



Entrepreneurship opportunities for agriculture graduate and rural youth in India: a scoping review

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Summary

The majority of the world's population lives in rural areas whereas, in the case of India, 73% population is dependent on agriculture and related works as their mainstream revenue resources. Entrepreneurship in rural areas could be one of the utmost vital initiatives towards the country's economic development under the adverse impacts of climate change. Entrepreneurship is a crucial feature for the sustainable survival of small-scale agriculture in a continuously increasing compound international economy. Contrarily, most rural entrepreneurs in developing nations, including India, face numerous problems due to the unavailable primary facilities in remote areas. Several agricultural entrepreneurship technologies have been scientifically studied and introduced by numerous countries. Information regarding the progress in modern agriculture entrepreneurship has become crucial for agriculture graduates and the rural youth engaged in the agriculture sector. Hence, it becomes essential for developed and developing economies to emphasize the large-scale demonstrations of agriculture entrepreneurship technologies. In the present manuscript, several such interventions are highlighted in the form of various points which will be of immense use to the self-reliant movement of India. In this endeavour, helpful information on agriculture entrepreneurship technologies from various research institutions and universities has been generated to benefit agriculture graduates and rural youth.

JAE 2023, Vol 15

Received: 25 January 2023

Accepted: 05 April 2023

Published: 30 June 2023

<https://doi.org/10.58628/JAE-2315-101>

Associated Editor: Dr. Bireswar Sinha

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Keywords: Entrepreneurship; agripreneurship; skill; technologies; opportunities; rural youth; agricultural graduates

Introduction

Achieving the seventeen Sustainable Development Goals (SDG 17) of all-encompassing and sustainable economic development, employment, and decent work requires devising strategies that are decisive to provide new employment opportunities for all individuals. This includes making seemingly unattractive but rewarding sectors of economies of developing countries attractive and more profitable to all parties (Akron & Kotu 2022;

Geza et al. 2022)^{1,2}. Several of the world's underprivileged youth live in rural areas where a weak economy offers them fewer opportunities to obtain civilized employment, and the numbers are continuously growing. Approximately 300 million young people are predicted to enter the labour force over the next 30 years, and about 195 million live in rural areas (IYF 2014)³. The need to generate viable economic prospects to keep the rural population and agriculture graduates is urgent. Simultaneously, the existing youth prominence offers an extraordinary opportunity for practitioners as well as the governments to utilize the energy, enthusiasm, and innovative mindset of these young people to strengthen socio-economic development while addressing critical food security requirements. Particularly for the rural youth, the new business concept in the agriculture division can bring about an essential and sustainable chance to ensure a decent living (IYF 2014)³. Thousands of agriculturists and related science graduates pass out of universities in India every year. If some of these graduates are channelled into start-ups, agriculture can have a business revolution (Verghese et al. 2022)⁴. While most rural youths are already bound in unceremonious agriculture systems, they may not find it an appealing or sustainable career option given obstacles, i.e., geographic separation, unfavourable land use policy, poor structure, higher transport expenses, and/or occupied agricultural input costs. Nevertheless,

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increasing substantial employment openings along with the agriculture value chain can provide the rural youth of the chance to appoint invaluable work and overcome stated challenges. An often-disregarded component of opportunities is the green economy (e.g., solar energy, organic agriculture), which has the budding to become a sustainable growth sector for the rural population, particularly the youth (IYF 2014)³.

