

ADOPTION OF DIGITAL AND INNOVATIVE FARMING TECHNIQUES

The current decade witnesses a 'digital agricultural revolution,' tackling challenges posed by a burgeoning population, surging food demand, and dwindling natural resources. To realize the UN's 'zero hunger' goal by 2030, the agrifood system must transform for productivity, sustainability, efficiency, and resilience. Digital agriculture promises economic gains, societal inclusivity, and environmental stewardship. India leads in milk, jute, pulses, and ranks second in various crops. Despite high output, small holdings limit farmer income. Digital technology can enhance efficiency, transforming agriculture to meet growing demands sustainably.

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 -

1. Precision Agriculture

Precision Agriculture, championed by the International Society for Precision Agriculture, integrates data analysis and technology to optimize resource use, enhance productivity, and ensure sustainability in farming, epitomizing the digital farming revolution.

2. Smart Farming

Smart farming integrates IoT devices to create an automated agricultural ecosystem. Utilizing robotics, drones, and AI, it enhances product quality and quantity while minimizing labor. Centralized platforms enable remote monitoring and control for improved efficiency.

3. Vertical Farming and Controlled-Environment Agriculture

Vertical farming and controlled-environment agriculture (CEA) are rising in urban areas, using stacked layers or regulated conditions to optimize land use, enhance yields, and enable crop growth in diverse climates.

4. Smart Irrigation System: Smart irrigation systems utilize soil moisture sensors to determine crop water needs, preventing over-irrigation, conserving water, and improving crop health. Remote control through web or mobile apps enhances efficiency.

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. GPS: Precision agriculture relies on GPS technology for precise field planning, facilitating efficient resource application. Field-based sensors provide real-time data on crop health, nutrient levels, and soil moisture, while IoT devices enhance environmental monitoring on farms.

2 Drones: Drones equipped with cameras and sensors capture high-resolution field images for crop monitoring. Farmers identify issues like pests, nutrient deficiencies, or water stress, enabling efficient surveying of vast areas.

3. Automated Technology: Autonomous tractors and harvesters, equipped with GPS and sensor technology, perform tasks like planting, harvesting, and ploughing without direct human intervention, ensuring precision, and reducing labour costs.

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. Data-driven Farm Management: Farm management software and digital platforms integrate data on crop health, soil conditions, and weather forecasts, aiding farmers in planning planting, watering, and harvesting operations confidently.

6. Robots for Agricultural Operations: Robotic agricultural operations are expanding, with autonomous vehicles harvesting crops and eliminating weeds efficiently. Robotics reduces labor needs while enhancing operational efficiency.

7. Machine Learning: Machine learning algorithms analyse historical and current data to forecast crop yields, disease outbreaks, and market trends (crop prediction models). Farmers can then make proactive decisions based on predictive analytics.

8. Blockchain: Blockchain enhances transparency in agriculture, enabling secure records of transactions and product movements. It ensures food authenticity, reduces fraud risks, and empowers consumers to make informed decisions about food quality and origin.

9. 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

- Indian startups are revolutionizing farm mechanization, employing drones for tasks like applying herbicides and fertilizers, reducing labor and hazardous exposure. Drone and remote sensing tech improve crop monitoring, vital in combating crop damage by pests like locusts.
- Agri-tech startups leverage SMS in local languages and multimedia to offer localized, actionable intelligence, incorporating data from weather, drones, and local conditions. Collaborations with various stakeholders ensure project success.
- Farmers heavily rely on dealers for agricultural advice, impacting productivity. Misaligned incentives may harm soil fertility. Digital technologies offer solutions to lower costs and improve access to high-quality inputs, benefiting both businesses and farmers.
- IBM's AgroPad uses AI to rapidly evaluate soil and water quality, providing instant test results via a smartphone app.
- Indian farmers tend to favour water-intensive crops (FAO and ICRISAT, 2022). Startups are utilizing IoT devices to monitor water usage efficiently and satellite data to manage irrigation remotely. Accelerating digital technology adoption requires access to quality inputs via digital platforms and incentives for market participants, particularly startups.
- Farmers faced challenges in realizing Minimum Support Price (MSP) due to high transportation costs and limited procurement sites. Startups use digital interventions for traceability, objective grading, and direct connections to global sellers.
- Digital technology revolutionizes agriculture with diverse applications. Trringo and EM3 Agriservices lead farm equipment rentals, akin to the 'Ubers of Agriculture'. EM3's 'Samadhan' app offers 'Farming as a Service'. Ergos' 'Grain Bank model' aids small farmers with post-harvest solutions. Ergos offers farmers instant liquidity during harvest by allowing them to retain or sell small quantities of grains.
- AgNext's Qualix platform assesses trade quality swiftly, while Yuktix Technologies provides digital tools for farm monitoring and risk management, enhancing yield and reducing losses with Green Sense IoT devices and dashboard.

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.
- Disparities in access, connectivity, and technological literacy persist in agriculture, with some regions enjoying advanced tools while others lacking in infrastructure and skills. Bridging this divide is vital for equitable and sustainable farming practices.

Conditions for Digital Transformation

- Digital agriculture's evolution depends on contextual factors like availability, connectivity, affordability, and ICT integration in education, along with supportive policies and e-government initiatives fostering digital strategies. Farmers' digital literacy affects technology adoption.
- Enabling conditions, or 'enablers,' like internet access, mobile phones, and social media, facilitate technology adoption. Digital skills, agripreneurial support, and innovation culture also play crucial roles in advancing agricultural technology.
- Digitalization is vital for Indian agriculture's competitiveness and self-sustainability. Startups must address literacy gaps and gender disparities, considering local sensitivities. Government support includes promoting partnerships, FPOs, and subsidizing access.

Way forward

India's National AI Strategy aims to leverage AI's benefits, especially in agriculture (Niti Aayog, 2019). 'Agriculture 4.0' integrates networking in farming akin to Industry 4.0, with web-based tools facilitating data management and communication. The future, 'Agriculture 5.0', emphasizes robotics and AI. FPOs in India offer an extensive scope for digital agriculture, covering the entire agricultural value chain. They facilitate connections between farmers, produce, and markets, making technology more accessible and affordable.

Conclusion

The introduction of cutting-edge digital farming practices marks a significant milestone in agriculture's history. Digital farming incorporates multiple technologies to enhance production, sustainability, and efficiency, ensuring a bright future for farming.

