilizers represent a significant advancement in agricultural technology, offering a transformative approach to nutrient management

to more efficient nutrient uptake by plants.

- **Sustained nutrient release:** Nano DAP fertilizers are designed for gradual nutrient release, minimizing leaching and ensuring a steady supply of essential nutrients over time.
- **Environmental sustainability:** The improved efficiency of nutrient use in Nano DAP reduces the need for excessive fertilizer application, thereby lowering the potential for runoff and environmental contamination.
- **Enhanced soil interaction:** The nano-sized particles in Nano DAP improve interaction with soil particles, enhancing nutrient availability and reducing nutrient fixation.



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- **Better compatibility with soil microorganisms:** The nanoscale formulation of Nano DAP enhances its interaction with beneficial soil microorganisms, promoting a healthier soil ecosystem and improving nutrient cycling, which contributes to better overall soil fertility.

How Nano DAP Addresses Fertilizer Loss Issues?

Nano DAP Fertilizer offers several key advantages that address common issues with traditional fertilizers, enhancing nutrient management and reducing environmental impact:

Reduced Leaching: Nano DAP fertilizers are designed with slow-release properties that help minimize nutrient loss through leaching. The nanoparticles release nutrients gradually over time, ensuring that they remain available for uptake by plant roots. This controlled release reduces the risk of nutrients being washed away by water, leading to more efficient use of applied fertilizers and less environmental contamination.

Lower Volatilization: Nano DAP's advanced formulation includes mechanisms to control the release of nutrients, which effectively reduces the volatilization of ammonia and other gases into the atmosphere. By minimizing the loss of gaseous nutrients, Nano DAP enhances overall nutrient use efficiency and contributes to better air quality.

Minimized Runoff: The improved nutrient uptake facilitated by Nano DAP fertilizers reduces the need for excessive fertilizer applications. By ensuring that plants absorb a higher proportion of the applied nutrients, Nano DAP decreases the likelihood of nutrient runoff into surface water bodies. This helps to prevent water pollution and mitigate eu-

trophication in aquatic systems.

Improved Nutrient Availability: The nanoscale particles in Nano DAP fertilizers are engineered to release nutrients in a form that is more readily accessible to plants. This design reduces the fixation of nutrients by soil particles, making them more available for plant uptake. As a result, Nano DAP increases the overall efficiency of nutrient use and enhances crop productivity.

Enhanced Soil Interaction: Nano DAP fertilizers are designed to improve interactions with soil components due to their small particle size. This enhanced interaction helps to integrate the nutrients more effectively into the soil matrix, promoting better nutrient distribution and reducing the likelihood of nutrient fixation. As a result, Nano DAP supports more uniform and efficient nutrient availability throughout the soil profile, further optimizing plant growth and soil health.

Traditional Fertilizers vs. Nano DAP

To highlight the benefits of Nano DAP in mitigating fertilizer losses, the following table provides a comparative analysis of the efficiency and environmental impact of traditional fertilizers versus Nano DAP fertilizers:

Challenges and Limitations

Cost of Production: The manufacturing of Nano DAP fertilizers involves sophisticated nanotechnology and specialized equipment, which results in higher production costs. This elevated cost can restrict access to Nano DAP for small-scale farmers and limit widespread adoption, potentially impeding its integration into mainstream agricultural practices.

Regulatory Concerns: The incorporation of nanomaterials in agriculture presents regulatory and safety chal-

Challenges in Nitrogen and Phosphorus Fertilizer Management

Nitrogen (N) and phosphorus (P) fertilizers are essential for crop growth, but their efficiency can be compromised by several key mechanisms of nutrient loss:

- Leaching
- Volatilization
- Runoff
- Nutrient Fixation
- Microbial Immobilization

lenges. There is a need for rigorous research to evaluate the long-term effects of nanoparticles on human health, soil ecosystems, and environmental safety. Current regulations may not fully address the complexities of nanotechnology, necessitating updates and comprehensive guidelines.

Market Penetration:

Although Nano DAP fertilizers offer significant benefits, they are still in the early stages of market adoption. Effective penetration into the agricultural market requires targeted education and training for farmers, as well as increased awareness about the advantages and optimal usage of these advanced fertilizers.