Entrepreneurship is a natural phenomenon in business and a part of the business spirit. It demonstrates that business is healthy where entrepreneurial skills exist, and management is adopted for wisdom. Thus, it will be advantageous for any business association to know the definition of entrepreneurship, its foundations, and types of entrepreneurships and be able to handle entrepreneurship (Diandra & Azmy 2020)⁵. Croci (2016)⁶ also defined entrepreneurship as an interdisciplinary self-governing discipline that can operate independently. Other studies defined entrepreneurship as a practice commencing with accomplishing and creating a new organization (Barot 2015)⁷. It was also stated that entrepreneurship is a justification for success, and every entity that establishes a modern organization of commerce enters the latest paradigm of entrepreneurship. Chang & Wyszomirski (2015)⁸ avowed that art entrepreneurship is a comparatively new research subject. The focus area is exploring the management practice of entrepreneurship such as imagination and autonomy, aptitude for adaptability and creating inventive as well as economic and community value. The world of entrepreneurship has become an extremely dynamic environment. Entrepreneurship means the individual or collective capacity to develop sustainable enterprise through production to marketing. Entrepreneurship is crucial for the endurance of small-scale agriculture and farming in a continuously increasing and diverse international economy. Furthermore, the skills and critical knowledge drive sustainable economic growth and social development in any country (Mahra et al. 2022)⁹.

The agriculture sector provides opportunities for youth to employ in entrepreneurship and innovation. Youth could then supply efforts to make agriculture 'smart' through digitization and pioneering solutions. Evolving ascendancy models and innovations sustain agriculture's digitization, also known as Agriculture 4.0 and a sustainable green economy (Mastewal 2021)¹⁰. The models generate opportunities for youth to create and apply digital technologies and innovations to construct data-driven evaluations in producing, handling and marketing agricultural products. A sustainable green economy also offers employment and stewardship prospects to youth—namely, opportunities to renovate and regenerate ecosystems while inhibiting the dilapidation of natural resources. However, the governance models lack breadth and rarely correspond to local desires and constraints. In addition, pursuing digital agriculture and a green economy without addressing gender gaps in access to digital technologies and acquiring commerce skills and women's profound

dependence on natural resources for food security and power sources, could reinforce existing gender disparity (Mastewal 2021)¹⁰. Agriculture has forever been the backbone of the Indian economy whereas, despite extensive industrialization in the last six decades, the agriculture sector still dominates. The importance of the agricultural sector in the national economy arises from its part in India's national economic income, employment, and exports. Nevertheless, over 85 % of the rural population in India relies on agriculture for employment. Still, the contribution of agriculture to national revenue has declined to 26 per cent, and that of the service sector has increased to more than half of the entire national income (Mahra et al. 2022)⁹.

In Indian villages, most of the farmlands are owned by a smaller section of the population and over 85% of the people are either marginal or small farmers or landless farm workers. Such ill-distribution of resources leads to large-scale migration of the rural folks towards urban centres, resulting in poverty of the rural populace. To tackle such a scenario, entrepreneurship in rural inhabitants is urgently required. If agriculture entrepreneurship is encouraged in rural India, it would be a revolutionary initiative and a supportive move to the nation's economy. Rural agriculture entrepreneurship changes people's lifestyles by generating employment opportunities and solving poverty problems and economic discrepancies. There are many examples of successful rural agriculture entrepreneurship with available resources in rural areas like biocontrol, honeybees, vermicomposting, organic farming, cookery for tourists, blacksmithing, carpentry and spinning, etc. Also, using resources in addition to land, including water, woodlands, constructions, existing skills and local landscapes, all fit into rural entrepreneurship. The business combinations of these resources are for instance, tourism, sports and recreation facilities, technical training, selling, industrial applications (engineering, crafts), servicing, value addition (products from milk, meat, wood, etc.), as well as the opportunity of off-farm employment (Dileep & Bhavani 2019)¹¹. The present paper attempts to compile the diverse agricultural entrepreneurship opportunities for rural youth and agriculture graduates in India.

Why is entrepreneurship required in India?