BAMBOO FARMING: GROWING METHODS AND REAPING BENEFITS

Bamboo farming, a sensation among progressive farmers, offers full or part-time options. It serves as both main and subsidiary crops, being eco-friendly, low-maintenance, and in high demand, making it lucrative for farmers nationwide.

Climate Requirement

- Bamboo thrives in various climates and soils, including valleys, water-rich areas, and hill slopes, with temperatures between 7°C and 40°C. Ideal rainfall ranges from 1200mm to 4000mm annually, while adaptable species like *Dendrocalamus strictus* tolerate drier conditions in well-drained, coarse, stony soils.
- Bamboo thrives in diverse soils, except those with large rocks, preferring well-drained sandy loam to clay loam with pH 5.0 to 6.5. Rich organic matter, moderate moisture, and high nitrogen promote optimal growth for maximum production.
- While some bamboo species tolerate low salt levels, saline soil isn't ideal. Bamboo suffers in swamps and flooding, with rhizomes drying up. Yet, varieties in Kerala, Tamil Nadu, Goa, and Karnataka withstand seasonal floods. Establishing a nearby nursery is key for large-scale plantations, ensuring proper drainage and essential facilities for propagation.

Site Selection and Land Preparation

- Bamboo species thrive in various climates, from high mountains to coastal areas. They grow on slopes, riverbanks, marginal lands, and agricultural boundaries. For large-scale plantations, consider market potential, road access, level land with good drainage, or slopes with water availability for diverse purposes.
- Before site preparation, surveying helps estimate labor and resources. Remove shrubs, weeds, and grasses competing with bamboo. Keep scattered trees for shade and safety. Deep tillage improves soil quality. Cleaning and ploughing three weeks prior to planting allow soil adaptation. Fly ash benefits as a soil conditioner.

- Adequate fencing prevents grazing and trampling. Fire safety requires clearing vegetation within a 5-meter radius for a fire break.

Irrigation

- Choose planting sites with even rainfall and avoid flooded areas. Create artificial drainage if needed. During dry periods, irrigate 8-13 times yearly, using 10-12 liters per plant for the first two years.
- Maximize water use with drip irrigation. Consider burying clay pots or using inverted plastic bottles with wicks for slow water release. Prepare a trench around bamboo and mound soil mixture to help retain water.

Manuring and Fertilisation

- Bamboo thrives in nutrient-rich environments, necessitating fertilization to maintain soil quality and yield. Essential fertiliser components include potassium, phosphorus, and nitrogen. Utilizing wood ash, compost, and green manures optimizes yield.
- Tailored fertilization based on soil analysis is vital, aiming for an NPK ratio of 4:1 or 5:2:1. Plantations may require up to 1,500 kg/ha annually for culm creation and 4,000 kg/ha for shoot production, adhering to a general dose norm of 150g N + 150g P + 150g K.
- For bamboo growth, NPK, dry farmyard manure, or vermicompost are effective. Boost growth with 15-20 kg of compost or manure per clump, or 0.5-1 kg of NPK fertilizer for mature bamboo plants.
- Apply fertilizer one or two months after planting. Use 50g NPK and 5kg well-rotted manure or compost initially. Next rainy season, apply 100-150g NPK and 10kg manure or compost. Third year, before rainy season, use 30kg compost or manure and 500g NPK.

Mulching

High-quality bamboo shoots necessitate mulching, inhibiting weed growth and preserving soil moisture. Mulch shields shoots from direct sunlight, ensuring they reach ideal size without becoming tough. Applying 10 cm of organic material uniformly around bamboo clusters enhances soil fertility, retains moisture, and recycles essential nutrients, promoting optimal growth.

Soil Mounding

Soil mounding is common for older sympodial bamboo plants where rhizomes become exposed due to soil degradation. Exposed rhizomes grow slowly with reduced nutrient and moisture intake.

Bamboo Pests and Control

- Certain insects, such as mealybugs, mites, scales, and aphids, exclusively feed on bamboo, weakening it and making it susceptible to rot and mildew. Regular weeding in the first year promotes optimal bamboo growth.
- To eradicate weeds and loosen soil, plough the plantation, or focus on loosening soil around bamboo. Remove weeds within a 1-1.5m radius and loosen soil 50 cm radius, 15 cm depth. Manage coppicing and clump congestion during early maturity for easier bamboo shoot collection. Culm management is vital for certain bamboo species.
- Pruning lower branches reduces clump congestion, aids airflow, and simplifies fertilization and harvesting. Intensive pruning starts in the fourth year, but mild pruning begins in the second and third year. Best pruning months are December and January.

Harvesting and Yield of Bamboo

Harvest bamboo four to six years post-planting for profit, considering scientific management including fertilization, pruning, thinning, and weeding. Harvest mature culms aged two to three years for non-structural uses. Avoid harvesting during the monsoon to prevent damage to immature shoots and future growth.

1. 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. Preserve current year culms for future generations and retain older culms to protect and ensure healthy development of younger ones.
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. Before harvesting, inspect culms thoroughly. Cut close to the ground, leaving one internode above. Use a sharp knife or saw to prevent splitting and damage.
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

Bamboo offers environmental benefits and is in high demand for furniture and home décor, creating a lucrative market that benefits farmers economically. Popular uses include:

Fabrication: Bamboo, known for its lightness and delicacy, is ideal for textiles due to its exceptional qualities. It creates cool, breathable cloth, absorbs more water than cotton or polyester, and has a natural glossy, antibacterial finish that prevents static electricity buildup.

Bamboo fabric excels with natural deodorizing properties, preventing Odor and abrasion while remaining highly permeable. Meeting quality standards, it's eco-friendly with hydroscopic properties, even when blended with cotton, maintaining its qualities.

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

In 2020, bamboo held a 35% market share in industrial goods, but in 2021, it surged to \$57.86 billion. With a 5.7% annual growth rate, bamboo is now a fast-growing market.

In 2020, industrial bamboo products held a 35% market share, dominating industries like flooring, pulp, paper, and plywood. The Asia-Pacific region contributed 75% of the total revenue, led by India, China, Vietnam, and Myanmar.

MUSHROOM CULTIVATION: A FRUITFUL AND LUCRATIVE INDUSTRY

Mushrooms, edible fungi found in natural habitats, grow in the wild, on soil, and wood. Scientists identify over 14,000 species, 2,000 of which are edible. People have consumed them for millennia across 85+ countries. Archaeological evidence dates back 13,000 years in Chile and earlier in China, while ancient Indian texts mention their use, including the possible extraction of 'Soma' from *Amanita muscaria*. In ancient Greek and Roman eras, edible fungi from forests were prized, especially by elites. Caesar's mushroom, like *Amanita caesarea*, favored by early Roman rulers for over 2000 years, spurred mushroom cultivation as a burgeoning industry.

