March 2024

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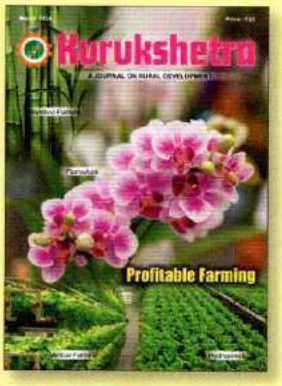

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JOINT DIRECTOR (PRODUCTION)
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COVER DESIGN
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EDITORIAL OFFICE
Room No. 653,
Publications Division,
Soochna Bhawan, C.G.O. Complex,
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1 Year : ₹ 230

Kurukshetra

A Journal on Rural Development

Vol. 72 | No. 5 | Pages 52 | March 2024

Contents

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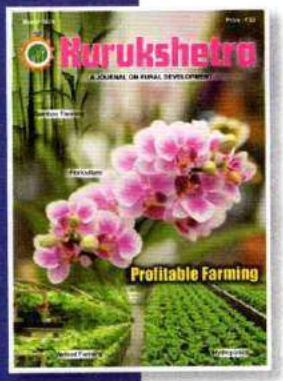

Editorial

In a time when there is a growing need for both profitable agricultural operations and sustainable food production, the farming industry has changed dramatically. Successful agricultural businesses nowadays have to handle a complicated web of obstacles, such as shifting market dynamics, environmental issues, and technological breakthroughs. The pursuit of profitability, which is at the core of this evolution, calls for creativity, resiliency, and a sharp awareness of new trends.

As we embark on this journey of exploration and discovery within the realm of Profitable Farming, it is imperative to recognise the multifaceted nature of the agricultural sector. The article *'Adoption of Digital and Innovative Farming Techniques'* discusses how innovative farming practices are ushering in a new agricultural era, which bring a remarkable transformation through the combination of cutting-edge technologies and novel approaches. The article also attempts to explain how the FPOs facilitate the connection between farmers, their produce, and the market, transforming the entire agricultural value chain, from upstream activities like planting and inputs to downstream ones like post-harvest handling and value addition, presenting a significant opportunity for digital agriculture.

The incorporation of technology is one of the main factors influencing the profitability of contemporary farming endeavours. Technological breakthroughs offer unparalleled efficiency improvements and resource optimisation in a variety of fields, including robotic automation, data analytics, precision agriculture, and vertical farming systems. Farmers may optimise their bottom line by streamlining processes, minimising waste, and increasing productivity by utilising digital tools and state-of-the-art solutions.

Moreover, farming endeavours must combine a dedication to sustainability with a desire of profitability. Farmers are essential to the preservation of natural resources, the mitigation of climate change, and the advancement of biodiversity since they are stewards of the land. The authors in the article *'Organic Farming: Benefits, Present Status, and Future Prospects'* comprehend on a multitude of benefits that organic farming contributes to the overall well-being of the environment, society, and economy. They further discuss that the atmosphere needed for the widespread adoption of organic methods will be created by bolstering current programmes, offering financial incentives, and addressing the difficulties farmers confront.

Apart from innovation in technology and sustainability, diversity is deemed essential for successful farming endeavours. Farmers can reduce their exposure to market volatility and external shocks by diversifying their product offerings, markets, and revenue streams.

This issue of Kurukshetra also provides insight into the multifaceted world of *'Bamboo Farming'*, *'Mushroom Cultivation'*, *'Apiculture'*, and *'Floriculture and Commercial Potential of Orchids'*, exploring their commercial potential, the variables influencing their development, and the particular opportunities and challenges that promise a vibrant future for growers, exporters, and enthusiasts alike.

In order to achieve profitability in farming ventures, a comprehensive strategy that incorporates technical innovation, sustainability, and diversity is needed. Through the adoption of these concepts and the utilisation of teamwork, modern farmers may set themselves up for success in a world that is changing quickly.

Adoption of Digital and Innovative Farming Techniques

Digitalisation is crucial for Indian agriculture to enhance competitiveness and achieve self-sustainability. With the advent of FPOs in India, there is a great opportunity for digital agriculture to cover the whole agricultural value chain, from upstream operations like cultivation and inputs to downstream activities like post-harvest handling and value addition like food processing. The FPOs facilitate the connection between farmers, their produce, and the market.

* Souvik Ghosh
** Shreya Anand

Agriculture has undergone a series of revolutions that have increased efficiency, production, and profitability to unprecedented levels. The present decade has been witnessing the emergence of a 'digital agricultural revolution' as the latest transformation, poised to address the numerous challenges of agriculture and the food sector caused by a growing population, resulting in increased demand for food and an increasingly limited availability of natural resources such as fertile land and fresh water. To achieve the UN Sustainable Development Goal of a 'world with zero hunger' by 2030, the existing agrifood system must be transformed into one that is more productive, sustainable, efficient, and resilient. In this setting, digital agriculture has the potential to generate economic benefits by increasing agricultural output, improving cost efficiency, and expanding market prospects. It can also have a positive impact on society and culture by encouraging more communication and inclusion. Furthermore, digital agriculture benefits the environment by improving resource utilisation and promoting climate change adaptation (FAO, 2019).

* *The author is Professor at the Department of Agricultural Extension, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati (A Central University), Sriniketan. Email: souvik.ghosh@visva-bharati.ac.in*
** *The author is Doctoral Scholar at the Department of Agricultural Extension, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati (A Central University), Sriniketan. Email: shreya6anand@gmail.com*

India ranks first in the production of milk, jute, and pulses, and second in wheat, rice, groundnut, vegetables, fruits, cotton, and sugarcane production. It is also one of the largest producers of fish, livestock, poultry, spices, and plantation crops (http://www.fao.org/india/fao-in-india/india-at-a-glance/en). Thus, while output is not the most serious issue in Indian agriculture, small holdings lead to insufficient revenue for farmers. One option for increasing farmer incomes is to use digital technology in agriculture to increase the overall efficiency of agricultural production operations and the entire value chain. In the ever-changing agricultural landscape, the use of digital and new farming practices is transforming the way crops and cattle are farmed. As the population continues to grow, farmers have the problem of producing more food in a sustainable and effective manner. Digital technologies and novel farming techniques provide options for increasing productivity, lowering environmental impact, and ensuring food security for the growing population.

Innovative Farming Practices

Innovative farming practices are ushering in a new agricultural era, one that is more sustainable, efficient, and resilient. It brings a remarkable transformation through the combination of cutting-edge technologies and novel approaches.

Some of the emerging farming practices that are reshaping the future of agriculture are briefly discussed here.

1. Precision Agriculture

The International Society for Precision Agriculture, asserting itself as the sole global scientific society entirely dedicated to Precision Agriculture, defines it as a management approach that involves collecting, processing, and analysing temporal, spatial, and individual data. This data is then integrated with other information to aid management decisions based on estimated variability, aiming to enhance resource utilisation efficiency, productivity, quality, profitability, and sustainability in agricultural production (https://ispag.org/site/newsletter/?id=90). Precision agriculture is at the forefront of the digital farming revolution, utilising Global Positioning System (GPS), sensors, drones, and data analytics to improve numerous areas of farming. Precision agriculture allows farmers to precisely regulate inputs such as water, fertiliser, and pesticides, leading to higher efficiency and less waste.

2. Smart Farming

Smart farming combines Internet of Things (IoT) devices with connectivity to form a networked and automated agricultural ecosystem comprised of sensors, actuators, and intelligent equipment that collect and exchange data in real time. It is a new term that refers to managing farms with IoT, robotics, drones, and artificial intelligence (AI) to boost the number and quality of products while optimising the human labour required for production. It specifically mentions sensors, software, networking, location (GPS, satellites, etc.), robots, and

data analytics as technologies that can be employed in smart agriculture. A centralised platform allows farmers to remotely monitor and control many parts of their business. Modern agriculture is increasingly reliant on automated machinery, such as self-driving tractors and robotic harvesters. These technologies reduce farmers' physical workload while increasing precision and efficiency in tasks such as planting, harvesting, and weed control.

3. Vertical Farming and Controlled-Environment Agriculture

Vertical farming and controlled-environment agriculture (CEA) are becoming increasingly popular as urbanisation increases. These novel methods involve growing crops in stacked layers or under regulated conditions, such as greenhouses or hydroponic systems. Vertical farming maximises land use efficiency while minimising the environmental impact of traditional farming operations. Farmers may establish ideal circumstances for plant development all year by using artificial lighting, climate control, and fertiliser solutions. This not only increases agricultural yields but also enables crop growth in climatically vulnerable areas.

4. Blockchain Technology in Agriculture

Blockchain technology is making its way into agriculture by improving transparency and traceability throughout the supply chain. Farmers, wholesalers, and consumers can use blockchain to keep a secure and unalterable record of all agricultural product transactions and movements. This ensures the authenticity of food products, lowers the danger of fraud, and allows consumers to make informed decisions about the origin and quality of their foods.

Digital Farming Techniques

Digital farming approaches include a wide range of technologies and strategies used to optimise agricultural processes with digital tools. Some important characteristics of digital farming and related techniques are discussed here:

1. **Technologies in Precision Agriculture:** A key element of precision agriculture is GPS technology. It enables farmers to plan their fields precisely, which makes it easier for machines to navigate and applies resources in the right places. Additional technologies, such as the use of field-based sensors, offer real-time information on crop health, nutrient levels, and soil moisture. Weather stations and environmental sensors are examples of IoT equipment that add to a thorough knowledge of the farm's conditions.

2. **Drones:** High-resolution photographs of fields are taken by drones fitted with cameras and sensors (crop monitoring). Farmers can spot problem regions, including pest infestations, nutrient shortages, or water stress, with the use of this aerial imagery. Surveying vast areas quickly and effectively is made possible by drones.

3. **Automated Technology:** Without the need for direct human assistance, automated equipment with GPS and sensor technology can carry out operations including planting, harvesting, and ploughing (autonomous tractors and harvesters). This guarantees accuracy in farming operations while simultaneously lowering labour expenses.

4. **Variable Rate Technology (VRT):** It enables the application of inputs such as water, herbicides, and fertilisers to a field at different rates. This method makes sure resources are applied exactly where and when they are needed by considering the spatial variability of crop and soil conditions.

5. **Smart Irrigation System:** Soil moisture sensors are used by smart irrigation systems to calculate the amount and timing of water that crops require. By doing this, excessive irrigation is avoided, protecting water supplies and enhancing crop health. Remote control of automated irrigation systems is possible via web or mobile applications.

6. **Data-driven Farm Management:** Software programmes and digital platforms assist farmers in managing several facets of their businesses. These technologies frequently combine information from several sources, such as crop health, soil conditions, and weather forecasts. With the use of farm management software, farmers can plan their planting, watering, and harvesting operations with confidence.

7. **Robots for Agricultural Operations:** The usage of robots for agricultural operations is growing. These autonomous vehicles can go across fields,

effectively harvesting crops or spotting and eliminating weeds. Robotics decreases the need for physical labour while increasing efficiency.

8. **Machine Learning:** To forecast crop yields, disease outbreaks, and market trends, machine learning algorithms examine both historical and current data (crop prediction models). Farmers may now make proactive decisions and modify their plans in response to situations that are predicted through these predictive analytics.

9. **Blockchain:** Supply chains may be made transparent and safe with the help of blockchain technology. A blockchain can record every step of the agricultural supply chain, from planting to delivery. In addition to ensuring traceability, this promotes consumer confidence in the origin and quality of agricultural products.

10. **Digital Twins:** Digital twins create virtual replicas of physical farms. This allows farmers to simulate and optimise various scenarios before implementing changes in the real world. Digital twins contribute to efficient planning and resource management.

Application and Adoption of Digital Agriculture Technologies

India's startups are contributing significantly to the increase in farm mechanisation. In certain clusters, for instance, herbicides and fertiliser are applied by drones. These kinds of solutions lessen the need for labourers while also lowering the risk of exposure to hazardous materials. Additionally, crop health monitoring is improved by drone and remote sensing-based technologies, which do not require physical field inspections. Since winter 2019, locusts have been relentlessly damaging India's crops, forcing the federal and state agriculture ministries to spray crops with anti-locust insecticides using drones. Particularly in the states of Rajasthan, Gujarat, Madhya Pradesh, and Uttar Pradesh, drones have shown promise in reducing agricultural losses (CSD, 2020).

A handful of agri-tech startups have found remarkable success with digital extension by utilising SMS in local languages along with audio and video material. An enormous advance above generic advisories in the classic extension is local actionable intelligence, which is being provided by several firms by combining data from various sources such as weather, drones, remote sensing, and local situations. A few companies have hired farmers as co-producers of information and set up phone centres to encourage two-way communication. Collaborations with progressive farmers, community-based groups, government-funded institutions, and FPOs are essential to the success of all these projects.

Productivity is significantly impacted by the cost and quality of agricultural inputs, and farmers mostly depend on dealers for advice. Misaligned incentives, however, have the potential to damage soil fertility by causing excessive input use or inferior results. The Economic Survey 2018–19 notes that several issues are causing fertiliser response ratios to decline, and input companies are facing high transaction costs because of intricate supply networks. By precisely determining plant requirements and aggregating input demand, digital technologies provide solutions that lower costs and improve access to high-quality inputs for the benefit of both businesses and farmers. IBM developed AgroPad, an AI-driven tool that helps farmers rapidly evaluate the quality of their soil and water. This business card-sized paper gadget has a microfluidics chip that analyses samples chemically in a matter of seconds. Farmers can view colorimetric test results on the back of the card by pouring a drop of soil or water onto the AgroPad. Farmers can take a picture of the AgroPad with their smartphone and get test results for their samples right away with a dedicated mobile app (CSD, 2020).

Indian farmers are inclined towards water-intensive crops in their cropping pattern (FAO and ICRISAT, 2022). Some startups are promoting the use of Internet of Things (IoT) devices to track water consumption and promote efficient use. Some, meantime, are using data from satellites to accurately estimate water needs and manage irrigation systems remotely. The adoption of digital technologies among farming communities could be accelerated by providing farmers with access to high-quality inputs at lower costs through digital platforms that disseminate the latest technological advancements, and by offering incentives to market participants, especially startup communities.

Minimum Support Price (MSP) realisation was impeded even when farmers were aware of it due to issues such high transportation costs, the lack of MSP-guaranteed procurement sites in neighbouring

villages, and the reluctance of mill owners to purchase small quantities. Nowadays, a few startups are using digital interventions to assist farmers get higher prices. These technologies enable traceability and use image recognition to objectively grade produce. Digital platforms facilitate produce aggregation and direct connections to global sellers, offering farmers information on nearby market prices and MSP to prevent distress sales (FAO and ICRISAT, 2022).

Digital technology in agriculture finds a diverse array of applications and uses. Trringo and EM3 Agriservices lead the farm equipment rental sector, often dubbed the 'Ubers of Agriculture'. They have successfully replicated the Uber model for renting farm machinery and tractors in India. EM3's app, called 'Samadhan', operates under the concept of 'Farming as a Service' (FaaS). Through a network of farm centres run by IT systems and manned by agricultural professionals, it offers a platform for technology to reach farmers effectively and economically while providing a range of basic and precision farm activities throughout the crop production cycle. In the agri-tech industry, Ergos has developed a special 'Grain Bank model' that offers small and marginal farmers complete post-harvest supply chain solutions. During harvest season, farmers can keep or remove grains as little as one bag, giving them instant liquidity and increased revenue by preventing them from selling all of their goods at once. Currently, Ergos provides these services to farmers at the farmgate in Bihar by means of effective technology utilisation and direct farmer interaction. AgNext developed Qualix, a technology platform capable of swiftly assessing trade quality and safety parameters for various commodities such as grains, pulses, tea, spices, herbs, milk, and honey. Yuktix Technologies, a Bangalore-based Agritech startup, specialises in developing digital tools for agriculture farm monitoring and risk management. Their solution assists growers in decision-making and adopting best practices to enhance yield and reduce losses. These tools utilise their hardware and software solution known as GreenSense IoT devices and GreenSense dashboard (CSD, 2020).

Digital Divide

The digital divide in the realm of digital agriculture represents a significant challenge that has far-reaching implications for the equitable adoption and benefits of technological advancements in farming practices. This divide manifests in disparities related to access, connectivity, and technological literacy among various stakeholders in the agricultural sector. While some farmers and agribusinesses in developed regions have seamless access to cutting-edge technologies, including precision farming tools, data analytics, and automated machinery, others in less-developed areas may lack the necessary infrastructure, connectivity, and skills to harness the full potential of digital agriculture. This divide not only widens existing disparities between rural and urban/developed and less-developed areas but also between large commercial farms and smaller, resource-constrained agricultural enterprises. Bridging the digital divide in digital agriculture is crucial for ensuring that all farmers, irrespective of their location or scale, have equal opportunities to leverage technology for sustainable and efficient farming practices. Efforts to enhance digital literacy, provide affordable access to technology, and implement supportive policies are essential in narrowing this gap and promoting an inclusive and technologically advanced agricultural landscape. Promotion of the FPOs is a potential option to tackle the issue of the digital divide.

Conditions for Digital Transformation

The digital transformation of agriculture is influenced by various factors across different contexts. The fundamental conditions necessary for technology utilisation encompass availability, connectivity, affordability, integration of information and communication technology (ICT) in education, and the implementation of supportive policies and programmes, such as those related to e-government, to promote digital strategies.

Additionally, there are enabling conditions, often referred to as 'enablers,' which contribute to the smoother adoption of technologies. These include the widespread use of the internet, mobile phones, and social media. Moreover, factors such as digital skills, along with support for agripreneurial and innovation culture, which involves talent development and initiatives like start-ups, incubators, and accelerator programmes, play a crucial role in further facilitating the incorporation of technological advancements in agriculture.

Digitalisation is crucial for Indian agriculture to enhance competitiveness and achieve self-sustainability.

The level of digital literacy among farmers influences their ability to adopt new technologies. Startups need to acknowledge and address digital literacy gaps, especially among illiterate farmers. Gender disparities in digital access and understanding local sensitivities are important factors to consider for sustaining digital solutions. Encouraging public-private partnerships, promotion of FPOs improving infrastructure, and subsidising access for small farmers are ways the government can support the scaling of digital solutions.