For various reasons, from helping the development of social change to driving the contraption of new possessions, the importance of entrepreneurship is significant. Entrepreneurs are also viewed as national assets for the furthestmost possible outcome. Some advanced countries are world leaders because of their forward-thinking of imagination (ability to create exciting things), science, and entrepreneurship. According to a UN report in 2014, the world's largest youth population of 356 million (10 years to 24 years of age) is present in India. According to the World Development Indicator, World Bank Data (2014), the census in 2011 indicated that roughly 41% of the total population of India is under the age of 20, 50% of the population is between 20- and 59 years age group and the remaining 9 % is beyond the age of 60 years old. While at the same time, only 32 % of

the country's youth (15-24 years old) population is engaged, which is also far below the 41% global average. On further dispense, according to National Sample Survey Organization (NSSO) statistics at each level of education, the joblessness rate is more significant for the 15 - to 29-year-old age groups than the broader population. The annual growth rate of India's population is 1.2% (World Bank, 2015) and a United Nations Development Programme (UNDP) report released in 2016 indicated that India would deal with the grave challenge of exploring jobs for an emerging population for the coming 35 years (<https://www.indiafellow.org/blog/2016>)¹².

Considering the foremost reasons for unemployment, it was found that the lack of employment opportunities, efficiency skill crisis, high population growth, sluggish growth of industrialization, and seasonality in agriculture and associated sectors at the zenith (Haldhar et al. 2022a)¹³. Figure 1 shows that the unemployed youth population has been escalating daily (Figure 1). At all stages, unemployment rates are top in rural compared to urban areas and the unemployment

rate in females exceeds that of males. In such a scenario, authors realized the requirement for entrepreneurship in developing economies, particularly India. India needs job makers as a replacement for job seekers. In its place of looking for jobs, youth can try to find new opportunities to create their enterprises with their ideas. It can be a possible solution to the unemployment dilemma by creating employment. Whereas, an entrepreneur collaborates with all possessions, takes the inventiveness to initiate incredible new, takes risks, provides employment to many and fills the gaps to make life easier. In overview, entrepreneurs can indeed help a country in many ways. The process of entrepreneurship is quite simple (Figure 2). It helps a country trim down its unemployment rate, become financially and technologically self-adequate, raise citizens' standard of living and condense regional imbalances (<https://www.indiafellow.org/blog/2016>)¹². Another way around entrepreneurship revolves around the famous quote of APJ Abdul Kalam: "Thinking is the money; Enterprise is the technique, and Hard work is the solution".