Present Production Scenario

- Global mushroom production reached 44.2 million tons in 2021. Shiitake mushrooms accounted for 26%, oyster mushrooms and black ear mushrooms each contributed 21%, followed by button mushrooms (11%), *Flammulina* (7%), paddy straw mushrooms (1%), and others (13%). India annually produces approximately 0.28 million tonnes of mushrooms, with per capita consumption at around 90 g, lower than the USA (1.49 kg) and China (1.16 kg). Mushroom cultivation began in 1961 in Solan, Himachal Pradesh, India.
- Initially, scientists at the Department of Mycology and Plant Pathology, now Dr. Y.S. Parmar University of Horticulture and Forestry, and State Department of Horticulture pioneered mushroom cultivation. The Indian Council of Agricultural Research established the National Research Centre for Mushrooms (NRCM) in 1983 at Chambaghat, Solan, later elevating it to the Directorate of Mushroom Research (DMR) in 2008. Solan was declared 'The Mushroom City of India' in 1997.
- In India, button mushrooms dominate cultivation (70%), followed by Oyster (17%), paddy straw (9%), and milky mushrooms (3%). Other species like Shiitake, *Cordyceps militaris*, *Ganoderma*, etc., make up the remaining 1%. Bihar leads production with 35.6 thousand tonnes, followed by Odisha (34.5 thousand tonnes), Maharashtra (32.5 thousand tonnes), Uttar Pradesh (23.4 thousand tonnes), and Uttarakhand (22.4 thousand tonnes). Northern states like Punjab, Haryana, and Himachal Pradesh focus mainly on button mushroom cultivation.
- These states are key for compost and button mushroom production from September to mid-March. Milky mushrooms are native to Southern India, while Paddy straw mushrooms thrive in Odisha and Chhattisgarh. Promising strains like Shiitake, *Hericium*, *Ganoderma* offer future prospects.

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

- Mushroom cultivation efficiently utilizes microbial technology to convert agricultural, industrial, forestry, and household waste into nutritious food. India produces 650 million tonnes of crop residues annually, with 368 MT from cereal crops, including 154 MT from rice and 131 MT from wheat. Approximately 178 MT of crop residues are surplus annually, with 87 MT being burnt, contributing to pollution and climate change. Currently, only 0.03% of these residues are used for mushroom production.
- Mushrooms thrive on agricultural and forest waste, transforming residues into valuable products like food, medicine, feed, fuel, compost, and manure. Utilizing them for cultivation can spur economic growth, mitigating environmental pollution and health risks from incineration. India could produce 3 million tonnes of mushrooms and 15 million tonnes of bio-compost from agricultural waste. In Japan, mushrooms contribute to 44% of the forestry industry's production value, utilizing 70% of the country's land.
- Efficiently utilizing agricultural residues and labor can position India as a significant mushroom producer, reducing pollution and creating employment opportunities.

Mushroom Cultivation-Profitable Venture

- Mushroom cultivation is a lucrative agricultural venture requiring minimal land. Recommended species include Button, Oyster, Paddy straw, and Milky mushrooms. Simple cultivation methods enable adoption by growers, even in small spaces, with standardized techniques for tropical varieties.

- Mushrooms are grown seasonally or year-round in controlled environments. Cultivation spans 1-3 months, with high yields. A minimum viable unit for button mushrooms requires <0.1 ha. Profit potential is significant, with farmers earning Rs. 40,000 to 50,000 from 500 bags in 3-4 months. With minimal investment, farmers can start this venture, earning higher profits in larger units with controlled environments. Shiitake cultivation is even more profitable, with farmers earning Rs. 45,000 to 70,000 from 500 bags.
- Mushroom cultivation offers economic and nutritional support to small farmers using locally available waste. Operational costs are minimal, around Rs. 30-40 per kg. The Directorate of Mushroom Research aids in establishing units and provides feasibility reports for various scales and species. Government support, including subsidies and funding from banks, facilitates venture initiation.
- The Government of India sponsors schemes like MIDH and NABARD to financially support mushroom farms. The Agriculture Infrastructure Fund (AIF), launched in 2020, offers medium to long-term debt financing, with interest subvention and credit guarantee facilities. AIF has sanctioned Rs. 32,472 crores for 43,318 projects, including mushroom cultivation, till November 2023.

Medicinal and Nutraceutical Properties

- Mushrooms, recognized globally for their medicinal and nutritional value, are recommended by the FAO as a protein-rich food, especially for developing nations. Species like Ganoderma possess significant medicinal and functional properties, with Ganoderma supplements alone estimated at USD 1.6 billion annually. Mushrooms are rich in proteins, vitamins, and minerals, low in fat and sugar, making them a superfood, with 30-40% quality proteins on a dry weight basis.
- Mushrooms contain essential amino acids like leucine and lysine, lacking in staple cereals. Low in sugar and fat, they benefit those with diabetes and heart issues. Rich in various vitamins, especially vitamin D, they help address widespread deficiencies.
- Additionally, mushrooms are rich in minerals like phosphorus, zinc, manganese, potassium, copper, selenium (an antioxidant), iron, and magnesium. Eating mushrooms twice a week may reduce the risk of early-stage memory loss. Various commercial products made from medicinal mushrooms are available, such as Lentinan from Lentinus edodes and Concord Sunchih from Ganoderma lucidum. In 2020, India earned 8.65 million USD from mushroom exports.

Highly Priced Mushrooms

- Highly prized mushrooms like Morchella esculenta, Shiitake, and Cordyceps militaris grow naturally in forests, providing income to rural collectors and foreign earnings. While M. esculenta resists artificial cultivation, technology supports Shiitake and Cordyceps farming.
- India exports 50-60 tonnes of dry morels annually. Shiitake, a culinary delight with medicinal benefits, contains 18 amino acids, rich in leucine and lysine, and over 30 enzymes. Cultivation technology, developed by various institutes, has reduced cultivation time to less than 2 months. Fresh Shiitake can fetch Rs. 750-1000 per kg, while dried Cordyceps militaris can exceed Rs. one lakh per kg.
- Found in higher hills, Cordyceps militaris is distributed in Nepal, Bhutan, India, and Tibet, at elevations of 3000-5000 m. Collected from Chamoli district and other Uttarakhand parts in May-June, it's rich in medicinal benefits. Cultivation technology exists, yielding medicines and energy boosters.