Way forward

India's National AI Strategy seeks to unlock the economic and societal advantages presented by the technology. Additionally, it acknowledges agriculture as a key sector for the deployment of AI-driven solutions (Niti Aayog, 2019). In the farming world, 'Agriculture 4.0' has gained popularity during the last decade. Agriculture 4.0 is the seamless integration of internal and external networking in farming processes, much like Industry 4.0. This means that all facets of farm operations must have digital information, electronic contact must exist with outside parties like suppliers and consumers, and automated data transfer, processing, and analysis procedures must be the norm. Using web-based tools can make managing massive amounts of data easier and improve communication between the farm and outside partners. The future of farming, which will be characterised by autonomous decision-making systems and unmanned operations, is laid out in Agriculture 4.0. Agriculture 5.0 is envisioned to centre around robotics and various forms of artificial intelligence.

With the advent of FPOs in India, there is a great opportunity for digital agriculture to cover the whole agricultural value chain, from upstream operations like cultivation and inputs to downstream activities like post-harvest handling and value addition like food processing. The FPOs facilitate the connection between farmers, their produce, and the market. Because farms are consolidating and there are larger land areas available for technology implementation, precision agriculture and smart agriculture, which cover a variety of digital agricultural technologies, hold potential for adoption within farm productivity organisations. Furthermore, FPOs make technology more accessible and inexpensive, which helps all parties involved — even the smallest-scale farmers—and creates a win-win situation.

Conclusion

An important turning point in the history of agriculture has been reached with the introduction of cutting-edge digital farming practices. Using a comprehensive strategy that incorporates multiple technologies to improve production, sustainability, and efficiency in agriculture is what digital farming entails. These innovations enable farmers to fulfil the demands of an expanding global population, produce more with fewer resources, and lessen their influence on the environment. Farming appears to have a bright future as long as the agricultural sector adopts these innovations and finds sustainable ways to feed the globe in the years to come. In terms of the adoption of digital farming technologies, the establishment and promotion of FPOs have broad potential. ❑

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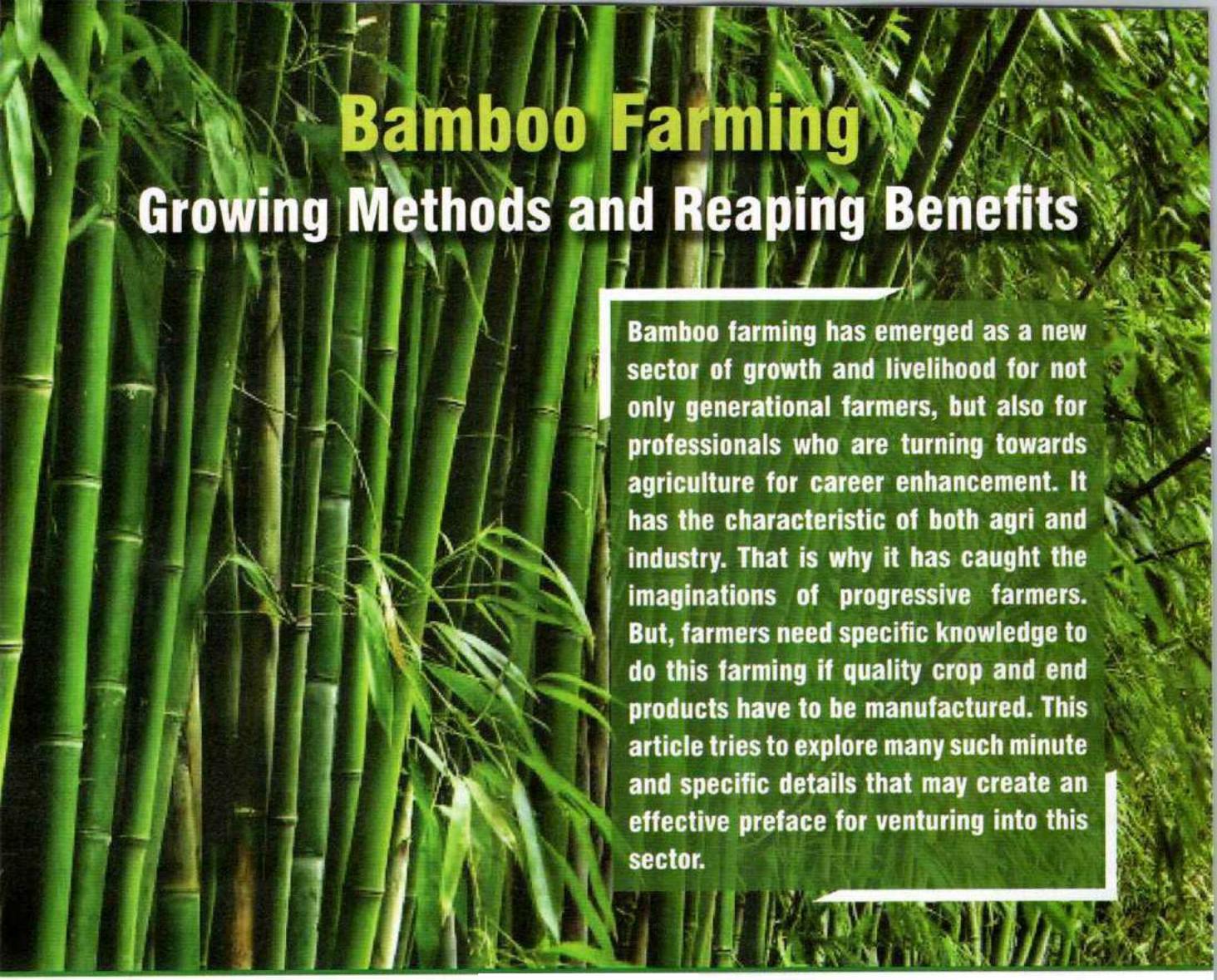


Bamboo Farming
Growing Methods and Reaping Benefits

Bamboo farming has emerged as a new sector of growth and livelihood for not only generational farmers, but also for professionals who are turning towards agriculture for career enhancement. It has the characteristic of both agri and industry. That is why it has caught the imaginations of progressive farmers. But, farmers need specific knowledge to do this farming if quality crop and end products have to be manufactured. This article tries to explore many such minute and specific details that may create an effective preface for venturing into this sector.

Bhuwan Bhaskar

Bamboo farming is the new sensation in the town of progressive farmers. The interesting and the most important fact about bamboo farming is that it could be done both as a full-time and part-time farming. Bamboo can be grown both as a main crop as well as subsidiary crop. It is an environment-friendly crop, requires less maintenance, and has a variety of diverse uses. Most importantly, it has a fast-growing market where people with higher spending capacity are ready to spend more. All these factors have made bamboo farming increasingly attractive for progressive farmers from across the country. Let us take a look on the various stages in bamboo cultivation and how an optimum benefit could be reaped from it.

Climate Requirement

Bamboo may be grown in a broad range of soil types and climates. Bamboo grows well in valleys, around streams, rivers, ponds, and other sources of water, as well as on the lower slopes of hills. Most types of bamboo grow in temperatures between 7°C and 40°C. Rainfall generally encourages bamboo growth, but it also benefits from the combined effects of high temperatures and rainfall. For bamboos, the ideal annual rainfall varies from 1200 mm to 4000 mm. However, semi-dry or dry deciduous woods

The author is Vice President, NCDEX, a leading agricultural commodity exchange and writes on contemporary issues related to agriculture and economy. Email: bhaskarbhuwan@gmail.com. Views expressed are personal.

can also support drought-resistant plants, such as *Dendrocalamus strictus*. They favour soils that are well-drained, poor, coarse, grained, and stony. They are temperature-adaptable, withstanding sporadic frosts with lows of -5°C and summer temperatures as high as 45°C. It can spread throughout regions with yearly rainfall ranging from 750 to 4,000 mm.

With the exception of soils containing large rocks, the majority of bamboo species may be planted and maintained on a wide range of soil types. They thrive best in well-drained, sandy loam to clay loam soils. Bamboo grows best in soil with a pH range of 5.0 to 6.5, while certain species can tolerate a pH of only 3.5. Rich organic matter, moderate moisture content, moderate humidity, and a loose, well-aerated, thick soil type are the ideal soil parameters for maximum production. Additionally, it has been discovered that the optimal growth of bamboo culms is encouraged by soil that is high in nitrogen, P_2O_5, K_2O, CaO, and SiO_2. The most significant element influencing bamboo growth is the nitrogen level of the soil.

While some bamboo species may tolerate little salt, saline soil is generally not ideal for bamboo development. Similar to this, bamboo rhizome and roots deteriorate in swamps and extended periods of flooding, and the rhizome eventually dries up. However, several varieties of bamboo found in Kerala, Tamil Nadu, Goa, and Karnataka are able to withstand brief seasonal floods when planted in flood plains. An excellent way to begin a large-scale bamboo plantation is to set up a bamboo nursery close to the plantation area in a suitable location. On the other hand, the nursery can be set up according to its goals and at varying production and activity levels. A well-drained nursery site is essential, and it should have provisions for irrigation, composting, a potting shed, seed germination beds, and a space for propagating rhizomes.

Site Selection and Land Preparation

The majority of bamboo species are tolerant of a variety of climatic conditions, and they can grow in areas as diverse as high mountains (up to 4,000 m above mean sea level) and coastal regions (below sea level). As a result, bamboos can be grown on a variety of surfaces, including slopes, riverbanks, huge expanses, marginal land, and agricultural boundaries. When choosing a suitable location for large-scale plantations, it is crucial to take into account factors like market potential for the species, access to roads, transportation, and level land with good drainage or slopes up to 10% with adequate water availability. Big plantations can be used for a variety of purposes, such as wood, the agarbathi industry, pulp, edible shoots, bioenergy, furniture, handicrafts, etc.

To get a ballpark estimate of the labour and other resources required, a survey must be completed before the site is prepared. Shrubs, weeds, and other grasses should be removed from the area as they compete with the bamboo for nutrients and moisture. Trees that are scattered over the area can be kept to offer shade and safety. The soil must be thoroughly and deeply tilled. The process of churning enhances the quality of the soil by rearranging its layers. It is necessary to clean and plough three weeks prior to planting. This allows the disturbed soil to adapt to the weather. Fly ash is a useful soil amendment since it may be used in bamboo plantations as a conditioner and soil enricher.

In order to prevent domesticated animals from grazing on young plants and immature culms, as well as human and animal trampling, adequate fencing protection is required. Likewise, it is crucial to take the required fire safety precautions. To create a fire break, all types of bushes, grass, and other vegetation must be cleared from at least a 5-metre radius surrounding the site.

Irrigation

In general, the planting location should have evenly spaced rainfall, and it is preferable to stay away from places that are flooded with plantation water. For plantations as well as bamboo nurseries, irrigation is crucial. Bamboo grows better when it is artificially irrigated. If adequate drainage is not present in the region, it must be

created artificially. During arid periods, 8–13 times a year irrigation can be given, using 10–12 litres of water per plant for the first two years.

The most effective way to maximise water use is with a drip irrigation system. Similarly, if the circumstances allow for frequent replenishment of the water as it is depleted, the use of a clay pot buried up to the neck in the bamboo's root zone may be taken into consideration. Another easy solution is to use an inverted plastic bottle with a wick placed in the neck to allow water to exit slowly. To help the bamboo plant retain water, prepare a trench around it with a minimum radius of 50 cm and pile or mound the soil mixture over and around the base of the plant.

Manuring and Fertilisation

Since bamboo plants need a nutrient-rich environment, even rich soils may be destroyed in a few years if no fertiliser is used. The purpose of fertilisers is to attain high quality and yield. Three essential ingredients of fertiliser are potassium, phosphorus, and nitrogen. Incorporating wood ash, organic compost, and green manures into fertiliser applications maximises yield. Following appropriate soil testing and analysis, manuring and fertilisation can be carried out. It should be mentioned that the NPK composition should be 4:1 or 5:2:1 in normal soil conditions. Chemical fertiliser application on plantations may be as high as 1,500 kg per hectare annually for the creation of culms, and up to 4,000 kg per hectare annually for the production of shoots. It is possible to adhere to the general dose norm of 150 grams N + 150 grams P + 150 grams K.

NPK and dry farmyard manure or vermicompost work well for bamboo. To encourage growth, the clump might get an addition of 15–20 kg of compost or manure. Alternatively, 0.5–1 kg of NPK fertiliser can be applied per well-grown clump in on-farm or high-intensity managed mature bamboo plants.

One or two months after planting, the first fertiliser application can be started. 50 g of NPK and 5 kg of well-rotted manure or compost can be applied. Following this, 100–150 g of NPK and 10 kg of manure or compost may be administered at the start of the following rainy season. The third application is made in the third year, right before the rainy season starts, using 30 kg of compost or manure and roughly 500 g of NPK.

Mulching

The creation of high-quality bamboo shoots requires mulching. Mulching inhibits the growth of weeds and preserves soil moisture. Mulch shields young shoots from direct sunlight and retains moisture in plantations managed for their edible shoots, enabling them to reach their ideal size without becoming hard and losing their edible qualities. Applying a thick layer (10 cm) of leaf litter or other organic materials to the soil's surface surrounding the bamboo cluster will enable uniform mulching. This technique not only stops weed development but also enhances soil fertility and organic carbon, supplies organic nutrients to the plant, and helps to retain soil moisture. It is best to leave the bamboo leaves under the plant rather than raking or sweeping them up since they provide excellent on-site mulch and help to keep the soil moist and soft while recycling silica and other natural chemicals that the bamboo needs.

Soil Mounding

With the rhizomes of older sympodial bamboo plants visible from the soil, soil mounding is typically done. In sympodial bamboos, the rhizome system tends to become exposed above ground when the clump ages, and only the just-emerging shoots grow upward from the horizontal rhizome growth beneath the soil. This typically occurs when there is little to no mulch and the soil is degraded. If exposed to sunlight, rhizomes in such a clump are likely to grow more slowly, and the amount of nutrients and moisture available to them generally tends to be lower.

Bamboo Pests and Control

Certain insects, like mealybugs, mites, and scales only feed on bamboo. Aphids are among those that lack discrimination. By eating the plant, these insects weaken it and leave it more vulnerable to other problems like rot and mildew. During the first few years of the plantation, regular weeding is necessary to prevent weeds and other vegetation from competing with the young bamboo for nutrients. After the rains and around the conclusion of the wet season, it is advised to clear weeds at least twice in the first two years. This will facilitate the fastest ablishment of rhizome and bamboo growth.

To eradicate all weeds and loosen the soil surrounding bamboo clumps, the plantation can be

ploughed from top to bottom. Another choice is to merely loosen the soil around planted bamboo plants and control weeds there. This approach involves removing weeds from a 1- to 1.5-metre radius around the bamboo clumps and loosening the soil from the plant to a minimum of a 50-cm radius and a maximum depth of 15 cm. Coppicing and clump congestion management are also crucial throughout the three- to five-year early maturity stage of bamboo in order to make it easier to collect mature bamboo shoots. Culm management is necessary for species of bamboo that belong to the genera Bambusa, Cephalostachyum, and Dendrocalamus, although it is not a major issue for running bamboos or bamboo with long-necked rhizomes.

Lower branches can be pruned to reduce clump congestion, encourage airflow, and make fertilisation and harvesting easier. For species with significant branching at the lower nodes, such as Dendrocalamus hamiltonii, Bambusa bambos, B. balcooa, and B. nutans, etc., this is crucial. Intense pruning might begin in the fourth year of development, but mild pruning can begin in the second and third years of growth. The best months to prune are December and January.

Harvesting and Yield of Bamboo

Depending on the type of bamboo being grown, harvesting might occur four to six years after a plantation is established for profit. Scientific management of the plantation should include fertilisation as well as pruning, thinning, weeding, and other management techniques. Culms from a mature clump that are two to three years old can be harvested for non-structural uses and applications that do not require their maximum mechanical and physical characteristics.

Zogam Bamboo at Churachandpur, Manipur uses Bamboo to make beautiful Tiffin carriers while utilising local resources

It is not advisable to collect culms during the growing season, which is often the monsoon season. Harvesting at this time could harm immature and developing shoots and prevent clumps from growing in the future. Below are some fundamental harvesting guidelines that need to be adhered to when handling bamboo strands.

I. For the Production of Timber

1. Harvesting is best done during the dry season, unless clump congestion needs to be controlled.
2. They should not be clear-felled as this will cause them to deteriorate into a bushy appearance.
3. After three years or more, all mature bamboo culms should be harvested.
4. It is best to save the current year culms for future generations. In a similar vein, some of the older culms must be kept around to safeguard the younger culms and guarantee their healthy development.
5. The cluster should be kept with a minimum of six culms older than a year, evenly spread out. More mature culms can be kept in proportion to the size of the clumps.
6. There should not be more harvestable culms than there were poles that sprouted the previous.
7. Culms should be carefully examined before being harvested from clumps. They should be felled or cut as low as possible, leaving just one internode above ground. To prevent splitting and damage, a sharp knife or saw should be used while felling.
8. The clump should be cleared of any dead and dry bamboo, as well as any leftover material from harvesting and high cuts (caused by lopping).

II. For Consumable Stems

1. Depending on the species, the shoots must be taken at a height of 15 to 50 cm.
2. The mother rhizome should not be harmed; the dirt around the shoots can be scraped off and sliced with a clean, sharp knife.
3. Shoots exhibiting illness symptoms or deformities ought to be averted, and the strongest and best-growing shoots at the peak stage should be saved to become a new mother bamboo.

4. To prevent congestion, it may be preferable to let some shoots from various cluster areas grow rather than all of the shoots from one location.

Bamboo Use

In addition to many environmental advantages of bamboo growing, it has also become a highly sought-after crop for making a variety of furniture and home décor items. These usage have created a vast premium market for bamboo which is ultimately benefitting farmers economically. Here are some popular usage of bamboo:

Fabrication: When compared to the other materials, bamboo is thought to be incredibly light and delicate. This is due to its exceptional qualities, which render it the most appropriate for use in the production of textiles. When worn, the cloth is cool and breathable. Furthermore, compared to fabrics like cotton and polyester, it absorbs more water. Bamboo fibre material is naturally glossy and antibacterial. This characteristic remains intact even when braided. In addition, compared to other fabrics, it inhibits the accumulation of static electricity.