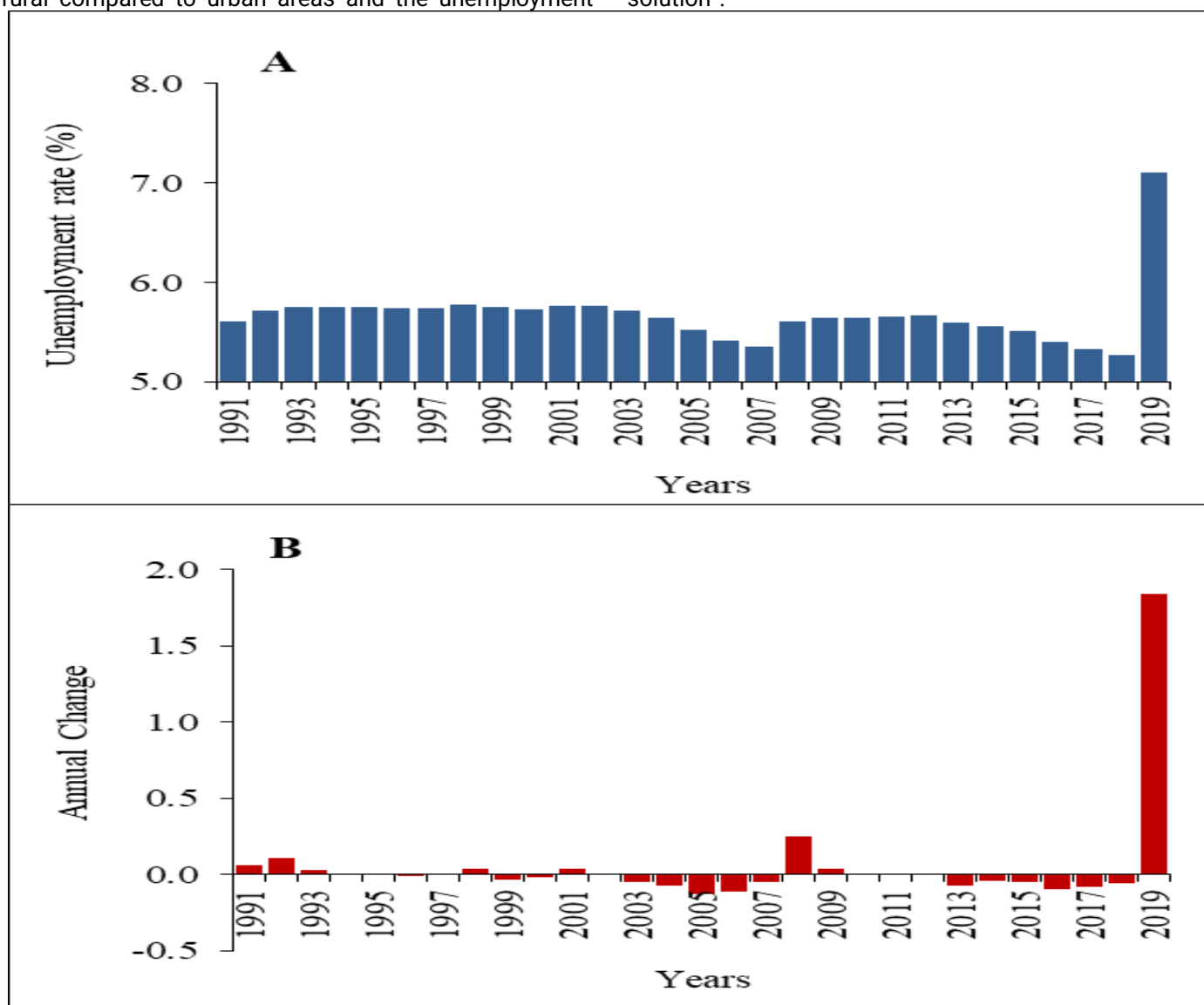


Figure 1. Unemployment rate (A) and annual change (B) in India from year 1991 to 2020. Source: <https://www.macrotrends.net/countries/IND/india/unemploymentrate>>Source

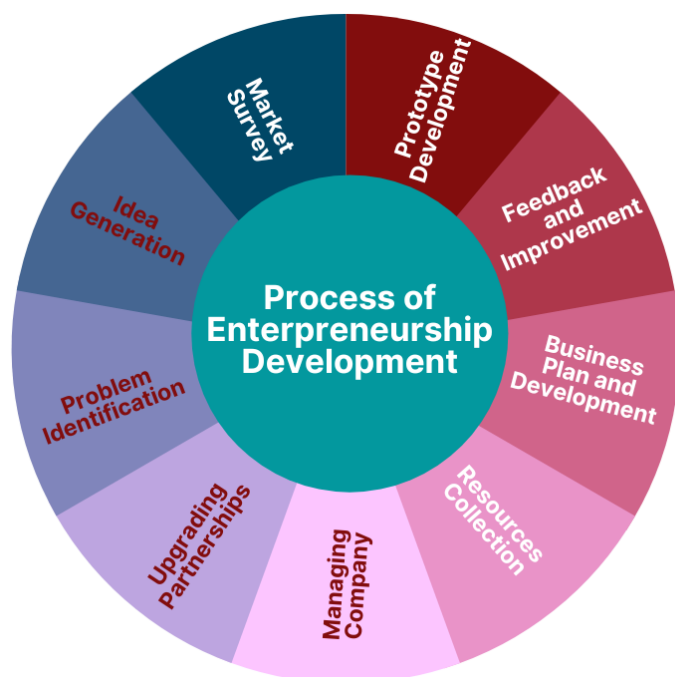


Figure 2. Flowchart of steps involved in entrepreneurship development

Why does India need Agri-preneurship?