Success Stories

- India boasts numerous success stories in mushroom cultivation, with farmers turning into successful entrepreneurs. Dr. Sangam Kurade's company in Goa produces 18,000 kg daily. Himalaya Food Company in Himachal Pradesh produces over 10,000 tonnes annually.
- Vikas Mushroom Farm expanded to Punjab, producing 6,000 metric tons of compost and 600 metric tonnes of mushrooms. Jiwa Foods in Maharashtra produces 4000 kgs daily.

- Bajwa Mushroom Farm in Kurukshetra, Haryana, serves over 10,000 clients globally, employing 1000+ workers. They utilize 2000+ tonnes of straw to produce 600+ tonnes of button mushrooms annually, along with 500 tonnes of spawn. Shubam Modi of Ranchi yields 60 tonnes monthly. Rishabh and Ayush Gupta in Agra earn Rs. 2.0 lakh daily with a net profit exceeding Rs. 70,000.
- Santosh Mishra's Kalinga Mushroom Centre in Puri, Odisha, a 30-year endeavour, yields 2,000 daily spawns. He trains 10 lakhs in cultivation and ventures into food processing with a Rs. 2 crore unit.

Use of Mushrooms Beyond Food

- Mushroom mycelium's strength is utilized in tech for leather, paper, textiles, packaging, and building materials. Its network structure offers mechanical resilience, while foam-like materials reduce petroleum dependency, benefiting animals and promoting upcycling.
- A consortium of leather alternative developers, including ADIDAS, HERMES, and KERING, collaborates with apparel companies. Similarly, packaging material developers partner with IKEA. Ganoderma mushroom is now commercially utilized for durable fashion items like caps, bags, and shoes.
- Startups like Bolt Threads, Ecovative Design, Grado Zero Espace, Mugo, Microteach, and MycoWorks highlight mushroom's potential for materials and food. Bio-based leather substitutes market reached USD 710.3 million in 2020, with fungal-based leading at 26.6%. Expected CAGR of 7.7% suggests growth. Integrating mushroom cultivation can boost farmer income, recycle agro-residues, and enhance food security.

APICULTURE: SCOPE AND OPPORTUNITIES

Apiculture, a global activity, supports millions of beekeepers' livelihoods. Bees and wild pollinators maintain biodiversity, aid plant survival, promote sustainability, forest regeneration, climate adaptation, and enhance agricultural production.

Apiculture contributes directly to various outputs like honey, beeswax, queen bees, colonies, pollen, royal jelly, bee venom, and propolis for cosmetics and medicine. It ensures nutritional, economic, and ecological security as vital pollinators in agriculture and ecosystems. It requires minimal land and capital, does not consume farmers' time, and appeals to all demographics. It can serve as a hobby, sideline, or 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 to collect honey and beeswax, or for the purpose of pollinating crops, or to produce bees for sale to another 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 hosts four major honey bee species: domesticated species *Apis cerana* (Indian or Asian honey bee) and *A. mellifera* (European honey bee), along with wild species *A. dorsata* (rock honey bee) and *A. florea* (dwarf honey bee).
- Beekeepers in Indian states like Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Telangana, Odisha, and Northeastern states cultivate *A. cerana* for livelihood, although its honey comprises only 5-10% of total production. *A. mellifera*, the Italian bee, was introduced in the 20th century due to outbreaks of tracheal mites and Thai sac brood virus, primarily in North India, where diverse flora like mustard, sunflower, eucalyptus, and safflower support beekeeping.
- Each colony yields 50-60 kg of honey yearly, with 70-75% from *A. mellifera*. Hive placement aids crop pollination for food production. *A. dorsata* contributes 20% of Indian honey. All bee species are crucial pollinators requiring conservation. Honey, consumed for centuries, offers medicinal and culinary benefits.
- Beekeeping in India is predominantly forest-based, utilizing natural resources for honey production. Bee hives require no additional land, making it compatible with agriculture. It offers sustainable income, nutrition, and medicinal products, with increasing use in food and industries.
- The table displays five main honey bee species in India: *Apis cerana* yields 8-10 kg per hive yearly, followed by *Apis mellifera* with 25-30 kg, *Apis dorsata* with 30-35 kg, *Apis florea* with less than one kg, and *Apis laborisa* with 40-45 kg.

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

- The Government allocated Rs. 500 crores for the National Beekeeping & Honey Mission (NBHM) over three years (2020-21 to 2022-23) under the Aatmanirbhar Bharat scheme. NBHM aims for the 'Sweet Revolution' through the National Bee Board (NBB), promoting scientific beekeeping for holistic industry growth, income and employment generation, agriculture/horticulture enhancement, and infrastructural development, including Integrated Beekeeping Development Centres (IBDCs), honey testing and disease diagnostic labs, and empowering women through beekeeping.
- Additionally, the scheme focuses on Mini Mission-I for scientific beekeeping awareness, Mini Mission-II for post-harvest management, including beehive product processing, and Mini Mission-III for beekeeping research and technology. Rs. 150.00 crore is allotted to NBHM for 2020-21.

Status

India currently boasts 19.34 lakh honey bee colonies with 2.50 lakh beekeepers and wild honey collectors, yielding 1,33,200 MT of honey valued at Rs. 2704.31 crore. India is a major honey exporter, sending 79,929.17 MT worth Rs. 1,622.77 crore in 2022-23 to over 83 countries, with USA, Saudi Arabia, UAE, Bangladesh, and Canada being major markets.

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

The above-mentioned equipment's 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

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

- Apart from agricultural areas, diverse nectar-rich plants in tropical and sub-tropical forests support bee foraging, potentially accommodating 200 million colonies versus 3.4 million now.
- **Genetic Diversity:** Of the seven globally significant honeybee species, five, including the Rock bee and Indian hive bee, are found in India. This enhances apiculture's resilience against climate change and environmental degradation.
- **Agrarian Economy:** Integrating bee pollination into agriculture in India holds great promise, ensuring effective pollination management and significant crop yield boosts.
- **Thrust on Food Processing:** The Government promotes food processing, enhancing rural income through initiatives like PM SAMPADA. Honey's high value aligns well with these strategies.
- **Rising Industrial Demand:** Honey plays a crucial role in Ayurveda and pharmaceuticals in India, aiding in treating various ailments. Growth in the AYUSH and pharmaceutical sectors is expected to boost honey's industrial use.
- **Rising Domestic Market:** Shifting food trends towards wellness and natural sweeteners drive increasing honey demand. COVID-19 concerns further elevate consumption due to its antimicrobial and anti-inflammatory properties.