It outshines other fabrics with its natural deodorising property, to keep oneself odour-free. It prevents abrasion and is extremely permeable. The fabrics made from bamboo are tagged best quality; they meet all the yardsticks of quality standards. The most important feature of bamboo fibre fabric is that it is environment-friendly. It possesses hydroscopic properties as well. Even fabric made from bamboo fibres, mixed with cotton, has the same properties. Bamboo fibres look like cotton when not spun. It is light and airy.

Bamboo as Medicine: Bamboo has several therapeutic uses. Cold, flu, and other common illnesses like nausea and nasal congestion can all be promptly cured with it. Patients are treated with the edible components of the bamboo plant. These components include bamboo shavings, leaves, sap, etc.

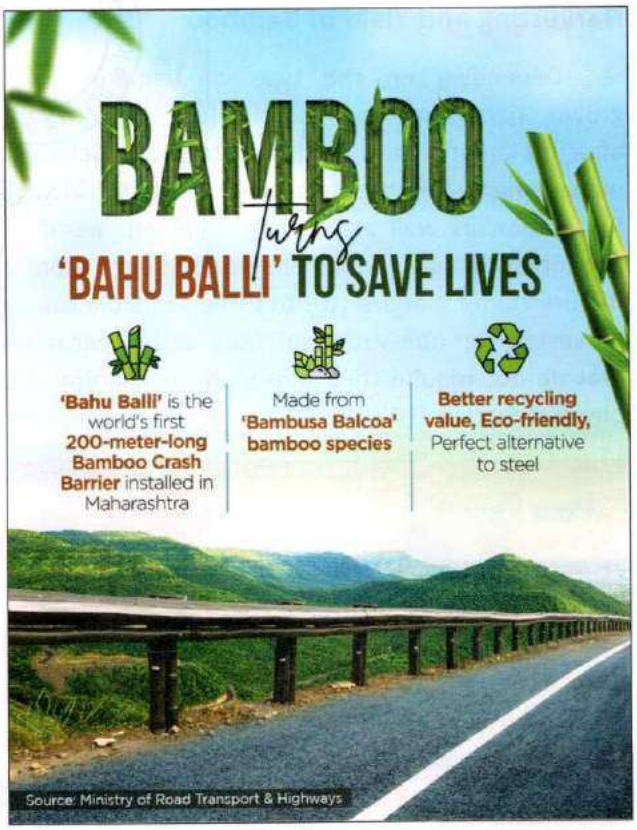
Bamboo Utensils: Bamboo utensils are reasonably priced and long-lasting. Using bamboo cookware is a long-standing and traditional method of cooking food. These dishwasher-safe utensils impart a strong smell to food. Cutlery such as spoons, chopping boards, knife-holders, glasses, cups, and bowls are common.

Bamboo is also used in the manufacture of musical instruments. These guidelines are well-liked and extensively disseminated. Among the instruments are several bamboo species and xylophones, flutes, drums, and so on. For the flute, a young, raw bamboo and an ancient hollow will be chosen.

Economic Contribution of Bamboo to India

As per the 2020 data, bamboo held a 35% market share in the industrial goods area. However, bamboo's market share climbed in 2021, with an estimated 57.86 billion dollars at stake. Bamboo's growing contribution and share have resulted in an estimated 5.7% annual growth rate in compound interest. Bamboo share is now considered a 'fast-growing market' because of its increasing rate.

Industrial bamboo products held a 35% market share in 2020, once again dominating the industry. Bamboo flooring, pulp, paper, and plywood are among the items that are dominated by bamboo. At 75% of the total revenue, the Asia-Pacific area made the largest contribution. India, China, Vietnam, and Myanmar make up these regions. ❑



Mushroom Cultivation
A Fruitful and Lucrative Industry

Mushroom cultivation is one of the most profitable agriculture entrepreneurs. Integrating mushroom cultivation in the existing farming systems will supplement the income of the farmers and promote proper recycling of agro-residues. Mushrooms can supplement and contribute in achieving nutritional and food security. India can emerge as a major player in mushroom production if we efficiently plan to harness the availability of plenty of agricultural residues and labour.

* **Dr. Harender Raj Gautam**
** **Dr. Dharmesh Gupta**

Mushrooms are edible fungi that grow in natural habitats in the wild, on soil, and on wood. Scientists have recognised more than 14,000 species of mushrooms, of which approximately 2000 are edible. These wild edible fungi have been collected and consumed by people for thousands of years in over 85 countries. The archaeological record reveals edible species associated with people living 13,000 years ago in Chile, but it is in China where the eating of wild fungi is first reliably noted, several hundred years before the birth of Christ. The use of wild edible/ medicinal mushrooms in India during the pre-historic period finds references in ancient Vedic literature dating back to 3,000 B.C. and *'Soma'*, a divine drink of immortality, extracted possibly from *Amanita muscaria*, was known to the Aryans.

* *The author is Former Professor and Head, Dr. Y.S.Parmar University of Horticulture and Forestry, Solan Himachal Pradesh. Email: hrg_mpp@yahoo.com*
** *The author is Principal Scientist, Dr.Y.S.Parmar University of Horticulture and Forestry, Solan Himachal Pradesh.*

Button mushroom

Edible fungi were collected from forests in ancient Greek and Roman times and were highly valued by high-ranking people. Caesar's mushroom *(Amanita caesarea)* is one such example, which is very popular edible mushroom and was a favourite of early rulers of the Roman Empire and has been so for more than 2000 years in Italy. This quest for edible fungi and their emerging importance in food developed mushroom cultivation as an entrepreneur industry.

Present Production Scenario

Global mushroom production was 44.2 million tons in 2021 (FAOSTAT, 2023) with the highest contribution from shiitake mushroom (26%), followed by oyster mushroom (21%), black ear mushroom (21%), button mushroom (11%), *Flammulina* (7%), paddy straw mushroom (1%), and others mushrooms (13%). India produces around 0.28 million tonnes of mushrooms every year. In India, per capita consumption is about 90 g, which is less compared to other countries, including the USA (1.49 kg) and China (1.16 kg). The cultivation of mushrooms was first started in 1961 at Solan in Himachal Pradesh. Initially, the scientists at the Department of Mycology and Plant Pathology of the then College of Agriculture, which is now elevated to Dr. Y.S. Parmar University of Horticulture and Forestry at Nauni and officials of the State Department of Horticulture have credit in generating the production technology, human resources, and popularisation of mushroom cultivation among the farmers in the country. As the mushroom cultivation gained adoption and keen interest among the farmers, the Indian Council of Agricultural Research (ICAR) established the National Research Centre for Mushrooms (NRCM) at Chambaghat, Solan in 1983 and then elevated the centre to the Directorate of Mushroom Research (DMR) in 2008. Solan city being the epicentre of mushroom cultivation from the beginning, was declared as 'The Mushroom City of India' by the State Government on 10 September 1997.

In India, button mushroom is the major species under cultivation, with a contribution of around 70%, followed by Oyster mushrooms (17%), paddy straw mushroom (9%), and milky mushroom *(Calocybe indica)* (3%). Other mushroom species like Shiitake, *Cordyceps militaris, Ganoderma,* etc. account for the remaining one per cent. Bihar is the major producer with a production of around 35.6 thousand tonnes with 11% share in total production. Odisha, with around 34.5 thousand tonnes of production is the second-highest producer, followed by Maharashtra (32.5 thousand tonnes), Uttar Pradesh (23.4 thousand tonnes), and Uttarakhand (22.4 thousand tonnes). The northern states of Punjab, Haryana, and Himachal Pradesh are majorly focused on button mushroom cultivation. These states have become the hub of compost preparation and seasonal button mushroom cultivation during the months of September to mid-March. Milky mushroom is a kind of native to tropical States, i.e. Southern India, while Paddy straw mushroom is mainly grown in Odisha and Chhattisgarh due to the availability of paddy straw as a substrate material. Various promising, short duration, and improved strains of other mushrooms such as Shiitake, *Hericium, Ganoderma* have been developed, which can be promising alternatives for the farmers in future.

Mushroom Cultivation- Efficient Way of Agro-industrial Waste Disposal and Zero-Emission Strategy for Food Production

Mushroom cultivation is a unique way of efficiently using microbial technology for the bio-conversion of the agricultural, industrial, forestry, and household waste into nutritious and proteinaceous food. India produces about 650 million tonnes (MT) of crop residues every year (NITI Aayog, 2023), out of which 368 MT comes

from cereal crops, out of which rice and wheat contribute about 154 and 131 MT, respectively. It is estimated that there is a surplus of 178 MT of crop residues every year out of which 87 MT is burnt leading to pollution which is a major contributor of climate change. Currently, we are using only 0.03% of these residues for mushroom production.

Mushrooms can be grown successfully on most of the waste of agricultural and forest origin, which can turn these lignocellulosic residues into value-added products such as food, medicine, feed, fuel, compost, and manures. Their use in mushroom cultivation can serve as a valuable resource leading to economic growth instead of causing environmental pollution and subsequent health hazards due to incineration. If we make use of agricultural waste for mushroom production, India can produce 3 million tonnes of mushroom and about 15 million tonnes of bio-compost. For example, in Japan, mushrooms account for 44% of the production value generated in the forestry industry, which utilises forests that occupy nearly 70% of the country's land. India can emerge as a major player in mushroom production if we efficiently plan to harness the availability of plenty of agricultural residues and labour. Utilisation of agro-residues for mushroom production will not only help to reduce environmental pollution but it can also generate a lot of employment opportunities.

Mushroom Cultivation- Profitable Venture

Mushroom cultivation is one of the most profitable agriculture entrepreneurs. Mushrooms are cultivated indoors and do not require arable land. At present, four mushrooms viz., Button mushroom *(Agaricus bisporus)*, Oyster Mushroom (*Pleurotus* spp), Paddy straw mushroom (*Volvariella* spp.), and Milky mushroom *(Calocybe indica)* have been recommended for year-round cultivation in India. Some mushrooms like oyster, paddy straw and milky mushroom require simple cultivation technology and can be easily adopted by the growers. The cultivation methods for sub-tropical/ tropical mushrooms like *Lentinula, Flammulina, Auricularia, Agrocybe, Stropharia, Macrocybe, Hericium, Ganoderma,* etc. have also been standardised in India. Farmers can start cultivation even in small rooms with minimum infrastructure. These are grown seasonally as well as in state-of-the-art environmentally-controlled cropping rooms all year round in the commercial units. It is a short-duration crop, ranging from 1-3 months depending on the different mushroom species with high yield per unit time. A minimum viable controlled unit of white button mushroom needs an area that is even less than 0.1 ha. Farmers with zero-energy poly tunnel technology of button mushrooms growing can earn ranging from Rs. 40,000 to 50,000 from 500 bags from a small room of 100-120 square feet in a duration of 3-4 months. Farmers with minimum investment and land can start this venture. The profit margins are 25-30 per cent higher in bigger units due to controlled environment conditions. Cultivation of Shiitake mushrooms is comparatively more profitable and the farmers fetch higher price and can earn ranging from Rs. 45,000 to 70,000 from 500 bags.

Mushroom cultivation can support the livelihood of small and marginal farmers economically as well as nutritionally. Mushrooms, like oyster can be grown on locally available agricultural and agro-industrial wastes and no sophisticated infrastructure is required which makes the operational cost as low as Rs. 30-40 per kg of mushroom. Thus, with such minimum requirements, mushroom farming is a promising diversification alternative. The Directorate of Mushroom Research is a leading institution in supporting the establishment of mushroom units of different scales. The institute prepares techno-economic feasibility reports for setting up button mushroom growing units to a capacity level of 500 tonnes per annum and also for growing Oyster, *Ganoderma,* Shiitake, and *Cordyceps*, as well as for establishing spawn production units. In addition, other agricultural institutes and universities also provide such facilities. Based on these techno-economic feasibility reports, Public Sector and other banks provide funding to start such ventures. Government of India and different State Governments also provide financial support in the form of subsidies to support farmers and entrepreneurs.

Government of India sponsored schemes like the Mission for Integrated Development of Horticulture (MIDH) and the National Bank for the

Agriculture and Rural Development extend financial support for the establishment of mushroom farms. In many such financial support schemes, Agriculture Infrastructure Fund (AIF) is a medium-long-term debt financing facility scheme that was launched by the Central Government in 2020, which also supports the establishment of mushroom-growing units. Under this Scheme, one lakh crore rupees is to be provided to the farmers and entrepreneurs for some selected agriculture-based ventures, including mushroom cultivation by banks and financial institutions with interest subvention @ 3% and Credit Guarantee facility. The Government of India has already sanctioned Rs. 32,472 crore worth of 43,318 projects, under AIF till November 2023 to fund such agriculture-based projects including mushrooms.

Medicinal and Nutraceutical Properties

Mushrooms have long been valued as medicinal and nutritional rich food around the world. The food and Agriculture Organization (FAO) has recommended mushrooms as a protein food, especially for developing nations. Mushroom species such as *Ganoderma, Lentinus, Auricularia, Hericium, Grifola, Flammulina, Pleurotus, Tremella,* and *Cordyceps* have high potential medicinal and functional properties. *Ganoderma* species (ling zhi or reishi) are the most valuable medicinal mushrooms and the global value of dietary supplements made out of Ganoderma has been estimated to be USD 1.6 billion per annum. Mushrooms are rich in proteins, vitamins, minerals and are low in fat and sugar, which is why they are considered a super food. Mushrooms contain a good amount of quality proteins (30-40% on dry weight basis) and are also rich in essential amino acids required for good health. Mushrooms are rich in amino acids like leucine and lysine, which are commonly lacking in many staple cereal foods. Mushrooms are low in sugar and fat and are thus very useful for the people suffering from diabetes and heart-related problems. Mushrooms provide several groups of vitamins, particularly vitamin D, thiamine, riboflavin, niacin, biotin, pantothenic acid, and ascorbic acid. Being the only vegetarian source of vitamin D, mushrooms can be very helpful in alleviating the prevalent vitamin D deficiency among the masses. Moreover, mushrooms are also rich in various minerals like phosphorus, zinc, manganese, potassium, copper, selenium (an antioxidant), iron, magnesium, etc. Incorporating mushrooms into diets at least twice a week is reported to reduce the risk of the early-stage of memory loss. Many commercial products made from different medicinal mushrooms are available in the market and some prominent among these are Lentinan from *Lentinus edodes,* Concord Sunchih and Reishi Plus from *Ganoderma lucidum,* Grifon from *Grifola frondosa,* Mycoformulas Endurance from *Cordycep sinensis* and Didanosine from *Cordyceps militaris*. In 2020, India earned a total of 8.65 million USD from the export of mushrooms.

Highly Priced Mushrooms

In mushrooms, there are some species like *Morchella esculenta,* Shiitake, and caterpillar fungus *(Cordyceps militaris)* that are highly priced. These grow in natural habitats in soil and wood in forests and are a major source of income to the rural folk who collect them, as well as a source of foreign earnings. While *M. esculenta* could not be still successfully cultivated artificially, technology for the commercial cultivation of other two species is available. *Morchella esculenta* is one of the economically important species which grow naturally in the higher-altitude villages of Central Himalaya and is locally known as *'Guchhi'*. It has a wide distribution in India and is very common in the temperate zones and forests of Himachal Pradesh, Jammu and Kashmir, and Uttarakhand.

India is a major exporter of these morels *(Guchhi)* and annually exports 50-60 tonnes of dry morels. Among other species of mushrooms, Shiitake *(Lentinula edodes)* is a real culinary delight with exceptional medicinal benefits. The proteins in Shiitake are composed of 18 types of amino acids with richness of leucine and lysine, which are deficient in many grains. Shiitake is also rich in over 30 enzymes. Technology for cultivation of Shiitake mushroom has been developed by the Directorate of Mushroom Research and also at Indian Institute of Horticulture Research, Hessaraghatta, Bengaluru. Time of cultivation of Shiitake mushroom has been reduced from more than three months to less than 2 months. This priced mushroom can fetch from

Rs. 750- 1000 per kg as fresh and these can also be dried. Another highly priced mushroom is caterpillar fungus *(Cordyceps militaris)* and this mushroom in dried form fetches more than Rs. one lakh per kg. This is also found in natural habitats in higher hills and is widely distributed in patches and is reported to be found at elevations of 3000- 5000 m in Nepal, Bhutan, India, and Tibet. It is collected from Chamoli district and some other parts of Uttarakhand in the months of May-June. This mushroom apparently has many medicinal benefits and is said to have 77 micro and macro substances, 80 varied enzymes, invaluable amino acids, vitamins, minerals, and unsaturated fats, all of which give the mushroom its rich medicinal value. Now, technology for the cultivation of this mushroom has been developed and some farmers are growing this mushroom from which some important medicines and energy booster products are made that are commercially available in the market.

Success Stories

There are hundreds of success stories of mushroom cultivation in India where individual farmers ventured into this technical trade and became successful entrepreneurs. Dr. Sangam Kurade from Goa is the founder of India's largest mushroom producer company which revolutionised the mushroom cultivation industry in India, produces 18000 kg of button and other mushrooms daily. Himalaya Food Company at Paonta Sahib in Himachal Pradesh has an installed capacity to produce more than 10,000 tonnes of mushrooms annually. Vikas Mushroom Farm was established by Vikas Benal initially at Solan in Himachal Pradesh has now been expanded to a fully automated mushroom compost with growing unit set up in Mohali, Punjab, with a capacity of 6,000 metric tons of compost and 600 metric tonnes of mushrooms per annum. Jiwa Foods Private in Raigad, Maharashtra is also one of the largest Mushroom Producers with a capacity of 4000 kgs of mushrooms per day.