Indian economy is considered an agrarian wealth. With merely 2.4% of the world's land, India feeds 17.5% of the global population. At the time of her independence in 1947, more than half of the national income was contributed by agriculture, with more than 70% of the population dependent on agriculture (Pandey 2013)¹⁴. Including all 15 foremost climates of the world, blizzards bound the Himalayas to the hot, humid southern peninsula and the Thar Desert to the world's heaviest rainfall areas, the country is bestowed with a wide diversity. There are 20 agro-climatic zones and almost 46 soil types in the country. Sunshine hours and day length are superlatively suited for round-the-year cultivation of various crops. India is the centre for biodiversity in vegetation, animals, insects, and micro-organism and accounts for approximately 17% of animals, 12% of plants and 10% of fish genetic of the earth. In the livestock sector, India has 16% of cattle, 57% of buffalo, 17% of goats and 5% of the sheep population of the planet. Agriculture sector shares 13.2% of GDP, and 15.2% of total exports. It employs 58.4% of the country's workforce (Mittal 2009)¹⁵. Agriculture and related sectors are vital sources of raw materials for industries and demands for several industrial products particularly fertilizers, pesticides, agricultural implements and various customer goods (Bairwa et al. 2014)¹⁶. Due to the changing socio-economic, political, environmental and cultural magnitude worldwide, farmers and nations alternate for survival and sustainably ensuring success in changing their respective monetary environments has become gradually more decisive. It is also appealing to note that the emergence of the liberated global market economy has resulted in the development of a new fortitude of enterprise "Agriprenurship" and the increased entity need for responsibility for running their businesses (Alex 2011)¹⁷. Hence, shifting from

agriculture to agribusiness is essential to revitalize Indian agriculture.

Agriprenurship technologies for agriculture graduates and rural youth

1. Plant health and phytosanitary clinics (PHPC) as agri-preneurship

A plant health clinic is a form of principal health care for agricultural and horticultural crops. It gives instruction, and recommendations and facilitates inputs to farmers based on field diagnosis and expert systems (Verhees et al. 2021)¹⁸. Plant health clinics provide demand-driven directions to farmers, rather than promoting pre-packaged and technology-centered solutions. It primarily intends to disseminate agri-science-based knowledge to help curtail quackery and non-professional advice. A PHPC needs agriculture or agri-related graduates from recognized State or Central Agricultural Universities (SAU's) and institutions. Identifying a dilemma afflicting a plant or a crop is essential to managing insects, pests and crops (Verghese et al. 2022)⁴. Farmers face multifaceted decision-making under unsafe environmental, climatic, and marketing conditions. They spend crop inputs to reduce the risks that might imperil their investment. Despite intensive pest management efforts, about 50% of the world's crops are lost to these organisms, at a predictable annual cost of about \$400 billion (Verghese 2021)¹⁹. A PHPC should provide essential diagnostic services (Figure 3) encompassing all probable causes for plant damage, which is the first step in a clinic. By providing recommendations based on sound principles, plant clinics can have a vital role to play in reducing addiction to pesticides, optimizing inputs, preventing ecological pollution, and enhancing economic viability through low but optimized inputs and higher qualitative and residue-free yields. An initial investment of \$4000 is required for setting up of necessary lab and office. PHPC ideally be in a separate building (rented or owned). It should be accessible to farmers by road. The clinic should have the essential equipment, and graduates should have diagnostic skills to guide farmers from land preparation to harvest. Diagnosis involves skills for soil tests, leaf analysis, pest, disease, and nutrient deficiency identifications. These can be done in collaboration with agriculture departments, the Indian Council of Agricultural Research (ICAR) and SAUs. For example, there is no need to invest in a soil laboratory if there is one around. Farmers can be directed there, or clinics can take this as an outsourced job (Verghese et al. 2022)⁴.