Scope

- The apiculture market is forecasted to grow at a CAGR of 4.3% from 2020-2025, with Asia-Pacific leading. India's apiculture market is projected to reach Rs. 33,128 million by 2024, growing at nearly 12% CAGR.
- India ranks sixth in natural honey exports, with 59,536.75 MT exported for Rs. 633.82 crore in 2019-20, majorly to the USA, Saudi Arabia, Canada, and Qatar. Leveraging demand for organic honey internationally could promote organic beekeeping guidelines and expand the sector commercially.
- Lucrative opportunities exist for beekeeping industries. Organized, tech-driven bee-farming can generate employment and skill-building, contributing to Sustainable Development Goals 1, 2, 3, and 15.
- Beekeeping thrives in regions with ample floral resources. India's diverse habitat and abundant flora offer vast potential for beekeeping development, supporting crops and woodlands across millions of hectares. At

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

- Beekeeping offers income opportunities for people of all ages and backgrounds. Hives can be placed in various locations, even on rooftops or in backyards. With dedication, beekeeping can become a profitable venture through the sale of honey and wax. Villages can establish cooperatives, utilizing local resources to create jobs and revenue.

Opportunities

End users of bee products encompass food & beverages, agriculture, military, medicine, cosmetics, paints, chemicals, etc. Propolis, collected and used by bees, possesses diverse pharmacological properties, including anti-inflammatory, antioxidant, antibacterial, antifungal, antitumor, and antiviral effects. Royal Jelly serves as a food supplement with potential cholesterol-lowering, anti-inflammatory, wound-healing, and antibiotic effects.

Market Trends

The Indian apiculture market reached nearly Rs. 18,836.2 million in 2020, projected to grow at a 12.4% CAGR to reach INR 37,235.9 million by 2026. FactMR anticipates a 5.1% CAGR for the honey market (2019-2029), driven by increased demand for healthy food globally. In the Asia-Pacific region, consumption of apiculture products like honey is rising due to their health benefits. The Indian honey market was valued at around INR 17.29 billion in 2020, expected to grow at a 10% CAGR to 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:** Honey, a viscous fluid from flower nectar, is a whole food rich in sugars, antibiotics, enzymes, acids, and minerals, serving as a high-energy source and carrier for Ayurvedic and Unani medicines.

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 traces back to ancient human civilization, coinciding with the emergence of flowering plants and co-evolution of honeybees. Primitive humans harvested honey from wild colonies, a practice continued by rural/tribal communities.
- Today, beekeeping serves as a full-fledged industry, providing honey, beeswax, royal jelly, propolis, and bee venom for therapeutic and daily use, while also playing a crucial role in pollinating various fruits and crops.
- India stands as one of the world's largest honey producers and consumers, with an estimated annual production of 1.2 lakh metric tonnes. With a rich tradition dating back to ancient times, India currently has around 12,699 registered beekeepers and 19.34 lakh honeybee colonies, producing approximately 1,33,200 metric tonnes of honey (2021-22 estimate).
- Additionally, 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 over 200 years.
- Beekeeping offers income and job prospects for rural households through honey and other products like wax and propolis. Honey's high value drives demand in domestic and international markets, providing nutrition and health benefits.

- Involving women and youth in beekeeping can empower them through entrepreneurship or self-help groups, contributing to economic growth. Additionally, beekeeping plays a vital role in environmental preservation, promoting sustainability and innovation for a prosperous future.

"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

Floriculture, cultivating flowers, is a thriving global industry. Orchids, renowned for beauty and commercial value, offer a captivating business opportunity in India's growing floriculture sector, blending tradition with modernity. India's floriculture industry has grown remarkably, with a 25.68% CAGR from 2017 to 2021, fueled by orchids' diversity and contribution. India's rich orchidaceous heritage supports both domestic and international trade. Orchids are commercially significant in India, evident from the robust export figures. In the financial year 2020-21, ornamental plants worth USD 74.82 million were exported, indicating a 31.3% growth.

Amidst rising demand for ornamental plants due to factors like urbanization and environmental awareness, orchids lead in horticulture. This article explores India's orchid floriculture, its commercial prospects, and challenges.

Diversity of Orchids in India

- India's diverse climate, from the Himalayan foothills to coastal plains, hosts over 1,300 indigenous orchid species. Thriving in various ecosystems, they enrich the nation's vibrant floral diversity.
- Dendrobium, Vanda, and Arachnis are prominent in India's orchid landscape. Dendrobium offers diverse species adaptable to varied climates. Vanda's enduring appeal suits tropical regions, while Arachnis adds uniqueness with its spider-like appearance.
- India's orchid wealth includes exotic species acclimated to its climate. Cultivation of hybrid varieties, through meticulous breeding, enriches the Indian orchid palette with diverse colours and forms.
- India has made strides in recording and conserving its orchid diversity. Government programs, research facilities, and botanical gardens play key roles. Initiatives like the Orchid Mission in Sikkim aim to preserve native orchids.
- India's orchid diversity reflects its botanical heritage and offers opportunities for floriculturists, researchers, and enthusiasts. Exploring and conserving this diversity contributes to biodiversity goals and drives the orchid floriculture industry's growth.

Commercial Demand and Market Trends in India

- India's floriculture industry undergoes transformation due to rising demand for exotic blooms. Orchids, captivating and popular, feature prominently in this burgeoning market.
- The floriculture sector in India saw impressive growth with a 25.68% CAGR from 2017 to 2021. Urbanization, rising disposable income, and cultural shifts contributed.
- Versatile and suitable for various occasions, orchids, especially the resilient Phalaenopsis variety, are staples in decorative arrangements for weddings, festivals, and interior decor nationwide.
- E-commerce platforms boost orchid accessibility and visibility in India. They offer a wide variety, catering to evolving consumer preferences with doorstep delivery and quality assurance.
- Phalaenopsis orchids, known for their long shelf life and vibrant colours, are favoured by consumers, florists, and event planners. The Orchid Society of India observes increased orchid usage in ceremonies, cementing their elegance and sophistication.

- India's orchid sector contributes to its global floriculture trade success. Ornamental plant exports reached USD 74.82 million in FY 2020-21, growing at 31.3% annually.
- Commercial demand for orchids in India grows due to changing consumer preferences, urbanization, and robust export market. Orchids, adaptable and charming, thrive in India's flourishing floriculture landscape, offering opportunities for cultivators and entrepreneurs.