Bajwa Mushroom Farm in Bhor Saidan in Kurukshetra, Haryana is a global distributor with over 10,000 clients and employ more than 1000 workers. According to the CEO, Sardar Harpal Singh Bajwa, they are putting to use more than 2000 tonnes of wheat and paddy straw and producing more than 600 tonnes of button mushrooms annually. In addition, they also produce 500 tonnes of spawn (mushroom seed). Shubam Modi of Ranchi is another successful mushroom grower who produces 60 tonnes of mushroom every month. Two brothers, Rishabh Gupta and Ayush Gupta, after leaving their high-professional jobs are growing button mushrooms at Shamsabad, Agra in Uttar Pradesh. They are earning daily Rs. 2.0 lakh with a net profit of more than Rs. 70,000. Santosh

Farmer growing Oyster mushrooms in Spiti valley (cold deserts) of Himachal Pradesh

Mishra's Kalinga Mushroom Centre in Pipli tehsil of Puri district in Odisha is another success story of hard work of the last 30 years that made him a millionaire. He produces 2,000 bottles of spawns (mushroom seed), daily besides growing oyster and paddy straw varieties of mushroom. He has trained more than 10 lakh people in mushroom cultivation and now he is setting up a food processing unit of Rs. 2 crore to make mushroom flour, pickles, snacks, and other items.

Use of Mushrooms Beyond Food

Recently, the strength of fungal mycelium, especially of fungi of mushrooms, has attracted attention and technology has been developed that utilises mushrooms as leather substitutes, paper, textiles, packaging, and building materials. The filamentous mycelial network structure of mushrooms has mechanical properties that are determined by network density, filament elasticity, and branching. Furthermore, mycelium can be used to create foam-like materials with resilient properties. Use of these materials will reduce our dependency on petroleum products and will be beneficial for the welfare of animals as well. In addition, using these materials promotes upcycling and these materials are both renewable and biodegradable. Companies involved in the development of leather alternatives have formed a consortium with apparel companies, such as ADIDAS, HERMES, and KERING. Similarly, companies involved in developing packaging materials have formed a partnership with home furnishing companies, such as IKEA. Earlier, Sacchachitin, a skin-like biomaterial used for wound dressing was developed from the fruiting bodies of *Ganoderma* mushroom. The utilisation of *Ganoderma* has now entered a commercial scale as it is being used to make different fashion items, including caps, bags, and shoes which are highly durable and of high performance. Several startup companies have also sprung up in different parts of the world and these include Bolt Threads, Ecovative Design, Grado Zero Espace, Mugo, MycoTech, and MycoWorks. Thus, mushroom production has the potential to become a sources of specific materials and food. Grand View Research has estimated that the global market for bio-based leather substitutes was to the tune of USD 710.3 million in 2020. According to Markets and Markets, fungal-based leather substitutes had a leading share of 26.6% of the total biobased/plant-based market in 2021 and are estimated to increase at a CAGR of 7.7% between 2022 and 2027. Thus, integrating mushroom cultivation into the existing farming systems will supplement the income of the farmers and promote proper recycling of agro-residues. Besides, mushrooms can supplement and contribute in achieving nutritional and food security of the country. ❑

FORM IV

Statement about ownership and other particulars about Journal Kurukshetra to be published in the first issue every year after the last day of February.

1	Place of publication	New Delhi
2	Periodicity of its publication	Monthly
3	Printer's Name, Nationality & Address	Ms Anupama Bhatnagar Indian Publications Division Soochna Bhawan, CGO Complex New Delhi-110003
4	Publisher's Name, Nationality & Address	Ms Anupama Bhatnagar Indian Publications Division Soochna Bhawan, CGO Complex New Delhi-110003
5	Editor's Name, Nationality & Address	Ms Shiela Rani Indian Publications Division Room No. 653 Soochna Bhawan, CGO Complex New Delhi- 110003
6	Name and addresses of individuals who own the newspaper and partners or shareholders holding more than one per cent of the total capital	Wholly owned by Ministry of I&B Government of India, New Delhi- 110001

I, Anupama Bhatnagar, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Date: 11 January, 2024

Anupama Bhatnagar
(Signature of Publisher)

Apiculture
Scope and Opportunities

India is one of the largest producers and consumers of honey in the world, with an estimated annual production of 1.2 lakh metric tonnes. The country has a rich tradition and culture of beekeeping dating back to ancient times. Beekeeping has the potential to generate income and employment opportunities for rural households.

* **Dr. Dheeraj Kumar Tiwari**
** **Dr. Shailesh Kumar Mishra**

Apiculture is a widespread and global activity, with millions of beekeepers depending on bees for their livelihoods and well-being. Together with wild pollinators, bees play a major role in maintaining biodiversity, ensuring the survival and reproduction of many plants, supporting forest regeneration, promoting sustainability and adaptation to climate change, and improving the quantity and quality of agricultural productions.

Apiculture is important because it directly contributes to the outputs produced, such as honey, beeswax, queen, and bee colonies, and other products such as pollen, royal jelly, bee venom, and propolis in cosmetics and medicine. Apiculture plays a role in providing nutrition, economic, and ecological security, as bees are valuable pollinators of both agricultural crops and natural ecosystems. The business almost requires less land and less initial capital, does not take much of the farmers' time, is undertaken by the young and old, men and women, and does not compete with other components of farming systems for resources. It can also be a fascinating hobby, a profitable sideline, or a full-time occupation.

- Apiculture is the science and culture of honeybees and their management.
- Beekeeping is the practice of intentional maintenance of honey bee colonies, commonly in hives, by humans.
- A beekeeper may keep bees in order to collect honey and beeswax, or for the purpose of

* *The author is Scientist (Agronomy) and In-charge Head, ICAR-Krishi Vigyan Kendra, Unnao (Uttar Pradesh). Email: dk9hau@gmail.com*
** *The author is Director (Extension), Ministry of Agriculture and Farmers Welfare. Email: shaileshk.mishra29@gov.in*

pollinating crops, or to produce bees for sale to other beekeeper. A location where bees are kept is called an apiary.

- Beekeeping (or apiculture, from Latin: Apis 'bee') is the maintenance of honey bee colonies, commonly in hives, by humans.
- In India, beekeeping has been mainly forest-based. Several natural plant species provide nectar and pollen to honey bees.

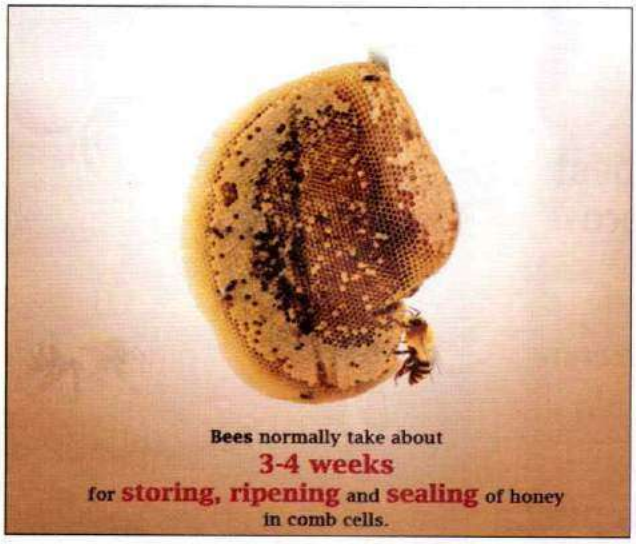
History of Beekeeping

- Globally, there are more than 20,000 species of wild bees, many of which are solitary or rear their young in burrows and small colonies, like mason bees.
- Commercially, it is done in Himachal Pradesh, where locals collect honey on hills and in forests.
- Beekeeping, or apiculture, is concerned with the practical management of the social species of honey bees, which live in large colonies of up to 100,000 individuals.

India is a country that inhabits four major honey bee species: two domesticated species, viz. Apiscerana (Indian or Asian honey bee) and A. mellifera (European honey bee), and two wild species, viz. A. dorsata (rock honey bee) and A. florea (dwarf honey bee). Beekeepers in many of the Indian States, including Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Telengana, Odisha, and the North Eastern States, cultivate A. cerana, the Indian honey bee, and are dependent on it for their livelihood. The honey obtained from A. cerana constitutes hardly 5-10% of the total honey produced in India. Among the four species, A. mellifera is an introduced species in India. A. mellifera ligustica, known as the Italian bee, was introduced into India in the 20th century, when the beekeeping industry with the native bee, A. cerana, was badly hit because of the outbreak of the tracheal mite, Acarapis woodi, and Thai sac brood virus during 1965-1986. Presently beekeeping with A. mellifera is more in North India because of the rich flora viz., Mustard, Sunflower, Eucalyptus, Safflower, etc. They produce 50 to 60 kg of honey per colony per year. About 70-75% of the honey produced in India is from A. mellifera. Placing a few hives in the vicinity of the cropped area helps a large number of honey bees working in a society and accomplishing crop pollination sufficient to produce

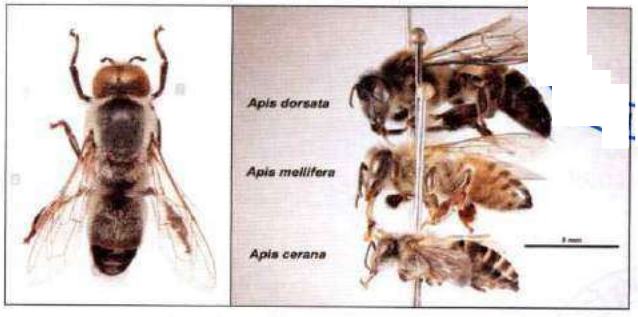
Bees have evolved to be the most efficient pollinators with a unique, though unambiguous style of communication

seeds and fruits that man consumes in his daily life. A. dorsata, the rock bee, contributes to approximately 20% of the total honey produced in India, even though there is no clear official estimate available. The quantity of honey that is taken from little honey bees (A. florae) is negligible. However, all the honey bee species are important pollinators and need to be conserved. Honey has a long history of human consumption and is most commonly consumed in its unprocessed state (i.e., liquid, crystallised, or in the comb). It is taken as medicine, eaten as food, or incorporated as an additive in a variety of foods and beverages. India has been known as the 'land of honey'. Since centuries, honey has been used to treat a variety of ailments through a wide range of applications. In India, beekeeping has been mainly forest-based. Thus, the raw material for the production of honey is free from nature. Bee hives neither demand additional land space nor do they compete with agriculture or animal husbandry for any input. The beekeeper needs only to spare a few hours a week to look after his bee colonies. Beekeeping is therefore ideally suited as a part-time occupation. Beekeeping constitutes a resource of sustainable income generation for the rural and tribal farmers. It provides them valuable nutrition in the form of honey, protein rich pollen, and brood. Bee products also constitute important ingredients in folk and traditional medicine. Honey has so far been consumed mainly as a medicine and for religious purposes. A small quantity has been used in the kitchen as an ingredient in pickles, jams, and preserves. With increasing production in recent years, there is an increasing trend to use honey in food. This is obviously the case with the affluent segments of the



population. Forest honey is used in the pharmaceutical, food, confectionery, bakery, and cosmetic industries.

Honey Bee Species in India



Species of True Honey Bees

Sl. No.	Common name	Scientific name	Honey yield per year per hive (kg)
1	Indian bee	*Apis cerena*	8-10
2	European bee	*Apis mellifera*	25-30
3	Rock bee	*Apis dorsata*	30-35
4	Little bee	*Apis florae*	<1
5	Himalayan bee	*Apis laboriosa*	40-45

Source: AICRP on Honey Bee, 2018

From the above table, we can see that there are mainly five species in India, i.e., *Apis cerena* with a yield of 8-10 kg per year per hive, followed by *Apis mellifera* with a yield of 25-30 kg, and then *Apis dorsata* with yield of 30-35 kg, *Apis florae* with less than one kg of yield, and finally *Apis laboriosa* producing the highest honey yield, i.e., 40- 45 kg.

Goal of 'Sweet Revolution' as part of Aatmanirbhar Bharat Abhiyaan

Keeping in view the importance of beekeeping as part of the Integrated Farming System in the country, the Government approved the allocation for Rs. 500 crore for National Beekeeping & Honey Mission (NBHM) for three years (2020-21 to 2022-23). The mission was announced as part of the Aatmanirbhar Bharat scheme. NBHM aims for the overall promotion and development of scientific beekeeping in the country to achieve the goal of 'Sweet Revolution', which is being implemented through the National Bee Board (NBB). The main objective of NBHM is to promote holistic growth of the beekeeping industry for income and employment generation for farm and non-farm households, to enhance agriculture/ horticulture production, to develop infrastructural facilities, including the setting up of Integrated Beekeeping Development Centres (IBDC)s/CoE, honey testing labs, bee disease diagnostic labs, custom hiring centres, Api-therapy centres, nucleus stock, bee breeders, etc., and to empower women through beekeeping.

Besides, the scheme also aims to create awareness about scientific beekeeping under Mini Mission-I, post-harvest management of beekeeping, beehive products, including collection, processing, storage, marketing, value addition, etc. under Mini Mission-II, and research and technology generation in beekeeping under Mini Mission-III. A total of Rs. 150.00 crore has been allotted to NBHM for 2020-21.

Interaction with Scientist on how to improve the skill of Farmers/Beekeepers

Status

Presently, it is estimated that with 19.34 lakhs honey bees colonies, 2.50 Lakhs beekeepers and

(To be continued on page no. 28)

Garib

Food Security for All with PM Garib Kalyan Anna Yojana (PMGKAY)

World's biggest social welfare scheme, extended for 5 years, aiming to provide food security to over **80 crore people**

Pucca Houses for Poor with PM Awas Yojana

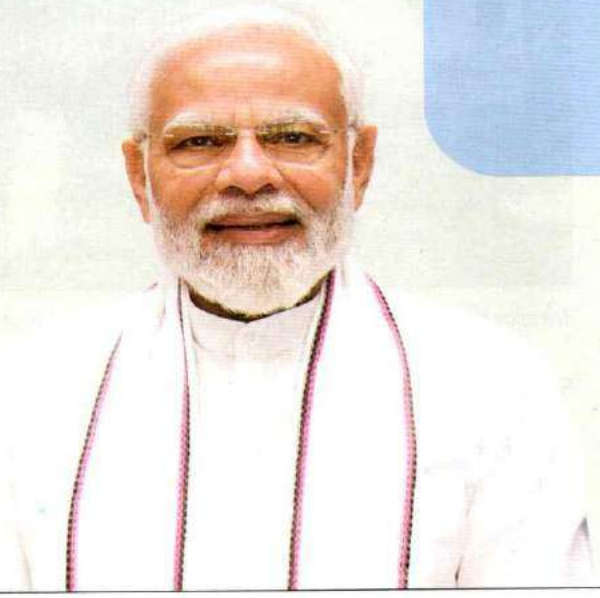
Over 4 crore pucca houses for the underprivileged allowing them a life of dignity and a place to call their own

Smokeless Kitchens with PM Ujjwala Yojana

More than 10 crore families enjoy a healthier life with clean cooking fuel connections

> **Bharat is changing, and it is changing rapidly. People's self-confidence, their trust in the government, and the commitment to build a new Bharat is visible everywhere.**
>
> *- PM Narendra Modi*

EMPOWERING



PRIME MINISTER NARENDRA MODI HAS PLACED UTMOST EMPHASIS ON INCLUSIVE GROWTH OF THE NATION, AND THEREFORE HAS GIVEN US THE ROADMAP FOR FOCUSING ON GYAN: GARIB, YUVA, ANNADATA & NARI SHAKTI.

Yuva

Loans for Young Entrepreneurs with PM Mudra Yojana

45 crore loans worth over **₹ 26 lakh crores sanctioned** to give wings to the dreams of young India and create opportunities for self-reliance

Job Creation Through Startups with Start Up India

India becomes the **3rd largest startup ecosystem** in the world, with more than 100 Unicorns & 1.14 lakh start-ups creating **12 lakh+ jobs** for the aspirational youth of India

New Avenues in Sports

Best performance of Indian players so far in Tokyo Olympics, Paralympics and Hangzhou Asian Games, fueled by schemes like **Khelo India & Target Olympic Podium**

Annadata

Prosperity for Farmers with PM Kisan Samman Nidhi

Assured income of ₹ 6,000 to farmers every year; **support of ₹ 2.8 lakh crore** delivered to **11.8 crore farmers** so far, for their financial security

Access to Immediate Credit with Kisan Credit Cards

Loans worth **₹ 9 lakh crore** provided to more than **7.3 crore farmers** with Kisan Credit Card (KCC); a lifeline supporting their crops and empowering them for newer possibilities of growth

Modernised Agri-Infra with Agriculture Infrastructure Fund

₹ 1 lakh crore investment approved under AIF, a major step towards **modernising farming practices and boosting farmer's income**

GYAN · Nari Shakti

Community Support for Women

More than **10 crore women** became part of self-help groups; a resolve to make **2 crore women Lakhpati Didis**

Financial Security for Daughters with Sukanya Samriddhi Yojana

Securing every daughter's future through **3.2 crore Sukanya Samriddhi Accounts** for girls under 10 years of age, a promise of empowered future

Access to Clean Water with Jal Jeevan Mission

Over **14 crore families** get access to clean tap water, nurturing the health and well-being of every woman, every family in rural areas

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(Continued from page no. 25)

wild honey collectors' harvest around 1,33,200 MT of honey in the country, which valued Rs. 2704.31 crore, considering the modem beekeeping which arrived in India only three decades ago with the advent of the Khadi and Village Industries Commission (KVIC). India is one of the major honey exporting countries in the world and has exported 79,929.17 MT of natural honey to the world for the worth of Rs. 1,622.77 crore during the year 2022-23. More than 50% of the honey production in India is being exported to other countries. India exports honey to about 83 countries. The major markets for Indian honey are the USA, Saudi Arabia, United Arab Emirates, Bangladesh, Canada, etc.

Development of Beekeeping Equipment's:

- Bee hives ISI (A type B type and C type),
- Bee hives stand (folding type and fixed type)
- Honey extractor Tangential and radial type
- Comb foundation sheets
- Comb foundation mill
- Travelling bee box
- Wasp trap
- Lay out of honey house
- Lay out of honey processing plant
- Solar wax extractor

Beekeeping Equipments and Unit

The above mentioned equipments have already been standardised by the Bureau of Indian Standards (formerly ISI). The following approved, drafts awaiting standardisation are (1) Cylindrical bee packages (2) Honey extractor tangential (3) Beeman's kit.