Scalability of Production: Scaling up production of Nano DAP fertilizers to meet global demand poses logistical and technical challenges. Ensuring consistent quality and availability at a large scale while maintaining cost-effectiveness is crucial for broader adoption.

Compatibility with Existing Practices: Integrating Nano DAP fertilizers with existing agricultural practices and

equipment can be challenging. Farmers may need to adapt their techniques and equipment to accommodate the unique properties of Nano DAP, which requires additional training and potential modifications to current practices.

Long-term Efficacy: While initial studies suggest benefits, the long-term efficacy and stability of Nano DAP fertilizers in diverse environmental conditions and soil types remain under investigation. Continued research is needed to validate their performance over extended periods and across various agricultural settings.

Public Perception: The use of nanotechnology in agriculture may face skepticism or resistance from the public due to concerns about the safety and environmental impact of nanomaterials. Addressing these concerns through transparent communication and evidence-based studies is essential for gaining public trust and acceptance.



Future Prospects

Nano DAP fertilizers represent a significant advancement in agricultural technology, offering a transformative approach to nutrient management. By enhancing nutrient absorption, increasing crop yields and reducing environmental impact, Nano DAP addresses several common issues associated with traditional fertilizers, such as nutrient loss through leaching, gas emissions, runoff and nutrient fixation. These advantages position Nano DAP as a more efficient and eco-friendly option for modern farming practices. Continued research and development are crucial to overcoming existing challenges and improving the technology's efficacy and affordability. With ongoing innovation and adaptation, Nano DAP could revolutionize nutrient management, leading to more sustainable farming practices that enhance productivity while safeguarding environmental health.

Fertilizer Type	Leaching Loss	Volatilization Loss	Runoff Loss	Nutrient Fixation	Overall Efficiency
Traditional DAP	High	Moderate	High	Moderate	60%
Nano DAP	Low	Low	Low	Low	85%

FOOD AND NUTRITIONAL SECURITY IN INDIA

CHALLENGES AND PATHWAYS FORWARD

In a country as vast and diverse as India, ensuring that every citizen has access to sufficient, safe, and nutritious food is a monumental challenge. Food security goes beyond just having enough to eat; it also encompasses nutritional security, which means ensuring that the food people consume is rich in the essential nutrients needed for a healthy life. Despite significant progress over the years, India continues to face persistent challenges in achieving comprehensive food and nutritional security.

Understanding Food and Nutritional Security

Food security is generally understood as having physical, social, and economic access to sufficient, safe, and nutritious food that meets dietary needs and food preferences for an active and healthy life. Nutritional security, on the other hand, focuses on the quality of the diet and the availability of essential micronutrients like vitamins and minerals. Food and nutritional security is defined as condition under which adequate food



A lack of agricultural emissions data prevents banks from informing customers about their progress in reducing emissions.

(quantity, quality, safety, socio-cultural acceptability) is available and accessible for and satisfactorily utilized by all individuals at all times to live a healthy and happy life.

India's struggle with food security has historical roots, but the issue has evolved over time. The Green Revolution of the 1960s and 70s significantly increased the country's agricultural output, helping to alleviate widespread hunger. However, while food production has improved, issues like unequal distribution, poverty, and malnutrition have persisted. The challenge today is not just to produce enough food, but to ensure that the food available is nutritious and accessible to all segments of society.



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The State of Food and Nutritional



Security in India

India has made substantial progress in reducing hunger, but the country still faces significant hurdles. According to the Global Hunger Index (GHI) 2023, India ranked 111th out of 125 countries, indicating that hunger remains a serious issue. The situation is particularly dire in rural areas, where poverty and lack of access to resources exacerbate food insecurity. The COVID-19 pandemic further intensified these challenges, pushing millions back into poverty and worsening food and nutritional insecurity.