Key Factors Contributing to Commercial Success in India

- **Local Adaptation and Cultivation Techniques:** Indian orchid growers adapt cultivation techniques to local conditions, optimizing temperature, humidity, and light levels to mimic natural habitats. This enhances orchid production and quality.
- **Cultural Significance and Traditional Use:** Orchids are culturally significant in India, featuring prominently in traditions, weddings, and decorations. Their consistent demand is driven by their incorporation into religious ceremonies and events.
- **Government Initiatives and Subsidies:** The Indian government supports floriculture, including orchid cultivation, through financial aid, training, and infrastructure development initiatives. The National Horticulture Board's overview highlights the government's commitment to boost the sector.
- **Export Opportunities:** India's orchid cultivation extends to significant exports, showcasing international appeal. Increased export figures, noted by the Ministry of Agriculture, reflect growing global recognition of Indian orchids.
- **Technology Adoption and Research Collaborations:** Technological advancements like greenhouse cultivation and tissue culture boost India's orchid cultivation. Collaborations between academia, research organizations, and private sectors enhance orchid varieties and production efficiency. Ongoing research drives industry innovation, supported by factors like local adaptation, cultural significance, government aid, and global markets, positioning orchids as a thriving sector in India's floriculture.

Challenges and Future Prospects in the Indian Context

- **Infrastructure and Technology Gap:** The orchid floriculture sector in India encounters challenges with infrastructure and technology adoption, especially in remote areas. Bridging this gap through government support and private initiatives is vital for sustainable growth.
- **Pest and Disease Management:** Pests and diseases pose a threat to orchid crops, affecting yield and quality. Effective management strategies, alongside ongoing research, and extension services, are vital for sustaining orchid cultivation's commercial success.
- **Environmental Concerns and Sustainability:** Orchid floriculture's intensive practices raise environmental sustainability concerns, notably in water usage, chemical inputs, and energy consumption. Implementing eco-friendly practices and promoting sustainable and organic alternatives can enhance long-term industry viability.
- **Skill Development and Training:** Successful orchid cultivation relies on skilled manpower, from growers to technicians proficient in advanced techniques. Ongoing training and skill development initiatives are vital to equip individuals with the necessary expertise. Collaboration between industry and educational institutions helps address this challenge.
- **Market and Saturation Diversification:** As the orchid industry grows rapidly, market saturation becomes a concern, necessitating diversification. Orchid breeders and growers must explore innovative varieties to capture niche markets and adapt to changing consumer preferences for sustained relevance.
- **Global Collaboration and Research:** Collaboration and research partnerships on a global scale can enhance the competitiveness of Indian orchids. Strengthening ties with global orchid organizations and research institutions is crucial for industry growth.

- **Promotion of Sustainable Practices:** To align with sustainability trends, India's orchid industry should embrace eco-friendly cultivation methods. Certifications for sustainable practices can enhance market reputation and access premium markets.

Conclusion

The Indian orchid floriculture industry's future success relies on overcoming challenges and embracing sustainable practices. Collaboration and innovation offer opportunities for economic and environmental sustainability.

The floriculture industry, particularly orchids, holds significant commercial potential. Orchids, diverse in species and culturally significant, are prominent in global and Indian markets. Despite challenges, factors like local adaptation, cultural relevance, and government support drive the industry's growth. With rising demand for ornamental plants, orchids offer a resilient and lucrative business opportunity, promising a vibrant future for growers, exporters, and enthusiasts.

ORGANIC FARMING: BENEFITS, PRESENT STATUS AND FUTURE PROSPECTS

Over seven decades of planned economic development, India's agricultural sector has made significant strides. Food grain production surged from 50.8 million tonnes in 1950-51 to 329.7 million tonnes in 2022-23, outpacing population growth. The surge in agricultural production, notably post-Green Revolution, relied on high-yield seeds and chemical inputs, raising concerns about health and ecosystem impacts. This spurred adoption of sustainable practices like organic farming.

Organic Farming

Organic farming eschews synthetic inputs, emphasizing sustainable practices and eco-friendly pest control methods. It relies on natural fertilizers and implements techniques like crop rotation and biological pest control for environmental harmony.

Need and Benefits of Organic Farming

- Organic farming in India fosters environmental, social, and economic well-being by promoting biodiversity, conserving soil health, and reducing water pollution. It enhances farmers' resilience, economic sustainability, and market access.
- Organic farming offers consumers healthier and safer food options, free from chemical residues and often with higher nutritional value. By emphasizing natural inputs and sustainable methods, it fosters environmental balance and supports a resilient agricultural future.
- Promoting organic farming at the governmental level aligns with environmental conservation goals, contributes to sustainable development, and enhances agricultural exports. It addresses public health concerns and offers holistic benefits.

Status of Organic Farming

- India's organic farming roots date back to ancient times, rooted in traditional agricultural practices across villages. Modern organic agriculture gained traction with increasing demand for organic products globally.
- The National Programme for Organic Production (NPOP), initiated in 2001, under APEDA and the Ministry of Commerce and Industry, establishes standards for accreditation and certification in organic agriculture. Internationally recognized, NPOP certification is mandatory for exporting organic products from India.
- The National Centre for Organic Farming, established in 2004, was renamed the National Centre for Organic and Natural Farming (NCONF) in March 2022. It promotes sustainable agricultural practices through training and information dissemination.

Area Under Organic Farming

- India ranks sixth globally in terms of total area under organic farming, with approximately 2.4% of the net cultivated area certified or in the conversion process. As of March 31, 2023, the total area under organic certification registered under the National Programme for Organic Production reached 101.72 lakh hectares. This includes 53.92 lakh hectares of cultivated land and 47.80 lakh hectares of wild harvest collection area.
- Among states, Chhattisgarh leads with nearly 32% of the country's total organic farming area, followed by Madhya Pradesh (22.83%), Maharashtra (12.63%), Rajasthan (9.22%), Gujarat (9.20%), Himachal Pradesh (2.10%), and Odisha (1.95%). Sikkim achieved the distinction of becoming the first fully organic state in the world in 2016, with other states like Tripura, Himachal Pradesh, and Uttarakhand also aiming for similar goals.
- 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.
- India boasts the highest number of organic farmers globally, with 15.99 lakh producers, representing over 43% of the world's certified organic farmers. Despite this achievement, India has untapped potential in organic farming, necessitating efforts to assert itself internationally.