Some of these techniques include:

(1) Management of apiaries year round
(2) Supplementary feeding in dearth period
(3) Swarm control
(4) Management for higher yields
(5) Apis mellifera management
(6) Migration both local and distant

Inspection of beehives

Problems

The following are issues related to beekeeping:

- Beekeepers cannot obtain honey boxes;
- There are no facilities for marketing honey; and
- Insufficient instruction in apiary management.

Strengthening beekeeping cooperatives, establishing the bee business nationwide, and establishing beekeeping farms on forest land are all feasible ideas in this regard.

Prospects of Apiculture

- Geographical Diversity: Besides the agricultural fields, several nectariferous plant species in the evergreen tropical and sub-tropical forests provide forage to honey bees. This offers a potential of about 200 million bee colonies as against 3.4 million bee colonies today.
- Genetic Diversity: There are only around seven commercially important honeybee species in the world, but five of them are present in India. i.e. Rock bee, Indian hive bee. Hence, apiculture is resilient to climate change and environmental degradation.
- Agrarian Economy: Bee pollination as a new agricultural production strategy has immense possibilities in an agrarian country like India. If bees are incorporated into agriculture, the pollination is well managed and crop yields increase significantly.
- Thrust on Food Processing: The Government is actively promoting food processing industries in the country to enhance rural income i.e. policy measures such as PM SAMPADA. Honey is a high-value product and hence aligns easily with government strategies.
- Rising Industrial Demand: Honey forms a key ingredient in the ayurveda and pharmaceutical sectors in India. It is also thought to support the treatment of several more specific ailments. Hence, the growth of the AYUSH and pharmaceutical sectors is expected to have a positive impact on honey as an industrial raw material in India.
- Rising Domestic Market: As a result of changing food habits and an increasing inclination of consumers towards wellness foods and healthy alternatives to artificial sweeteners, the demand for honey is expected to increase in the coming years. The threat of Covid-19 infection has made people consume more because of its anti-microbial and anti-inflammatory properties.

BeeKeeping Unit

Scope

The apiculture market is estimated to register a CAGR of 4.3% during the period 2020–25, with Asia–Pacific as the dominant producer. As per a report by IMARC, the Indian apiculture market is expected to reach a value of Rs. 33,128 million by 2024, expanding at a CAGR of nearly 12% by 2024. India is the sixth-largest natural honey exporting country. During 2019–20, the recorded export of natural honey was 59,536.75 MT for Rs. 633.82 crore. The major export destinations were the USA, Saudi Arabia, Canada, and Qatar. The demand for organic honey in the international market could be leveraged to promote organic beekeeping guidelines. By propagating the sector, the landscape for beekeeping and the species could be expanded on a commercial scale.

This provides lucrative opportunities for beekeeping industries. An organised and tech-driven bee-farming sector is an excellent initiative for generating employment opportunities, with skill-building projects. It will also help attain Sustainable Development Goals 1 (No Poverty), 2 (Zero Hunger), 3 (Good Health and Well-Being), and 15 (Biodiversity and Vibrant Ecosystem).

In regions with appropriate floral pasturage, beekeeping can be a lucrative profession. India has a vast potential for beekeeping development because of its diverse habitat and abundant floral resources from both produced crops and natural plants. Based on current data, over 50 million hectares of land are farmed for oilseeds, pulses, orchards, and other crops that benefit from bee pollination and are valuable to bees. Furthermore, there are an estimated 60 million hectares of woodland with potential for beekeeping.

At least one crore bee colonies may easily be supported by this enormous expanse of woodland and agriculture.

Men, women, kids, farmers, orchardists, the landless, and the underemployed can all make money from beekeeping. Bee hives can be located on the roof of a house or in the backyard. Beekeeping can yield a larger income for a subsistence farmer than other hobbies. Selling the extra honey and wax from their hives can help beekeepers turn their hobby into a successful business, provided they have the necessary time and enthusiasm. A village or collection of villages may come together and form a cooperative, creating jobs and revenue because basic beekeeping supplies like hives, frames, smokers, extractors, and containers can be made locally, as can beewax and honey.

Opportunities

The various end users assessed include food & beverages, agriculture, military, medicine, and cosmetic, paints and chemical, and others. Propolis, which consists of a range of plant resins collected by the bees and used to seal holes in the hive, has been used for a variety of purposes. It is now known to have a diverse range of pharmacological properties, including anti-inflammatory, anti-oxidant, anti-bacterial, anti-fungal, anti-tumour, and some anti-viral properties. Royal Jelly is widely used as a food supplement, and there is some evidence that Royal Jelly may have some cholesterol-lowering, anti-inflammatory, wound-healing, and antibiotic effects.

Market Trends

The Indian apiculture market attained a value of almost Rs. 18,836.2 million in the year 2020. The industry is further expected to grow at a CAGR of 12.4% over the forecast period of 2021–2026 to reach a value of INR 37,235.9 million by 2026. A FactMR study predicts the honey market to grow at a positive CAGR of 5.1% during the forecast period (2019–2029). Honey continues to witness augmented demand for healthy food applications across the globe. The consumption of apiculture products like honey is increasing in the Asia-Pacific region due to the health benefits associated with honey and its by-products. The Indian honey market reached a value of about INR 17.29 billion in 2020. The market is further expected to grow at a CAGR of about 10% between 2021 and 2026 to reach a value of nearly INR 30.6 billion by 2026.

Competitive Landscape

Major players like Dabur India Limited, Bartnik, Baidyanath, Patanjali Ayurveda, Khadi, Himalaya, Arnold Honeybee, Miller's Honey Company, and Beehive Botanicals Inc are making strategic moves to make their business grow.

Advantages of Honey

List of health benefits of honey and make use of this golden sweetener.

- Honey cleans blood and arteries
- Use of honey is also beneficial to the throat infection
- Use of honey by children is the best technique to increase their memory power at the small age
- Use of honey avoids a cough, colds, digestive problem, eye disorders, blood pressure, etc
- Honey is also used in the cosmetic
- A teaspoon of honey with fresh butter prevents you from fever
- The use of honey provides lots of energy to the body & helps in increases athletic performance
- Helps prevent cancer and heart disease
- Reduces ulcers and other gastrointestinal disorders
- Anti-bacterial and anti-fungal

Possible Products from Beekeeping (By-Products of a Honeybee Farm)

Apart from honey, there are other commercially important by-products like royal jelly, bees wax, pollen, propolis, and bee venom.

Honey: It is a viscous fluid produced from the flower nectar by the bees. It is a whole food containing sugars, antibiotics, enzymes, acids, and minerals, and is used as a high energy source. It is a useful carrier for many ayurvedic and unani medicinal preparations. Honey is also recommended for regular consumption in cases of malnutrition. Different types of honey are categorised by the flower sources as discussed here:

Acacia Honey	Alfalfa Honey
Aster Honey	Avocado Honey
Basswood Honey	Beechwood Honey
Blueberry Honey	Blue gum Honey
Buckwheat Honey	Clover Honey
Dandelion Honey	Eucalyptus Honey
Fireweed Honey	Heather Honey
Ironbark Honey	Jarrah Honey
Leatherwood Honey	Linden Honey
Macadamia Honey	Manuka Honey
Orange blossom Honey	Pinetree Honey
Sourwood Honey	Sage Honey
Tupelo Honey	

Royal Jelly: It is a secretion from the bees and contains proteins, lipids, and carbohydrates, minerals like iron, sulphur, copper, and silicon. It is used as a general tonic and stimulant improving resistance to fatigue, learning capacity and memory, appetite, and general health improvement.

Beeswax: Beeswax is secreted as a liquid but solidifies when exposed to air. It is chiefly used in the candle industry. Other major places where the bees wax is important are for making creams, ointments, capsules, deodorants, varnish, shoe polish, etc.

Propolis: It is a mixture of the beeswax and the resins collected by honeybee from plants. It has an adhesive quality and is also used for preparing ointments that treats cuts, wounds, dermatological, and cosmetic treatment, etc.

Bee Venom: It contains active chemicals like histamine, hydrochloric acid, formic acid, apamine, etc. It is injected into patients suffering from rheumatism. It also helps in curing neuralgia, endoarthritis, necrosis, etc.

Pollen: It is a mixture of flower pollen, nectar, enzymes, honey, wax, and bee secretions. It is loaded with nutrients, amino acids, vitamins, lipids and several active substances. Hence, it is increasingly being recognised as a medicine.

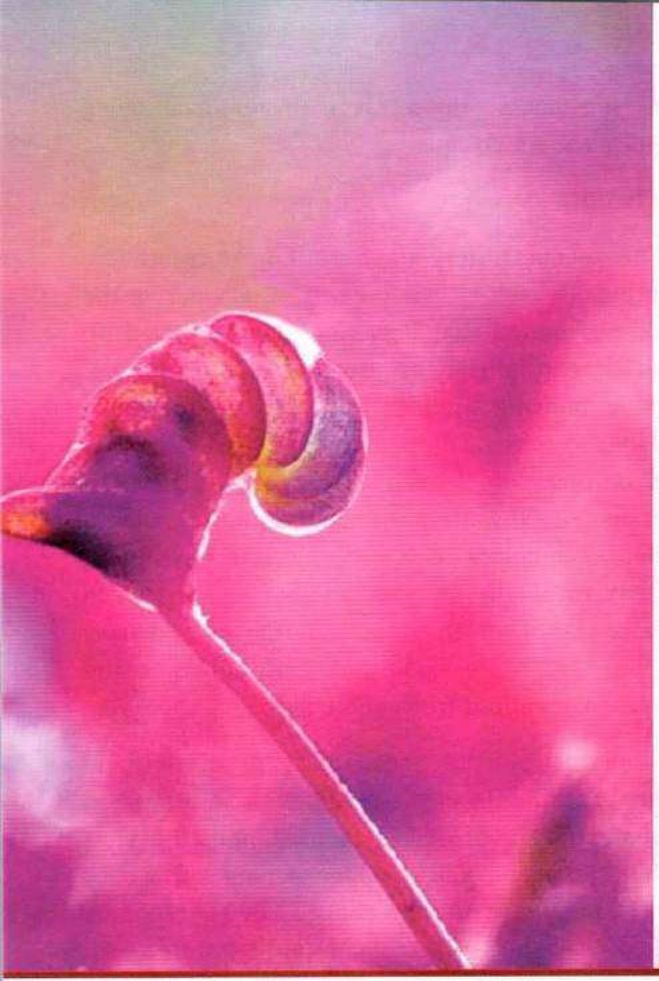
Conclusion

Beekeeping history is as old as human civilisation, when people used to live in caves. It was during the Cretaceous period that flowering plants evolved on the earth, and honeybees also co-evolved in nature. Primitive humans used to hunt honey from wild honeybee colonies found in the cavities of hollow trees, on rocks, etc., which is still practised by rural/tribal people. Nowadays, beekeeping has become a full-fledged industry, as it not only provides honey, beeswax, royal jelly, propolis, and bee venom, which are very useful for therapeutic purposes and daily uses but also has a significant contribution to the pollination of various fruits and crops.

India is one of the largest producers and consumers of honey in the world, with an estimated annual production of 1.2 lakh metric tonnes. India has a rich tradition and culture of beekeeping dating back to ancient times. At present, about 12,699 beekeepers and 19.34 lakh honeybee colonies are registered with the National Bee Board, and India is producing about 1,33,200 metric tonnes of honey (2021-22 estimate). In November 2022, a new species of endemic honeybee, the Indian black honeybee (Apis karinjodian), was discovered in the Western Ghats after a gap of more than 200 years.

Beekeeping has the potential to generate income and employment opportunities for rural households by producing honey and other bee products such as wax, propolis, etc. Honey is a high-value product that has huge demand in domestic and international markets. It is also a source of nutrition and health for consumers. It can also help empower women and youth by involving them in beekeeping activities as entrepreneurs or in self-help groups. It not only presents economic opportunities but also plays a pivotal role in preserving the delicate balance of our environment. By fostering sustainable practices, embracing innovation, and nurturing knowledge-sharing platforms, we pave the way for a thriving future for beekeeping entrepreneurs.

"Beekeeping may be the best source of income, self-employment generation as well as nutritional security in the future." ❑



Floriculture and Commercial Potential of Orchids

A Blossoming Business Opportunity

The floriculture industry is experiencing a transformative phase, driven by an upsurge in consumer demand for exotic and aesthetically pleasing blooms. This article endeavours to unravel the multifaceted world of orchid floriculture in the country, delving into its commercial potential, the factors shaping its growth, and the unique challenges and opportunities that define this blooming business landscape.

*** Ajay Kumar Singh**
**** Pankaj Kumar Ojha**

Floriculture, the art and science of cultivating flowers, has transcended mere aesthetics to become a burgeoning industry globally. Within this vibrant tapestry of blooms, orchids emerge as jewels of unparalleled beauty and commercial significance. In the Indian context, where the floriculture sector is witnessing remarkable growth, orchids stand out as a captivating business opportunity, bridging tradition and modernity.

India's floriculture industry has experienced a remarkable transformation, marked by a compound annual growth rate (CAGR) of 25.68% from 2017 to 2021, according to a report by the National Horticulture Board ("Floriculture in India - An Overview"). Orchids, with their diverse and intricate forms, contribute significantly to this upward trajectory. With over 1,300 indigenous orchid species, India boasts a rich orchidaceous heritage, providing a robust foundation for both domestic consumption and international trade.

The commercial allure of orchids within the Indian landscape can be gauged from the impressive export figures. The country exported ornamental plants worth USD 74.82 million during the financial year 2020-21, showcasing a growth of 31.3% over the previous year ("Horticulture Statistics at a Glance 2021"). Orchids, being a key component of this export portfolio, underscore the global appeal and market demand for these exquisite blooms.

** The author is Professor and Head, Department of Floriculture and Landscape Architecture, College of Horticulture, Banda University of Agriculture and Technology, Banda, Uttar Pradesh*
*** The author is Assistant Professor, Department of Agricultural Extension, Banda University of Agriculture and Technology, Banda, Uttar Pradesh. Email: pankajext.buat@gmail.com*

As the demand for ornamental plants continues to surge, driven by factors such as increasing disposable income, urbanisation, and a growing awareness of environmental well-being, orchids find themselves at the forefront of this horticultural revolution. This article endeavours to unravel the multifaceted world of orchid floriculture in India, delving into its commercial potential, the factors shaping its growth, and the unique challenges and opportunities that define this blooming business landscape.

Diversity of Orchids in India

India, endowed with diverse climatic zones ranging from the Himalayan foothills to the coastal plains, stands as a haven for a myriad of orchid species. The country's orchid wealth is staggering, encompassing over 1,300 indigenous species that contribute to its vibrant floral tapestry (Singh et al., 2018). These orchids thrive in varied ecosystems, from the temperate zones of the Northeastern states to the tropical landscapes of the Western Ghats and the Eastern Himalayas.

Among the notable native orchid genera, Dendrobium, Vanda, and Arachnis find a prominent place in India's orchidaceous landscape. Dendrobium, with its diverse species, exhibits a wide range of shapes and colors, adapting to different climatic conditions across the country. The vibrant and gracefully arching Vanda orchids, known for their enduring appeal, are well-suited to tropical climates. Arachnis, with its spider-like appearance, adds a touch of uniqueness to the Indian orchid repertoire.

The Northeastern states, particularly Arunachal Pradesh, Assam, and Sikkim, emerge as orchid hotspots, hosting a significant portion of the country's orchid diversity. The Eastern Himalayas, recognised as a global biodiversity hotspot, house an impressive array of orchids, contributing to India's status as one of the world's orchid-rich regions (Singh et al., 2018).

Moreover, India's orchid wealth extends beyond its native species, as the country has successfully acclimated various exotic orchids to its climate. The cultivation of hybrid varieties, a result of meticulous breeding efforts, has added a kaleidoscope of colors and forms to the Indian orchid palette.

India has made significant progress in recording and conservation of its orchid variety. Governmental programmes, research facilities, and botanical gardens have all been instrumental in cataloging and protecting the variety of orchid species. The Orchid Mission in Sikkim is one initiative that aims to preserve and reproduce native orchids, guaranteeing the longevity of this varied floral legacy.

India's orchid diversity not only showcases the country's rich botanical heritage but also presents a tremendous opportunity for floriculturists, researchers, and enthusiasts. The exploration and conservation of this diversity not only contribute to the nation's biodiversity goals but also fuel the growth of the orchid floriculture industry, making it a compelling aspect of India's blooming horticultural landscape.

Commercial Demand and Market Trends in India

The Indian floriculture industry is experiencing a transformative phase, driven by an upsurge in consumer demand for exotic and aesthetically pleasing blooms. Orchids, with their captivating allure, have become a focal point in this burgeoning market, showcasing an impressive surge in popularity.

According to the National Horticulture Board's report, the floriculture sector in India witnessed remarkable growth with a CAGR of 25.68% from 2017 to 2021 ("Floriculture in India - An Overview"). This growth can be attributed, in part, to the rising urbanisation, increased disposable income, and a cultural shift towards incorporating ornamental plants into everyday life.

The demand for orchids in the Indian market is underscored by their versatility and suitability for a myriad of occasions. Orchids, particularly the resilient and elegant Phalaenopsis variety, have become a staple in decorative arrangements for weddings, festivals, corporate events, and interior decor. The demand is not limited to specific regions, with urban households across the country embracing the trend of indoor gardening, further fueling the market for potted orchids.

The advent of e-commerce platforms has significantly contributed to the accessibility and visibility of orchids in the Indian market. Online platforms facilitate the easy purchase of a wide variety of orchids, catering to the evolving preferences of consumers who seek unique and exotic blooms. The convenience of doorstep delivery and the assurance of quality have

played a pivotal role in encouraging consumers to explore and purchase orchids through online channels.

Phalaenopsis orchids, with their extended shelf life and vibrant colors, have become the preferred choice for consumers, florists, and event planners. The Orchid Society of India notes a substantial increase in the adoption of orchids in traditional ceremonies and events, further establishing them as a symbol of elegance and sophistication ("Orchid Society of India Annual Report 2022").