Nutritional security is another area of concern. Despite being a major food producer, India is home to a large population of undernourished people. The National Family Health Survey (NFHS-5) reveals that nearly 36% of children under five years are stunted, and 19% are wasted. Additionally, a significant portion of the adult population suffers from micronutrient deficiencies, including iron, vitamin A, and iodine. These deficiencies can lead to serious health

According to the Global Hunger Index (GHI) 2023, India ranked 111th out of 125 countries, indicating that hunger remains a serious issue.

issues, including impaired cognitive development in children and increased vulnerability to diseases.

Challenges to Food and Nutritional Security

Several factors contribute to the ongoing challenges of food and nutritional security in India:

- **Poverty and Inequality:** A significant portion of India's population lives below the poverty line, limiting their access to sufficient and nutritious food. Economic disparities also mean that

even when food is available, not everyone can afford it.

- **Agricultural Productivity:** While India is a top producer of several crops, agricultural productivity is often hampered by factors such as inadequate infrastructure, lack of access to modern farming techniques, and climate change. Small and marginal farmers, who make up the majority of India's farming community, are particularly vulnerable.
- **Climate Change:** Changing weather patterns, increased frequency of extreme weather events, and rising temperatures are affecting crop yields. Climate change also poses a threat to water security, which is crucial for agriculture.
- **Post-Harvest Losses:** India loses a significant portion of its food produce due to inadequate storage, poor transportation, and lack of processing facilities. These post-harvest losses not only reduce the availability of food but also affect its affordability.

- **Malnutrition and Dietary Diversity:** The Indian diet is often heavily reliant on staples like rice and wheat, leading to a lack of dietary diversity. This contributes to micronutrient deficiencies, particularly in children and women.
- **Public Distribution System (PDS) Inefficiencies:** India's PDS, which is designed to provide subsidized food to the poor, faces issues such as corruption, inefficiency, and exclusion errors. These problems prevent the most vulnerable populations from accessing the food they need.

Pathways to Achieve Food and Nutritional Security

Addressing the challenges of food and nutritional security requires a multi-faceted approach. Here are some key strategies:

- **Improving Agricultural Productivity:** Enhancing agricultural productivity is crucial for food security. This can be achieved through better access to technology, improved irrigation, and the adoption of sustainable farming practices. Initiatives like the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) aim to improve irrigation infrastructure, while the promotion of organic farming and agroforestry can help make agriculture more sustainable.
- **Strengthening the Public Distribution System:** Reforming the PDS to make it more efficient and inclusive is essential. This includes leveraging technology to reduce leakages, improving targeting mechanisms to ensure that the right people receive benefits, and enhancing the nutritional quality of the food provided.
- **Promoting Dietary Diversity:** Educating the population about the importance of a balanced diet and promoting the consumption of a variety of foods, including fruits, vegetables, pulses, and animal-sourced foods, can help address micronutrient deficiencies. Programs like the Mid-Day Meal Scheme in schools, which pro-



While significant progress has been made, much work remains to be done to ensure that all Indians have access to sufficient, safe, and nutritious food.

vides nutritious meals to children, play a vital role in this regard.

- **Reducing Post-Harvest Losses:** Investing in better storage facilities, improving transportation infrastructure, and developing food processing industries can help reduce post-harvest losses. The government's Pradhan Mantri Kisan Sampada Yojana (PMKSY) is a step in this direction, aiming to create modern infrastructure for the food processing sector.
- **Combating Climate Change:** Adapting to and mitigating the impacts of climate change is critical for food security. This includes developing cli-

mate-resilient crops, promoting water conservation practices, and investing in renewable energy for agriculture.

- **Empowering Women:** Women play a crucial role in food production and nutrition within households. Empowering women through education, access to resources, and involvement in decision-making can have a positive impact on food security and nutrition.

Towards a Food and Nutritional Secure India

Achieving food and nutritional security in India is a complex challenge that requires coordinated efforts from the government, private sector, and civil society. While significant progress has been made, much work remains to be done to ensure that all Indians have access to sufficient, safe, and nutritious food. By addressing the root causes of food insecurity, promoting sustainable agricultural practices, and enhancing the efficiency of food distribution systems, India can move closer to achieving the goal of food and nutritional security for all its citizens.



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INDIAN CHAMBER OF FOOD AND AGRICULTURE



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