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.
- India's rich cultural heritage provides a strong foundation for organic farming. In the fiscal year 2022-23, the country produced 2,972.39 thousand metric tonnes of organic products, including cereals, pulses, millets, oilseeds, tea, coffee, fruits, vegetables, spices, dry fruits, sugarcane, and processed food.
- Additionally, organic production encompasses non-edible sectors like cotton, fibre, medicinal, herbal, and aromatic plants.
- India's organic commitment is evident in diverse product output. Madhya Pradesh leads with 28%, followed by Maharashtra, Rajasthan, Karnataka, and Uttar Pradesh. These top states account for 81% of production, highlighting nationwide potential. Fiber crops lead, followed by oilseeds and sugar crops.

Exports of Organic Products

India's organic farming tradition and diverse climate make it a global organic product leader. In FY 2022-23, exports totalled 312,800.51 MT, generating Rs. 5,525.18 crore (USD 708.33 million). Major markets include the USA, EU, Canada, and Japan. With increasing global demand, India's organic exports are forecasted to reach USD 2,601 million by 2026.

Initiatives

- India promotes organic farming via schemes like the National Mission for Sustainable Agriculture (NMSA) operational since 2014-15. NMSA emphasizes water efficiency, organic nutrient management, and climate-resilient practices.
- It offers financial incentives, training, and technical support to farmers. Additionally, the Paramparagat Krishi Vikas Yojana (launched in April 2015) provides financial aid to encourage organic farming.
- PKVY forms farmer groups to grow organic crops, providing financial aid for inputs. This fosters community participation and addresses environmental challenges, promoting sustainable agriculture and farmer well-being.

Challenges

- Organic farming in India encounters challenges like limited awareness, high certification costs, and market infrastructure gaps. Yield fluctuations and pest management complexities further hinder adoption.

- Addressing quality control, certification, and scaling up while maintaining standards complicates organic farming. A comprehensive approach involving education, policy, research, and infrastructure is essential.

Way Forward

- To leverage India's organic potential, addressing low productivity requires enhanced R&D and knowledge dissemination. Integrating technology like precision farming and data analytics can optimize resource use and boost yields.
- Investing in R&D is vital to enhance organic farming's efficiency and appeal. Developing resilient crops, exploring pest control methods, and improving soil health are key. Government support through strengthened policies and incentives is essential for widespread adoption.
- Fostering collaboration among stakeholders can create a supportive ecosystem for organic farming. Knowledge sharing, access to resources, and collective marketing efforts are vital. Educating consumers about organic benefits is crucial. India has the potential to lead in sustainable agriculture.

OPPORTUNITIES IN DAIRY AND FISHERIES SECTOR

- Rising income influences food choices, with higher per capita income linked to increased protein intake, especially in developing countries. India's growing national and per capita income has led to higher protein consumption, impacting public health.
- India's dairy and fisheries sectors are vital to the economy, contributing significantly to GDP and employment. With one of the world's highest milk productions, India is a key player in global milk production.
- Over the past decade, India has seen a notable 58% rise in milk production, with the dairy sector contributing 5% to the national economy. Directly employing over eight crore farmers, the dairy industry serves as a significant source of employment.
- Furthermore, it holds substantial economic potential, fostering growth in related sectors like fodder production and food processing, thus creating a mutually beneficial economic ecosystem.
- India boasts a flourishing fisheries industry, witnessing consistent growth since 2016-17. It contributes 1.1% to the nation's gross value added and 6.72% to the total agriculture sector GVA. Additionally, fisheries play a crucial role in earning foreign exchange through exports of fish and fish products.
- India holds the position as the third-largest fish producer globally and the second-largest in aquaculture, contributing 8% to global fisheries production. It's also the fourth-largest fish exporter, showcasing its economic resilience and global recognition.

Development Post-White Revolution

- Operation Flood, or the White Revolution, transformed India's dairy industry in the 1970s, spearheaded by the NDDB under Dr. Verghese Kurien's leadership. It aimed to boost milk availability and succeeded in surpassing population growth.
- Post-revolution, per capita milk production surged from 40.6 kg/year in 1971-72 to 154.9 kg/year in 2021-22, exceeding the recommended dietary allowance.
- The White Revolution advocated for a cooperative model in dairy, fostering farmer empowerment through collective processing and marketing, exemplified by Amul. This shift led to accelerated milk production growth post-2005, inspiring entrepreneurs to scale up using advanced techniques and supply chains.
- The burgeoning dairy startup ecosystem in India spans from family-run ventures to large-scale operations, enriching the agricultural landscape. With a vast consumer base, the dairy market offers ample opportunities for innovation and growth.

- Established players like Amul, Mother Dairy, and Country Delight exemplify success in this sector, catering to evolving consumer preferences and promoting healthy lifestyles.
- India's burgeoning dairy market, driven by a large population and increasing demand, attracts startups, buoyed by government support and 100% FDI allowance in Animal Husbandry. Dynamic modern dairy farms, embracing advanced technology and integrated value chains, exemplify the sector's evolution.
- The Paavni Organic Farm in Bihar implements Farming 360, integrating dairy and crop farming with processing units to offer organic products directly to consumers. Initially self-funded, it later received support from government startup schemes, employing advanced technology throughout its operations for efficient production and management.
- Challenges such as the affordability and availability of IT personnel and IoT devices, along with awareness gaps among farmers and access to long-term funding, persist. Despite this, the farm's innovative approach has garnered recognition and inspired numerous startups in Bihar's dairy sector.

Development Post-Blue Revolution

India ranks third globally in fish production, contributing 8% to the total. The "Blue Revolution" scheme, initiated in 2015, aims to revolutionize the fisheries sector, recognizing its significant potential for growth.

The National Fisheries Development Board (NFDB) oversees the "Blue Revolution" scheme, while the newly formed Department of Fisheries (DoF) manages the Pradhan Mantri Matsya Sampada Yojna (PMMSY). This ambitious scheme aims to revolutionize the fisheries sector with a record investment of over Rs. 20,050 crores.

India's aquaculture sector offers vast opportunities for expansion, including advanced technologies like recirculating aquaculture systems (RAS) and integrated multi-trophic aquaculture (IMTA). The government's Fisheries Startup India initiative supports the growth of startups in this domain.

Jalkafal, a startup in Bihar, specializes in Animal Husbandry and Fishery, providing fresh fish directly from ponds to consumers. It aims to serve as a comprehensive solution for all fisheries-related needs, fostering a professional network for producers, retailers, and wholesalers. The organization is developing an e-Portal to connect individuals within the fisheries industry and enhance sector organization. Financed by the Directorate of Fisheries, Government of Bihar, the startup faces challenges in areas such as awareness, technology, and market expansion. Nevertheless, its innovative approach has inspired others to pursue entrepreneurship in the fisheries sector.