The growth in demand for orchids is not confined to the domestic market, as India emerges as a key player in the global floriculture trade. The country exported ornamental plants worth USD 74.82 million during the financial year 2020-21, witnessing a commendable growth rate of 31.3% over the previous year ("Horticulture Statistics at a Glance 2021"). This includes a significant contribution from the orchid sector, highlighting its global appeal.

The commercial demand for orchids in India is on a trajectory of sustained growth, fueled by changing consumer preferences, increased urbanisation, and a robust export market. Orchids, with their adaptability and aesthetic charm, have carved a niche in the flourishing Indian floriculture landscape, presenting a compelling opportunity for cultivators, exporters, and entrepreneurs alike.

Key Factors Contributing to Commercial Success in India

- **Local Adaptation and Cultivation Techniques:** Orchid growers in India have recognised the importance of tailoring cultivation techniques to local conditions. Research and experimentation in optimising temperature, humidity, and light levels have led to the development of practices that mimic the natural habitats of specific orchid species. The success of such local adaptation is evident in the increased production and improved quality of orchids in India ("Orchid Floriculture in India: Potential and Constraints," Singh et al., 2019).
- **Cultural Significance and Traditional Use:** Orchids, deeply rooted in Indian culture, hold significant value in various traditions and festivities. The incorporation of orchids in religious ceremonies, weddings, and decorative arrangements has fostered a consistent demand. The Orchid Society of India's annual report emphasises the cultural relevance of orchids, which has played a crucial role in sustaining their popularity ("Orchid Society of India Annual Report 2022").
- **Government Initiatives and Subsidies:** Recognising the potential of floriculture, including orchid cultivation, the Indian government has introduced various initiatives to support growers. Financial assistance, training programmes, and infrastructure development are key components of these initiatives. The National Horticulture Board's overview of floriculture in India outlines the government's commitment to bolstering the floriculture sector ("Floriculture in India - An Overview").
- **Export Opportunities:** Orchid cultivation in India has expanded beyond meeting domestic demand, with the country emerging as a significant exporter of orchids and orchid products. The international appeal of Indian orchids has opened up avenues for growers to explore global markets. The growth in export figures, as highlighted in the Ministry of Agriculture and Farmers Welfare's statistics, underscores the increasing global recognition of Indian orchids ("Horticulture Statistics at a Glance 2021").
- **Technology Adoption and Research Collaborations:** Advancements in technology, including greenhouse cultivation and tissue culture techniques, have contributed to the commercial success of orchid cultivation in India. Research collaborations between academic institutions, research organisations, and private enterprises have played a pivotal role in enhancing orchid varieties, disease resistance, and overall production efficiency. Ongoing research initiatives continue to drive innovation within the industry. In short, the commercial success of orchid cultivation in India is intricately woven with factors ranging from local adaptation and cultural significance to government support and global market opportunities. The synergy of these elements positions orchids as a flourishing sector within the Indian floriculture industry, offering both economic opportunities for growers and a rich floral tapestry for consumers.

Challenges and Future Prospects in the Indian Context

- **Infrastructure and Technology Gap:** Despite technological advancements, the orchid floriculture sector in India faces challenges related to infrastructure and technology adoption. Many growers, especially in remote areas, lack access to modern greenhouse facilities and advanced cultivation technologies. Bridging this gap through government support and private sector initiatives is crucial for ensuring sustainable growth ("Orchid Floriculture in India: Potential and Constraints," Singh et al., 2019).
- **Pest and Disease Management:** Orchids are susceptible to various pests and diseases that can significantly impact crop yield and quality. Effective pest and disease management strategies are essential for sustaining the commercial success of orchid cultivation. Ongoing research and extension services play a vital role in educating growers about integrated pest management practices ("Orchid Diversity in India: An Overview," Singh et al., 2018).
- **Environmental Concerns and Sustainability:** The intensive cultivation practices associated with orchid floriculture raise concerns about environmental sustainability. Issues such as water usage, chemical inputs, and energy consumption need careful consideration. Adopting eco-friendly practices, implementing sustainable cultivation methods, and promoting organic alternatives can address these concerns and enhance the long-term viability of the industry.
- **Skill Development and Training:** The success of orchid cultivation requires skilled manpower, from experienced growers to technicians proficient in advanced cultivation techniques. Ongoing training programmes and skill development initiatives are essential to equip individuals with the knowledge and expertise needed for successful orchid cultivation. Collaborations between industry stakeholders and educational institutions can contribute to addressing this challenge.
- **Market Saturation and Diversification:** The rapid growth of the orchid industry may lead to market saturation, emphasising the need for diversification. Orchid breeders and growers should explore innovative varieties, colors, and forms to capture niche markets and differentiate their products. Continuous market research and adaptability to changing consumer preferences will be crucial for sustaining market relevance.
- **Global Collaboration and Research:** Orchid cultivation in India can benefit from increased global collaboration and research partnerships. Knowledge exchange, collaborative breeding programmes, and access to international markets can enhance the competitiveness of Indian orchids. Strengthening ties with global orchid organisations and research institutions can contribute to the industry's growth on a global scale.
- **Promotion of Sustainable Practices:** With an increasing emphasis on sustainable and eco-friendly practices, the orchid industry in India should proactively adopt and promote environmentally responsible cultivation methods. Certifications for sustainable practices can not only enhance the industry's image but also open doors to premium markets that value environmentally conscious products.

In conclusion, long-term success in the Indian orchid floriculture industry hinges on overcoming challenges and implementing sustainable practices, despite the industry's great potential. India's orchid industry has a promising future thanks to chances for economic and environmental sustainability brought about by innovative thinking, collaboration, and well-planned initiatives.

Conclusion

The floriculture industry, especially concerning orchids, represents a blooming frontier of commercial potential. Orchids, with their diverse species and cultural significance, have emerged as key players in the global and Indian markets. Despite challenges, the industry thrives on factors such as local adaptation, cultural relevance, and government support. As the demand for ornamental plants continues to rise, orchids stand poised as a resilient and lucrative business opportunity, promising a vibrant future for growers, exporters, and enthusiasts alike. ❑

Organic Farming

Benefits, Present Status and Future Prospects

Organic farming in India has evolved from being a niche practice to a growing movement with significant potential for transforming the agricultural landscape. The benefits of environmental sustainability, healthier produce and soil health make organic farming a viable and attractive option for farmers and consumers alike. While the present status reflects positive growth, addressing challenges and focusing on future prospects, including technology integration, research, policy support and consumer awareness, is instrumental in realising the full potential of organic farming in the country. With concerted efforts from farmers, policy makers and the public, organic farming can contribute to a greener, more sustainable future for Indian agriculture.

* **Dr. H.L. Sharma**
** **Dr. Shyam Lal**

India has witnessed a remarkable progress in its agricultural sector over the course of seven decades of planned economic development. The country has witnessed significant growth in food grain production, soaring from 50.8 million tonnes in 1950-51 to an impressive level of 329.7 million tonnes in 2022-23. Notably, this surge in food grain production in India (with an annual compound growth rate of 2.71 per cent) has outpaced the growth rate of the population (1.98 per cent) during the last 72 years, as per the latest United Nations projected population data. The unprecedented spurt in agriculture production in the country has been achieved mainly during the post Green Revolution period, through the increased use of high yield variety seeds, chemical fertilisers, pesticides, insecticides, and fungicides. While these inputs contributed to increased

* *The author is Principal, Govt. P.G. College Nerwa District Shimla, Himachal Pradesh, Email: hlsharmablp@gmail.com*
** *The author is Associate Professor of Economics, Govt. College Shri Naina Devi Ji, District Bilaspur, Himachal Pradesh*

yields, they also raised concerns about their adverse impact on human health and the eco system. The indiscriminate and excessive application of chemical inputs during the post Green Revolution period has raised concerns about the sustainability of agriculture in the long run, prompting the adoption of sustainable agricultural practices, such as organic farming.

Organic Farming

Organic farming is an alternative to the conventional farming system. It involves sustainable and environment friendly agricultural practices that avoid synthetic pesticides, fertilisers and genetically modified organisms. It relies on achieving high crop yields without harming natural environment, disrupting eco system and posing no health hazards to the people who work on farm and use the produce. Organic farming is based on the application of non-synthetic farm inputs like vermi-compost, green manure, bio-fertilisers, crop residues, etc. to enhance soil fertility. For the pest and disease control, organic farming embraces eco-friendly methodologies, such as strategic crop rotation, trap crops, the use of bio-pesticides, biological control of insects, mechanical traps etc. This holistic approach not only fosters environmental harmony but also promotes long-term health and vitality of agricultural ecosystem.

Need and Benefits of Organic Farming

The adoption of organic farming in India is imperative for several reasons. It offers a multitude of benefits that contribute to the overall well-being of the environment, society and economy. First and foremost, organic farming promotes biodiversity, conserves soil health and reduces water pollution by avoiding the use of synthetic pesticides and fertilisers and thus ensuring the long-term sustainability of agriculture. Further, embracing organic farming practices contributes to the resilience and prosperity of farmers. It provides economic sustainability to the farmers by reducing input cost on one hand and simultaneously creating better market access on the other. The growing demand for eco-friendly and chemical-free products, fetches a premium price and thus provides better income and market access. The reduced dependence on chemical inputs improves the overall health of the farming community.

Organic farming brings significant benefits to consumers by providing them with healthier and safer food options. Organic produce is free from chemical residues and often contains higher nutritional value, contributing to better overall health of consumers. The cultivation practices emphasise natural inputs and sustainable methods, resulting in nutrient-rich crops that often have higher levels of vitamins, minerals, and antioxidants. Moreover, the absence of genetically modified organisms in organic products aligns with consumer preferences for natural and unmodified food products. By fostering environmentally friendly practices, organic farming not only safeguards the well-being of farmers and consumers but also contributes to India's overall ecological balance, supporting a resilient and sustainable agricultural future. At the governmental level, promoting organic farming aligns with environmental conservation goals and contributes to sustainable development. It potentially opens up international market for organic products, thereby significantly enhancing the country's agricultural export. The emphasis on organic farming can also address public health concerns related to chemical residues in food, leading to potential healthcare cost savings. Overall, the widespread adoption of organic farming in India presents a holistic solution that harmonises environmental, economic and public health interests.

Status of Organic Farming

The organic farming system in India has a rich historical foundation, dating back to ancient times. Its origin can be traced to the traditional agricultural practices that have thrived in numerous villages and farming communities over the course of millennia. The modern standards-based organic agriculture gained momentum only during the recent past with the growing demand for organic products in the western world.

The National Programme for Organic Production (NPOP) launched in 2001, laid the foundation for systematic development of organic agricultural sector in the country. NPOP is being implemented by APEDA under Ministry of Commerce and Industry, Government of India. The NPOP provides an institutional framework for accreditation and certification of various facets

of organic agriculture processes. Notably, the NPOP standards for production and accreditation have earned international recognition including the countries like USA, European Union and Switzerland. The NPOP was brought under the ambit of Foreign Trade Development and Regulation (FTDR) Act in 2004. As per this mandate, no organic products can be exported from India unless certified under NPOP.

The National Centre for Organic Farming, established in 2004, is a nodal organisation for promoting organic farming in the country. It was renamed as National Centre for Organic and Natural Farming (NCONF) in March 2022. The NCONF along with its five regional centres is committed to promote chemical free sustainable agricultural practices, including organic, natural and regenerative farming methods. It focuses on the capacity building of stakeholders by conducting training programmes, workshops, and disseminating information to them.

Area under Organic Farming

India is the sixth largest country in the world in terms of total area under organic farming. Currently, around 2.4 % of net cultivated area is either under certified or in conversion process of organic farming. As on March 31, 2023, total area under organic certification registered under the National Programme for Organic Production reached at 101.72 lakh hectares in the country. This encompasses 53.92 lakh hectares of cultivated and 47.80 lakh hectares of wild harvest collection area (Table 1). Among all states, Chhattisgarh (due to its large wild harvest collection area) emerged as a frontrunner, contributing nearly 32 per cent of country's total area under organic farming. (Fig. 1). It was followed by Madhya Pradesh (22.83 per cent), Maharashtra (12.63 per cent), Rajasthan (9.22 per cent), Gujarat (9.20 per cent), Himachal Pradesh (2.10 per cent) and Odisha (1.95 per cent). Sikkim became the first State in the world to become fully organic with effect from 2016, other States, including Tripura, Himachal Pradesh and Uttarakhand have also set similar targets. Historically, North-East India has adhered to organic practices, with significantly lower chemical consumption compared to the rest of the country. Likewise, efforts are underway to preserve and foster the organic narrative in tribal and island territories.

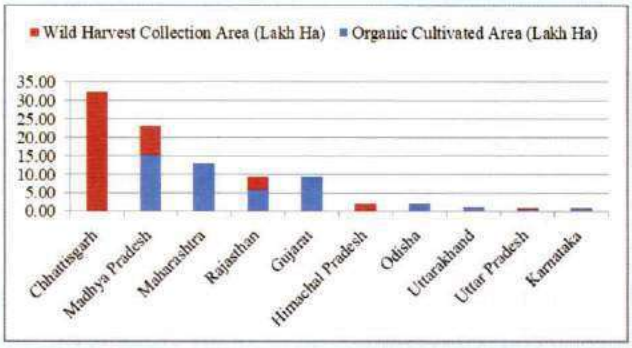
Table 1: Top Ten States of India with Largest Organic Area (NPOP 2022-23)

Sr. No	State	Organic Cultivated Area (Lakh Ha)	Wild Harvest Collection Area (Lakh Ha)	Total Organic Area (Lakh Ha)
1	Chhattisgarh	0.17	32.36	32.5
2	Madhya Pradesh	15.17	8.05	23.2
3	Maharashtra	12.84	0.00	12.8
4	Rajasthan	5.81	3.57	9.4
5	Gujarat	9.36	0.00	9.4
6	Himachal Pradesh	0.11	2.02	2.1
7	Odisha	1.95	0.04	2.0
8	Uttarakhand	0.98	0.06	1.0
9	Uttar Pradesh	0.68	0.30	0.98
10	Karnataka	0.82	0.03	0.8
	All Other States	6.02	1.38	7.4
	India	**53.92**	**47.80**	**101.72**

Source: APEDA, Statistics for the year 2022-23.

Note: Total organic area=cultivated organic area + cultivated area in conversion + wild harvest collection area.

Figure 1 : Top Ten States of India with Largest Organic Area (NPOP 2022-23)



Source: APEDA, Statistics for the year 2022-23.

India, with 15.99 lakh organic producers, has the honour of having highest number of organic farmers in the world. The country accounts for over 43 per cent of the world's certified organic producers as per the latest FiBL data for the year 2021. Thus, India has made significant strides in the field of organic farming, positioning itself among the top countries of the world. However, when compared to leading nations, the country still has untapped potential. Bridging this gap is imperative for the country to assert itself competently on the international level.

Organic Production

India, with its diverse agro-climatic conditions, is endowed with significant potential to cultivate a wide array of organic products. The presence of an inherent tradition of organic farming in various regions further enhances this potential.

Table 2: Top Ten States of India with Largest Organic Production (2022-23)

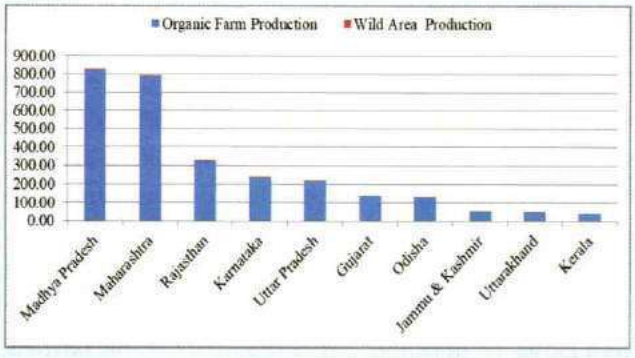
(Thousand Metric Tonnes)

Sr. No	State	Organic Farm Production	Wild Area Production	Total Organic Production
1	Madhya Pradesh	825.63	2.34	827.96
2	Maharashtra	790.33	0.02	790.35
3	Rajasthan	322.97	2.77	325.74
4	Karnataka	237.09	0.42	237.51
5	Uttar Pradesh	217.52	0.15	217.67
6	Gujarat	139.73		139.73
7	Odisha	130.08	0.32	130.39
8	Jammu& Kashmir	50.23	1.57	51.81
9	Uttarakhand	43.95	0.11	44.06
10	Kerala	42.73		42.73
	All Other States	152.66	11.77	164.44
	India	**2,952.93**	**19.47**	**2,972.39**

Source: APEDA, Statistics for the year 2022-23.

Figure 2: Top Ten States of India with Largest Organic Production (2022-23)

(Thousand Metric Tonnes)



Source: APEDA, Statistics for the year 2022-23.

This cultural legacy not only adds a unique dimension but also provides an advantageous foundation for organic producers. India achieved a commendable milestone by producing 2,972.39 thousand metric tonnes of organic products from both organic farms and wild areas during the fiscal year 2022-23 (Table 2). This substantial production encompasses a diverse array of food items, ranging from cereals, pulses, millets, oilseeds, tea, coffee, fruits, vegetables, spices, dry fruits, sugarcane, and processed food. The organic production is not limited to the edible sector but also extends its reach to include the cultivation of organic cotton, fiber, medicinal, herbal and aromatic plants. India's commitment to organic practices is evident not only in the sheer volume of output but also in the broad spectrum of product categories, reinforcing its pivotal role in promoting sustainable and eco-friendly agricultural practices. Among different states, Madhya Pradesh is the single largest producer of organic products. It accounts for nearly 28 per cent of the country's organic production (Fig.2). It is followed by Maharashtra (27 per cent), Rajasthan (11 per cent), Karnataka (8 per cent) and Uttar Pradesh (7 per cent). These top ranking five states collectively account for nearly 81 per cent of the country's organic production, underscoring a substantial opportunity for the widespread adoption of organic farming practices in other regions across the nation. In terms of commodities, fiber crops are the single largest category followed by oil seeds and sugar crops.

Exports of Organic Products

The rich tradition of organic farming at village level and diverse agro-climatic conditions enables India as a key player in meeting the escalating demand for organic products on a global scale. Organic farming in India is mainly export intensive. During the fiscal year 2022-23, the organic export volume of India reached an impressive 312,800.51 metric tonnes. The revenue generated from the export of organic products amounted to approximately Rs. 5,525.18 crore (USD 708.33 million). The high-quality organic exports of India, find their way to various international markets, including the USA, European Union, Canada, Great Britain, Switzerland, Turkey, Australia, Ecuador, Korea, Vietnam, Japan and more. The demand for organic products is growing in these countries due to their substantial purchasing power and prevalence of a considerable number of

health conscious consumers. The organic exports of India are expected to grow rapidly to reach a value of about USD 2,601 million by 2026.

Initiatives

In India, organic farming has been actively promoted through schemes, aiming to enhance sustainability and reduce the environmental impact of agriculture. In this direction, the National Mission for Sustainable Agriculture (NMSA) has been made operational from the year 2014-15. The NMSA focuses on increasing water-use efficiency, promoting organic nutrient management and adopting climate-resilient sustainable agricultural practices. It provides financial incentives, training programmes and technical support to farmers to encourage the adoption of organic and sustainable farming techniques. Furthermore, Paramparagat Krishi Vikas Yojana (launched in April 2015) encourages the adoption of organic farming practices by providing financial assistance to farmers. Under PKVY, groups of farmers are formed to cultivate organic crops and are supported with financial aid for inputs, seeds, and other essential resources. This scheme not only facilitates the transition to organic farming but also promotes community participation and cooperation. The aim of the implementation of these schemes is to create a more environmentally friendly and economically viable agricultural sector, addressing the challenges of soil degradation, water scarcity and promoting the overall well-being of farmers and the environment.

Challenges

Despite the positive trends, organic farming in India faces several challenges. Limited awareness and education among farmers about organic practices, high initial costs of certification and lack of a well-established market infrastructure for organic products are some of the hurdles that need to be addressed. During the transition period to organic farming, initially yields may temporarily decrease, which poses financial challenge to the growers. Farmers often encounter difficulties in managing pests and diseases by using natural methods and traditional farming practices which creates scepticism about the effectiveness of organic methods. The issues related to quality control & certifications coupled with the imperative to scale up operations while upholding stringent standards, further complicate the organic farming landscape. Addressing these challenges requires a comprehensive approach involving education, policy support, research, and infrastructure development to ensure the sustainable growth of organic farming in India.

Way Forward

The demand for organic products has been rising rapidly due to increasing health consciousness and environmental concerns. To take the advantage of the potential of the country, strategic emphasis is imperative. First and foremost, addressing the issue of low productivity under organic farming necessitates increased research and development on farming techniques and better dissemination of knowledge to enhance the efficiency and profitability of organic farming. The integration of technology can play a pivotal role in the future of organic farming in the country. Precision farming techniques, IT-based monitoring system and data analytics can optimise resource utilisation, provide real-time information to the farmers, and improve crop yield. Further, investing in research and development is crucial to make organic farming more efficient and attractive to a new generation of farmers. Developing resilient crop varieties, exploring new organic pest control methods, and enhancing soil health through innovative techniques will contribute to the long-term sustainability of organic farming. Continued policy support from the Government is essential for the growth of organic farming. Strengthening existing schemes, providing financial incentives and addressing the challenges faced by farmers, will create environment conducive for the widespread adoption of organic practices. Encouraging collaboration and networking among the stakeholders including farmers, consumers, non-governmental organisations, researchers, farmer producer organizations (FPOs) and industry will foster a supportive ecosystem. Knowledge sharing, access to resources, and collective marketing efforts can enhance the overall viability of organic farming in India. Above all, educating consumers about the benefits of organic produce is the key to sustain the demand for organic products. In nutshell, by effectively addressing challenges and seizing opportunities, India stands poised to emerge as a global front runner in the realm of organic farming and sustainable agricultural practices. ❑

Opportunities in Dairy and Fisheries Sector

Over the years, the dairy and fisheries sectors in India have emerged not only as a sustainable supplier of affordable nutrition to the masses, they also positioned themselves as prominent players in the international market as well as contributing significantly to national income and employment. Recently, these sectors have become one of the favourite choices for startups of new-age entrepreneurs. Sustainable growth of these sectors needs to address the problems that emerged due to supply chain interruptions and the effects of climate change.

* **Dr. Debabrata Samanta**
** **Nitish Nigam**

The income growth has an impact on the food choices of people. It is argued that nutrition is a central condition for human well-being. It is evident that in a developing country, an increase in per capita income has been linked to higher protein intake. Studies also indicate that an increase in income is equivalent to an increase in protein intake, especially in lower-income countries (Taffesse et al., 2000). India has witnessed growth in national income as well as per capita income in the recent past. The increase in protein consumption has a potential impact on public health. Protein is an essential macronutrient involved in numerous physiological processes including growth, repair, and maintenance of tissues. However, it is also important to note that protein sources must be available and affordable for individuals to reap these benefits. Both vegetables and animals are sources of protein to people. In India, dairy and fisheries are two of the most popular sources of animal protein.

Dairy and fisheries are two important sectors in Indian economy, contributing significantly to GDP and providing employment opportunities. India has one of the highest milk production in the world. The National Invest Promotion and Facilitation Industry reports that India produces 126 million litres of milk per day and contributes around 24.64 per cent of global milk production in the year 2021-22. The dairy industry in India is the largest in the world. It also plays a crucial role in supporting rural economies, where small farmers often rely on dairy farming as their primary source of income. The other top milk-producing countries are the United States, China, Brazil, and Pakistan. It is reported that milk production in India has registered a 58 per

* *The author is Assistant Professor, Chandragupt Institute of Management Patna, Email: debabrata@cimp.ac.in*
** *The author is Research Scholar, Chandragupt Institute of Management Patna, Email: f0301@cimp.ac.in*

cent increase in the last decade. It is also reported that the dairy sector contributes 5 per cent to the national economy (National Invest Promotion and Facilitation Agency, n.d.). It is one of the most critical sectors in terms of employment as the sector employs more than eight crore farmers directly (Government of India, 2023). Moreover, the dairy sector presents significant economic prospects within the realm of agribusiness. As a catalyst for growth, it interconnects with other industries such as fodder production, organic manure manufacturing, and food processing, which specialise in products like cheese, curd, and paneer. The interconnected growth not only strengthens the dairy sector but also bolsters the resilience and prosperity of related industries, fostering a cohesive and mutually beneficial economic ecosystem.

India has a thriving fisheries industry, with significant production of fish and fishery products, including fish oil and marine chemicals. The Indian fisheries sector has been growing at an annual average growth rate of 7 per cent since 2016-17, and contributing to 1.1 per cent to India's gross value added (GVA) and 6.72 per cent to the total agriculture sector GVA (Department of Fisheries, 2022; Government of India, 2023). Furthermore, fisheries contribute to the country's foreign exchange earnings, with significant exports of fish and fish products to other countries.

India is the third-largest producer of fish globally, and the second-largest aquaculture producing nation, with an estimated contribution of 8 per cent to global fisheries production (Department of Fisheries, 2022). Consequently, India became the fourth-largest exporter of fish and fisheries products, promoting the brand India from 'Local to Global' (PIB, 2022). Additionally, the fisheries industry provides employment opportunities to millions of people, especially in rural areas. It serves as a source of livelihood for over 2.8 crore fishers and fish farmers at the primary level, offering not only employment opportunities but also fostering entrepreneurship (PIB, 2023b). The growth and vibrancy of this sector carry a story of economic resilience, global acknowledgment, and substantial impact on the lives of millions, extending beyond mere numerical data.

Development Post-White Revolution

Operation Flood, also known as the White Revolution was a significant development in the Indian Dairy industry, that took place in the 1970s, initiated by the National Dairy Development Board (NDDB) under the leadership of Dr. Verghese Kurien. The White Revolution aimed to increase the availability of milk. Before the White Revolution, milk output in India increased by meagre 1.36 per cent per year during 1950-51 to 1973-74 which was lower than the population growth rate. Operation Flood produced a quick result and milk production outpaced population growth after 1973/74. Post-White Revolution, the Indian dairy sector has witnessed several changes. The per capita milk production increased from 40.6 kg/year in 1971-72 to 71.5 kg/year in 1996-97 to 154.9 kg/year in 2021-22. This fast growth in milk output enabled India to raise per capita milk production to 387 grams per person per day by the year 2018-19 which is higher than the average recommended dietary allowance for the country (Chand, 2023). The White Revolution promoted the cooperative model in the dairy industry, where small-scale farmers could join hands to collectively process and market their milk. This cooperative structure, exemplified by the success of Amul (Anand Milk Union Limited), helped empower farmers by giving them better bargaining power, fair pricing, and access to modern dairy technology. It is reported that the growth rate in milk production accelerated after 2005 when the emphasis shifted from exotic breeds to indigenous breeds. The idea of cooperative and new technology also has inspired several small entrepreneurs to scale up their businesses by harnessing the advanced dairy technique, diversifying milk products, and expanding the market through an efficient supply chain and taking advantage of new advancements in research and development taking place in the industry.

This has opened the market for dairy startups in India. These startups range from large-scale operations to small, family-run farms, and they play a crucial role in the country's agricultural economy. India has a large population, and many households consume dairy products for their dietary needs, which is why the dairy market is such an important one. While the dairy sector is highly competitive, there is also a lot of innovation and new ideas emerging in this field. Several dairy startups in India are focused on producing high-quality milk products and promoting healthy eating habits. Some of the successful dairy startups in India include Amul, Mother Dairy, and Country Delight. These companies have been in operation for several years and have established a strong reputation in the Indian

market. Additionally, India has a large population and a growing demand for dairy products, making it an attractive market for startups. The government has also created a conducive environment for larger investment in the Dairy sector. 100% FDI is allowed in the Animal Husbandry sector through an automatic route. Research shows that, in India, a large number of dynamic modern dairy farms have emerged. These farms are much larger, use only modern technology, and are fully integrated into vertically coordinated value chains that support these modern farms' management and investments (Burkitbayeva et al., 2020).

The Paavni Organic Farm, a new-age dairy business farm, working in Bihar, works on the idea of Farming 360 degrees. The idea is termed Farming 360 where clusters of dairy farmers, crop-based farmers, and processing units are formed to build a range of products that can be directly supplied to clusters of consumers. The objective behind this is to provide organic farming opportunities to farmers by integrating their activities. Initially, financed by the founder, it also has received funds under Startup schemes by the Government of India and the Government of Bihar. The farm employs sophisticated technology to produce organic milk and other dairy products, as well as, organic wheat, pulses, etc. The idea is to integrate dairy and non-dairy production to make the process profitable. The business has adopted new technology not only in production but also in operation and management; from order receiving to delivery to consumer. However, lack of resources at affordable prices like IT personnel, and IoT-based devices for farming emerge as challenges. The other challenges are the gap in awareness and motivation among the farmers and the availability of long-term funding. However, the farm has not only been recognised and acknowledged with different awards and accolades for its unique intervention in dairy industry, it also has inspired a large number of new businesses and startups in the dairy sector in a state like Bihar.

Development Post-Blue Revolution

India is the third-largest fish-producing country, contributing 8 per cent to global fish production and ranks second in aquaculture production. Fish production in 2021-22 is 16.24 million tonnes, comprising marine fish production of 4.12 Million Tonnes and 12.12 Million Tonnes from Aquaculture (PIB, 2023a). To give a boost to the sector and bring about a revolution owing to its potential, Government of India launched a centrally sponsored scheme named "Blue revolution: Integrated development and management of fisheries" in 2015. The scheme is being implemented through the National Fisheries Development Board (NFDB). The second new initiative is the creation of a separate Department of Fisheries (DoF) under the new Ministry of Fisheries, Animal Husbandry and Dairying (MFAH&D). A mega scheme for the sector named Pradhan Mantri Matasya Sampada Yojna (PMMSY) was announced during 2019-20. It is aimed to bring economic revolution through the blue revolution which includes sustainable and responsible development of the fisheries sector with the highest ever investment worth Rs. 20,050 crores (more than 200 billion USD) during 2020-2025 (Lakra & Gopalakrishnan, 2021).

There is an immense scope in aquaculture sector through both horizontal expansions and vertical intensive farming using advanced technologies of recirculating aquaculture systems (RAS) and integrated multi-trophic aquaculture (IMTA) (Lakra & Gopalakrishnan, 2021). Fisheries Startup India is a new initiative launched by the Indian government to promote and support the development of the fisheries industry in the country. India houses 50+ startups operating in fisheries and aquaculture domain. Department of Fisheries, through its partnership with Startup India would like to identify and support innovations and startups working in the aquaculture and fisheries sector to accelerate the growth of this sector (Startup India, Government of India, n.d.).

Jalkafal is an Animal Husbandry and Fishery startup working in Bihar. They provide fresh fishes to consumers directly from the pond. The objective of this startup is to act as a one-stop solution for all fisheries-related needs and build a professional network of fish and fisheries-related product for producers, retailers and wholesalers. The organisation is working on developing the e-Portal as a professional network for people related to the fisheries industry to help better connect them and work as an organised sector. The startup was financed by Directorate of Fisheries, Government of Bihar. Though, they are facing multiple challenges on different aspects like awareness, technology and market expansion, however, this sort of advanced and unique business has inspired many to come forward to become entrepreneur in the fisheries sector.

Policy Provision for Dairy and Fisheries Sector

Various policy measures have been implemented to enhance infrastructure and improve livestock productivity and disease control. These initiatives are intended to support the expansion and long-term viability of both industries from a business perspective. In recent times, range of policy measures have been taken to promote sustainable development, increase productivity, and tackle the challenges faced by the dairy industry. The recent initiatives include introduction of Rashtriya Gokul Mission (RGM), National Livelihood Mission (NLM), Livestock Health and Disease Control (LHDC), National Programme for Dairy Development (NPDD), National Animal Disease Control Programme (NADCP), Diary Infrastructure Development Fund (DIDF), Animal Husbandry Infrastructure Development Fund (AHIDF), and Supporting Diary Cooperatives and Farmers Producer Organisations (SDCFPO) (Department of Animal Husbandry and Dairying, n.d.).

RGM launched in 2014, focuses on the genetic improvement of indigenous breeds through selective breeding and the enhancement of bovine productivity. By promoting the use of high-genetic-merit bulls and strengthening artificial insemination services, the RGM aims to increase milk production sustainably. Further, NLM underscores the importance of entrepreneurship development, innovation, and extension services in the livestock sector. By promoting employment generation, fostering risk management through livestock insurance, and investing in research and development, the NLM seeks to increase productivity and create a more resilient livestock industry. To promote animal health, LHDC and NADCP have been implemented. The LHDC's objective is to eradicate and control critical diseases through the implementation of preventive vaccination programmes and the strengthening of veterinary infrastructure. In 2019, NADCP was launched to control foot and mouth diseases (FMD) and brucellosis by vaccinating 100 per cent of the buffalo, sheep, goat, and pig population. FMD is globally recognised as a priority disease for control and eradication, as it has a significant economic impact on animals. Brucellosis, on the other hand, poses a threat to human health and is a serious occupational hazard.

To support the financial needs of the dairy sector, the Indian government has instituted two funds: the Dairy Processing & Infrastructure Development Fund (DIDF) and the Animal Husbandry Infrastructure Development Fund (AHIDF). Introduced post the Union Budget 2017-18, DIDF, managed by the National Bank for Agriculture and Rural Development (NABARD), boasts a corpus of Rs. 8,040 crores. DIDF's objective is the modernisation of milk processing facilities, equipment, and capacity expansion. Further, in 2020-21, AHIDF, established under the Aatma Nirbhar Bharat (ANB) package with a budget of Rs. 15,000 crores, aims to encourage investments from various entities, including individual entrepreneurs, private companies, MSMEs, Farmers Producers Organizations (FPOs), and Section 8 companies. AHIDF focuses on enhancing infrastructure for dairy and meat processing, promoting value addition, and developing facilities for animal feed plants.

The NPDD, with its dual components, focuses on enhancing the quality of milk and increasing the share of organised milk procurement. This initiative aims to create market linkages, strengthen capacity building, and boost the overall efficiency of dairy production in specific regions. The SDCFPO scheme, focusing on financial support during crises, highlights the government's commitment to ensuring stable market access for dairy farmers. By providing soft working capital loans to cooperative federations, the initiative aims to mitigate the impact of adverse market conditions and natural calamities. This proactive approach contributes to the resilience of the dairy sector and ensures the well-being of farmers, crucial stakeholders in the industry.

In May 2020, as part of the AatmaNirbhar Bharat programme, the Indian government introduced the Pradhan Mantri Matsya Sampada Yojana (PMMSY), a flagship scheme for the fisheries sector with a total investment of Rs. 20,050 crore (Department of Fisheries, 2023). PMMSY aims to address critical gaps in fish production and productivity, infuse innovation and modern technology, improve post-harvest infrastructure and management, modernise and strengthen value chain and traceability, establish framework for a

robust fisheries management and fishers' welfare. Emphasis has been laid towards creating awareness for harnessing of fisheries potential in a sustainable, responsible, inclusive and equitable manner.

Prior to PMMSY, to address the infrastructural requirements for fisheries sector, Fisheries and Aquaculture Infrastructure Development Fund (FIDF) was developed during 2018-19. It provides concessional finance to the eligible entities including sub-national governments for the development of identified fisheries infrastructure facilities through nodal loaning entities. In addition, the Kisan Credit Card (KCC) facilities has been extended to animal husbandry and fisheries farmers since 2018-19.

Challenges and Way Forward

Indian dairy and fisheries industries have experienced significant growth, positioning them as prominent players in the international market. However, these industries face challenges resulting from supply chain interruptions and the effects of climate change. For instance, disruptions in transportation, insufficient cold storage facilities, and distribution barriers may hinder the seamless movement of dairy products from producers to consumers, potentially jeopardising the industry's growth trajectory. Similarly, the fisheries sector also confronts supply chain-related challenges. To maintain its competitive advantage, it is essential to ensure the prompt and efficient distribution. Factors such as inadequate logistics and insufficient processing facilities may impede the sector's overall success.