Policy Provision for Dairy and Fisheries Sector

- Various policy measures aim to enhance infrastructure and improve livestock productivity and disease control, supporting the expansion and long-term viability of both industries.
- Recent initiatives include the Rastriya Gokul Mission, National Livelihood Mission, Livestock Health and Disease Control, National Programme for Dairy Development, National Animal Disease Control Programme, Dairy Infrastructure Development Fund, Animal Husbandry Infrastructure Development Fund, and Supporting Dairy Cooperatives and Farmers Producer Organisations.
- RGM launched in 2014, focuses on enhancing bovine productivity through selective breeding and promoting high-genetic-merit bulls and artificial insemination. Additionally, the National Livelihood Mission (NLM) promotes entrepreneurship and innovation in livestock, while programs like LHDC and NADCP target animal health.
- The Livestock Health and Disease Control (LHDC) aims to eradicate critical diseases through preventive vaccination and veterinary infrastructure strengthening. The National Animal Disease Control Programme (NADCP) targets foot and mouth diseases (FMD) and brucellosis control through mass vaccination.
- The Indian government introduced two funds to support the dairy sector: the Dairy Processing & Infrastructure Development Fund (DIDF) and the Animal Husbandry Infrastructure Development Fund (AHIDF). DIDF aims to modernize milk processing facilities with an Rs. 8,040 crore corpus, while AHIDF, with a budget of Rs. 15,000 crores, focuses on enhancing infrastructure for dairy and meat processing.

- The NPDD aims to improve milk quality and increase organized procurement, while the SDCFPO scheme offers financial support during crises to ensure stable market access for dairy farmers, fostering sector resilience.
- Introduced in May 2020 under the Aatmanirbhar Bharat programme, the Pradhan Mantri Matsya Sampada Yojana (PMMSY) aims to enhance fish production and productivity, improve infrastructure, and promote sustainability in the fisheries sector.
- Before PMMSY, the Fisheries and Aquaculture Infrastructure Development Fund (FIDF) was established in 2018-19 to address infrastructural needs in the fisheries sector.

Challenges and Way Forward

- The Indian dairy and fisheries sectors, while experiencing notable growth, confront supply chain interruptions and climate change effects. Challenges like transportation disruptions and inadequate storage may hinder distribution efficiency.
- Climate change presents a dual challenge for the dairy and fisheries industries, affecting production levels, product quality, and livelihoods. Shifts in weather patterns and rising temperatures pose significant threats to these sectors and the communities reliant on them.
- Investing in infrastructure, technology, and climate-smart practices, along with promoting innovation, can fortify India's dairy and fisheries sectors, ensuring long-term prosperity, economic growth, and sustainability.

VERTICAL FARMING AND HYDROPONICS: FUTURE URBAN AGRICULTURE

To meet global food demand amidst land scarcity and urbanization, advanced farming methods like vertical farming and hydroponics are crucial. India is adopting these technologies to ensure future food security. By 2050, urbanization will increase globally, with 70% living in cities, and in India, 53% expected to reside in urban areas. Vertical and hydroponic farming can alleviate pressure on agricultural land, promoting sustainability. The global vertical farming market is forecasted to reach USD 33.02 billion by 2030, with an anticipated CAGR of 25.5% from 2022-2030. In India, the vertical farming market is projected to demonstrate a CAGR of 25.4% from 2023-2028.

Understanding Hydroponics Vertical Farming and

Vertical farming (VF) redefines agriculture with soilless cultivation in multi-level indoor settings, diverging from conventional soil-based methods. Prof. Despommier pioneered VF to address nutritional needs, especially in megacities, proposing it as a solution to challenges like diminishing agricultural resources and climate change. VF has potential to enhance food production sustainably and is crucial for urban agriculture in low- and lower-middle-income countries. Successful commercial urban farms are present in Europe, highlighting the global significance of VF.

Vertical farming maximizes space by growing plants in vertically stacked layers, typically indoors. This method is ideal for urban areas where space is limited, utilizing controlled environments to optimize growth conditions.

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

Hydroponics: Vertical farming utilizes soil-free substrates continuously irrigated with nutrients, reducing water usage by 60-70% compared to traditional agriculture, making it popular globally.

Aeroponics: Aeroponics, pioneered by NASA, grows plants in a mist environment, requiring no soil. With roots suspended in air, it uses 90% less water than hydroponics, yielding healthier produce.

Aquaponics: Aquaponics merges fish farming with plant cultivation, recycling fish waste as plant nutrients and purifying water. While ecologically beneficial, its complexity and cost limit widespread adoption.

Hydroponic farming offers a soil-less approach, nurturing plants in nutrient-rich water solutions for quicker growth. Popular in India, it's favoured for urban farming and often integrated into vertical farming.

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.

1) Deep Water Culture (DWC): Plant roots submerged in nutrient-rich, oxygenated water promote nutrient absorption, making hydroponics a straightforward and low-cost system suitable for beginners.

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

Hydroponic vertical farming optimizes space and resources, enabling year-round cultivation of crops like lettuce, kale, and spinach in controlled urban environments, enhancing efficiency and productivity.

Crop Management in Hydroponics

Plants grown hydroponically thrive in slightly acidic conditions, with a pH range of 5.5 to 6.5, optimizing nutrient uptake. Adjustments are made using acids to lower pH and bases to raise it.

Maintaining optimum conductivity is crucial for productivity. Auto hydroponic systems manage EC, while manual measurement requires daily checks. pH and EC must be optimal. Temperature affects growth, with an ideal range of 15-18°C. Oxygen in the nutrient solution is crucial for root absorption, with aeration beneficial.

Crops Suitable for Vertical Farming and Hydroponics

ICAR-CISH, Lucknow, standardizes vegetable, herb, and strawberry cultivation in subtropical climates using four hydroponic systems: aeroponic, ebb and flow, Nutrient Film Technique, and drip hydroponic.

ICAR-Indian Institute of Horticulture Research, Bengaluru (IIHR) introduced "Cocoponics," a hydroponic variant utilizing cocopeat as a substrate for soilless cultivation of various vegetables and exotic leafy greens.

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 initially costly, becomes more accessible through repurposed shipping containers and abandoned warehouses. Collaborative research is crucial for sustainable technology integration. Hydroponics and vertical farming offer efficient and sustainable urban agriculture solutions.