Climate change poses a significant challenge to both the dairy and fisheries industries. The impact of climate change on these sectors is two-fold. Firstly, shifts in weather patterns, rising temperatures, and unpredictable environmental conditions can directly affect production levels and the quality of output. Secondly, these challenges pose a threat to the livelihood of those dependent. Moreover, the consequences of climate change are not limited to the quantity and quality of dairy and fisheries products. The looming threat of climate change has significant implications for the livelihoods of individuals who depend on these sectors.

Addressing the inefficiencies in the supply chain by investing in infrastructure and technology, implementing climate-smart practices, and promoting innovation can help strengthen the Indian dairy and fisheries sectors against the challenges they face. By pre-emptive addressing these issues, the industries can continue to prosper, contributing to the country's economic growth while ensuring food and nutritional security and sustainability for the long term. ❑

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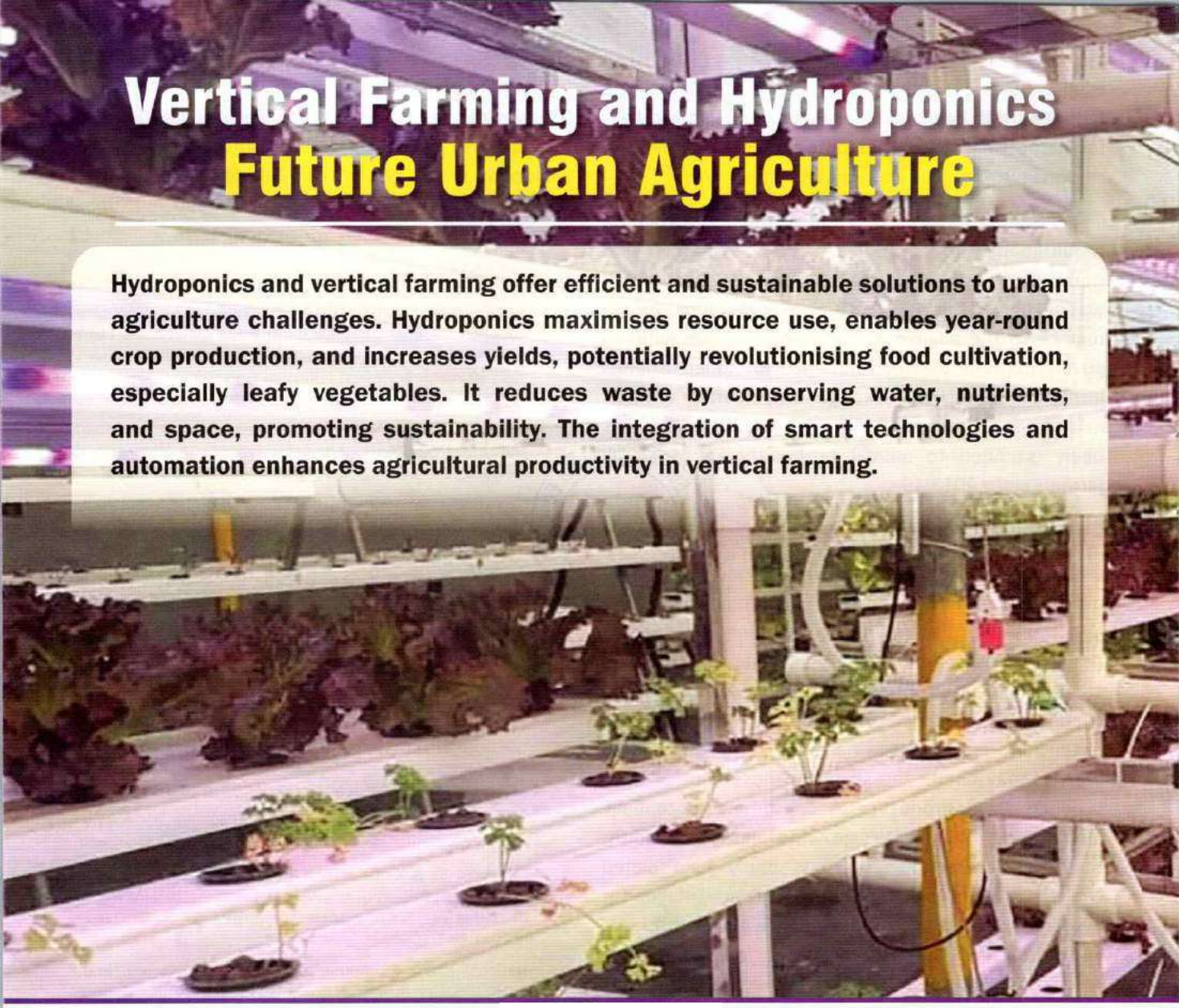
Vertical Farming and Hydroponics
Future Urban Agriculture

Hydroponics and vertical farming offer efficient and sustainable solutions to urban agriculture challenges. Hydroponics maximises resource use, enables year-round crop production, and increases yields, potentially revolutionising food cultivation, especially leafy vegetables. It reduces waste by conserving water, nutrients, and space, promoting sustainability. The integration of smart technologies and automation enhances agricultural productivity in vertical farming.



* **Dr. Y S Shivay**
** **Kadapa Sreenivasa Reddy**

Addressing the rising global food and nutritional demand with a growing global population, diminishing farmlands, declining soil fertility and increasing urbanisation has prompted the adoption of advanced farming methods that are crucial for sustainable and efficient food production systems. Vertical farming and hydroponics, innovative techniques capable of addressing urban agriculture challenges, have gained prominence. Countries that have long struggled with sustainable domestic food production and supply constraints are implementing these technologies to achieve future food security and nutrition. In India, hydroponics and vertical farming are gaining importance considering the increasing demand for leafy, green vegetables and fruits viz. strawberries and blueberries.

* *The author is Principal Scientist and Professor, at the Division of Agronomy, ICAR–Indian Agricultural Research Institute, New Delhi. Email: ysshivay@hotmail.com*
** *The author is Ph.D. Scholar, at Division of Agronomy, ICAR–Indian Agricultural Research Institute, New Delhi. E-mail: ksreddyagro@gmail.com*

By 2050, the global population is projected to reach 9.8 billion, with 70% living in cities. Globally, 55% of people live in urban areas, and urbanisation is on the rise. In India, 53% are expected to live in cities by 2050 (United Nations, 2018). Limited agricultural land for conventional farming necessitates the exploration of innovative food production technologies like Urban Farming (UF) including vertical and hydroponic farming, which can ease pressure on agricultural lands for a healthier and more sustainable future. The worldwide vertical farming market is projected to reach USD 33.02 billion by 2030, with an anticipated compound annual growth rate (CAGR) of 25.5% from 2022–2030. According to IMARC Group's latest research report, the India vertical farming market is expected to demonstrate a CAGR of 25.4% during the period 2023–2028.

Understanding Vertical Farming and Hydroponics

Vertical farming (VF) revolutionises traditional agriculture by employing soilless cultivation in a multi-level, protected indoor environment, departing from conventional soil-based farming and horizontal crop growth on a single level. Prof. Despommier is acknowledged as the founding father of 'Vertical Farming,' who created high-tech vertical farms as an alternative solution to address nutritional needs, particularly in megacities. Despommier proposed that overcoming challenges like diminishing agricultural resources and changing climate could involve the concept of vertical farming, a contemporary practice of cultivating crops in stacked layers within protected indoor environments. Vertical farming has the potential to enhance food production, maintain quality and contribute to sustainable urban farming. It is an indoor urban technique involving large-scale food production within multistorey buildings. Successful commercialised urban farms exist in European countries like France, Germany, the Netherlands, and the United Kingdom. The significance of urban agriculture and vertical farming is particularly crucial in low-and lower-middle income countries, such as sub-Saharan Africa and parts of Southern Asia.

Vertical farming adopts a unique approach to maximise space and efficiency by cultivating plants in vertically stacked layers or inclined surfaces, often within controlled environments like greenhouses or warehouses. This method proves particularly advantageous in densely populated urban areas where space is limited, allowing for optimal use of available space. This farming method involves growing crops in vertically stacked layers indoors, frequently utilising controlled-environment agriculture (CEA) techniques to optimize factors such as light, temperature, humidity, and nutrients as shown in Fig 1.

Fig. 1- Vertical farming technology at ICAR-IARI, New Delhi

Various shapes and sizes of vertical farms worldwide employ one of three nutrient-providing methods: Hydroponics, Aeroponics, or Aquaponics (Farkhondehmonfared, 2022).

Hydroponics: This prevalent technique in vertical farming involves growing plants on soil-free substances continuously irrigated with nutrients. Plant roots are submerged in a nutrient solution, and the system uses 60–70% less water than traditional agriculture, making it widely utilised in numerous vertical farms worldwide.

Aeroponics: Developed by NASA in the 1990s for space plant growth, aeroponics cultivates plants in a soil-free mist environment with roots hanging down in a closed-air container. This method uses 90% less

water than hydroponics, making it a highly efficient system of food production. Plants grown aeroponically absorb more nutrients, resulting in healthier and more nutritious produce. Globally, the largest aeroponic vertical farm is currently situated in New Jersey.

Aquaponics: Going beyond hydroponics, aquaponics integrates fish production into plant cultivation. The system utilises fish-produced nutrient-rich waste as a feed resource for plants, and plants, in turn, purify and recycle wastewater for fishponds. While this system offers ecological benefits, its complexity and higher cost make it less common in vertical farming.

Hydroponic farming presents an intriguing alternative to traditional soil-based agriculture by nurturing plants in nutrient-rich water solutions instead of soil, fostering quicker and more efficient growth. This soil-less approach proves versatile, cultivating a diverse range of crops, from vibrant leafy greens to fruitful plants. In India, hydroponics is a relatively new concept gaining popularity among entrepreneurs and innovative farmers seeking sustainable and efficient crop cultivation methods. Currently, this technology is primarily utilised in urban farming, rooftop gardening, and commercial farming. Moreover, vertical farming often integrates hydroponic systems, contributing to a sustainable and compact cultivation approach.

Different Hydroponic Systems

When considering hydroponic systems, numerous options exist, each with distinct advantages and limitations. The choice of the best hydroponic system for growing vegetables depends on factors like space, budget, and the specific crops you intend to cultivate. Here are some popular hydroponic systems to consider (Rajaseger et al., 2023).

1) **Deep Water Culture (DWC):** Plant roots are submerged in a nutrient solution. It is a straightforward and low-cost system suitable for beginners. This method involves suspending the plant roots in a solution of nutrient-rich, oxygenated water that promotes nutrient absorption.

2) **Nutrient Film Technique (NFT):** NFT involves a constant flow of nutrient solution over the roots, providing them with a steady supply of nutrients and oxygen.

3) **Ebb and Flow System:** This method involves cyclic submersion of plants in the nutrient solution, providing nutrients and oxygen to the roots through periodic drainage back into a reservoir.

4) **Drip System:** Drip system directly deliver nutrient solutions to plant roots using tubes and drippers. The solution is dripped onto the growing medium, like perlite or coco coir, and can be drained back for potential reuse.

5) **Aeroponics:** In aeroponics, plant roots are suspended in the air and misted with a nutrient solution, promoting rapid growth.

6) **Wicking System:** Plants in an inert medium use a cotton rope wick to draw nutrient solution from a reservoir to the root zone.

7) **Vertical Tower Systems:** These systems allow plants to grow vertically, making the most of limited space.

8) **Krakty Method:** A cost-effective hydroponic system that doesn't require electronic devices or electric current. It involves an initial administration of water and nutrients, proving efficient for plant production while minimising water wastage.

Combining hydroponics and vertical farming enhances the efficiency and productivity of resources used for food production. This approach, successful in urban farming, particularly for leafy green vegetables, allows year-round cultivation of crops like lettuce, kale, and spinach in controlled environments. Hydroponic vertical farming optimises space and resources, making it an attractive choice for food production in urban areas as depicted in Fig. 2.

Crop Management in Hydroponics

Plants grown hydroponically thrive in slightly acidic conditions, with a pH range of 5.5 to 6.5, optimising nutrient uptake. Neutral water is preferred for the hydroponic system. The pH of the nutrient solution should be adjusted twice a day to stay within an acceptable range. Acids like sulphuric, nitric, phosphoric, citric, or acetic are used to lower pH and potassium hydroxide, sodium hydroxide, or bicarbonate of soda are used to raise it. The strength of nutrient solution, measured by an Electrical Conductivity (EC) meter, impacts plant growth.

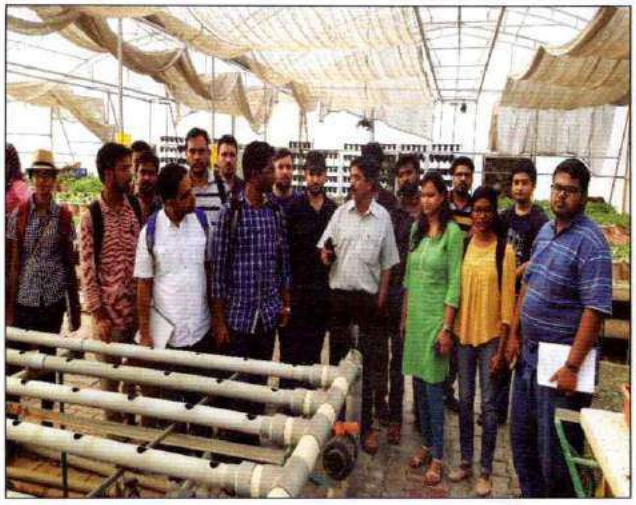


Fig. 2- Hydroponics and Vertical Farming Facilities at ICAR–IARI, New Delhi

Maintaining the optimum conductivity for each crop is crucial for maximising productivity. Automated hydroponic systems automatically manage nutrient solution EC, while manual measurement requires daily checks for adjustments. Maintaining optimal pH and EC is crucial. A favourable temperature significantly influences crop growth, with an ideal range of 15–18°C for leafy and exotic vegetables, although they can tolerate temperatures as low as 7°C. Adequate oxygen in the nutrient solution is crucial for root absorption, and plants benefit from aeration, avoiding waterlogged conditions. The solubility of oxygen in water decreases with rising temperatures (Singh and Ranjan, 2022).

Crops Suitable for Vertical Farming and Hydroponics

The most commonly grown commercial crops under vertical farming and hydroponics are given in the table:

Leafy greens and vegetables	**Lettuce, spinach, kale (karam Saag), pak choi, arugula, coriander, chard, collard green tomatoes, pepper, broccoli, cucumber, beans**
Herbs	Chives, basil, mint, oregano, fennel and parsley
Fruits	Strawberries, blueberries

ICAR-CISH, Lucknow, has initiated the standardisation of vegetable, herb, and strawberry cultivation in subtropical climates. The institute demonstrated four hydroponic systems: aeroponic, ebb and flow, Nutrient Film Technique, and drip hydroponic. The drip system is found suitable for indeterminate tomatoes, cherry tomatoes, and parthenocarpic cucumber, and nutrient film techniques for leafy vegetables, indeterminate tomatoes, and capsicum. The ebb and flow system proved effective for growing leafy vegetables and seedlings (Singh and Ranjan, 2022).

ICAR-Indian Institute of Horticulture Research, Bengaluru (IIHR) has developed a variant of hydroponics, "Cocoponics" or the soilless production of vegetables, using cocopeat as a substrate. The Institute has developed the complete production technology including a liquid nutrient formulation (Arka Sasya Poshak Ras) for soilless cultivation of zucchini, colour cabbage, chilli, brinjal, palak, amaranthus, coriander, etc. and exotic leafy vegetables viz., lettuce, parsley, broccoli, bok choy, etc. on arka fermented cocopeat (substrate) under open as well as in protected conditions (PIB, 2023).

Some examples of hydroponics companies in India are: Nutrifresh, India's largest hydroponic farm. Akarshak hydroponics, involved in the cultivation of hydroponic saffron and indoor saffron. Urban Kisaan, Future Farms, Rise Hydroponics, Evergreen Farms, and many more are yet to come. Vertical farming presents a range of benefits and challenges that make it a compelling option for future agriculture. Here are some advantages and disadvantages listed below:

Advantages

- Hydroponics in conjunction with vertical farming utilises 99% less land compared to traditional farming due to the concentrated root system

- Hydroponics require less water compared to conventional farming practices
- Enables the creation of a controlled microclimate, allowing year-round indoor cultivation of regional or seasonal crops
- Protects crops from soil-borne pests and diseases, and adverse weather conditions, thereby reducing the need for pesticides and fertilisers
- Flexible to set up locations anywhere, to reduce transportation and warehouse costs, streamlining the supply chain
- Facilitates access to fresh produce, ensuring reliable and sustainable food sources
- Vertical farming enhances plant productivity per unit area compared to horizontal hydroponic methods
- Automated monitoring and control systems enable growers to optimise growing schedules and provide optimal environmental conditions for crops
- In urban areas, vertical farming provides both environmental benefits, such as biodiversity and sustainability, and socio-economic advantages, including leisure and education

Disadvantages

- High upfront infrastructure costs pose a significant hurdle to the widespread adoption.
- Shortage of expertise and the need for a controlled growing system necessitate a highly educated workforce, leading to elevated labour costs
- It is energy-intensive and requires artificial lighting, temperature, and humidity requirements, which increases the cost of production
- The absence of natural pollinators in controlled conditions can result in poor fruit sets and the production of small, misshapen fruits
- The range of crops cultivated commercially is usually confined to leafy vegetables and microgreens
- Require continuous attention and care, with components like pumps and nutrient delivery systems needing regular maintenance

Way Forward

Vertical farming, though expensive, is more affordable by utilising cheap and available shipping containers and abandoned warehouses. Collaborative research is important to bring together current technology practices for increased sustainability. Hydroponics and vertical farming offer efficient and sustainable solutions to urban agriculture challenges. Hydroponics maximises resource use, enables year-round crop production, and increases yields, potentially revolutionising food cultivation, especially leafy vegetables. It reduces waste by conserving water, nutrients, and space, promoting sustainability. The integration of smart technologies and automation enhances agricultural productivity in vertical farming. While hydroponics and vertical farming can be a good solution, they need more acceptance for widespread adoption. Research shows that supportive policies and incentives, like grants and tax benefits, can encourage investment and promote urban agriculture through agri-startups. ❑

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