Figure 3. Inspection kit items for Plant Health and Phytosanitary Clinics (PHPC) (Verghese et al. 2022)⁴

2. Agripreneurship through protected cultivation

The increasing demand of the high-quality fresh vegetable produced by world markets has led to more and more vegetable crops under protected and controlled conditions. With time, it has also been proved that protected cultivation is a better technology to improve the productivity and eminence of vegetable crops by providing a logical and technical solution to manage the significant biotic and abiotic stresses encountered under the open-field cultivation of these crops. The effectiveness of the technology has been observed worldwide (Singh 2013)²⁰. The area under protected cultivation in various parts of the world has increased exponentially in countries in and around the Mediterranean region, in China, Africa, Latin America and Asian Countries for adopting various protected cultivation structures. Glasshouses, Climate controlled, semi-climate-controlled, naturally ventilated greenhouses, and in other forms like mulching, use of temporary plastic walls in open fields, low plastic tunnels, plastic covered walk-in-tunnels, high tunnels, temporary and permanent insect-proof net houses, net shade houses etc (Figure 4). But the promotion of protected cultivation technology will not only help create massive self-employment for unemployed educated youths, but it will also increase the national economy by selling high-quality products in domestic and international markets. This technology is suitable for entrepreneurship development (Tuzel & Kacira 2021)²⁷. Furthermore, this technology possesses excellent potential, especially in peri-urban areas adjacent to the major cities which are fast-rising markets for fresh quality food of the country, since it can be profitably used for growing high worth vegetables crops like tomato, cherry tomato, coloured peppers, parthenocarpic cucumber and brinjal, etc. in addition to virus free seedlings in agro-entrepreneurial models. However, protected cultivation technologies require careful planning, attention and details about the timing of production and harvest time to coincide with high market prices, options of varieties adapted to the off-season environments, and the ability to produce reasonable yields of high-quality produce *etc.* (Singh 2022)²².

Even though applying chemicals for controlling biotic stresses is also low beneath protected structures, it gives a high-class safe vegetable for human consumption. Using protected structures, raising off-season and long-duration vegetable crops with high yield (3-5 folds compared to open field cultivation) and quality is also possible. Vegetable farming in agro-entrepreneurial models targeting various niche markets of the big cities is inviting regular attention of the growers for diversification from traditional ways of crop cultivation to modern methods like protected cultivation of vegetable crops (Singh 2005)²³. The basis behind the successful implementation of protected cultivation technology in various regions of India entirely lies in the selection of suitably protected structures with suitable designs, crops, and cultivation models and the selection of cultivars for protected cultivation are the fundamental variables that may significantly affect the success and economic return of the entire production system (Singh

2005)²³. The protected growers must recognize the two other basic options *i.e.*, choice of crop or variety for its high economic perspective or return and develop the most appropriate production system (Tuzel & Kacira 2021)²⁷. Crop should be selected based on the accessible structures, vast consumption and good adoption to wavering climatic conditions and suitability for long cultivation cycles. While adopting the protected cultivation technology the following most essential points *viz.*, the market requirement of the produce, distance from the market for the fresh produce, climatic conditions of the area, soil characteristics and quality of water, economic convenience, crop requirement, labour and skilled manpower requirement should be well considered in advance (Singh 2022)²².

Protected cultivation has shown yield enhancement up to 4-5 times in several vegetable crops, which is a potential technology to achieve vertical growth in horticulture but would need investment and region-specific technological upgradation. The future of protected cultivation technology in India is enormous but highly dependent upon the trifle and recommendation of the technology implementation (Singh 2013)²⁰. It is assumed that protected cultivation technology has to play a significant role under diverse agro-climatic conditions of the country as a means for sustainable crop diversification, intensification, and vertical growth of productivity of vegetable crops leading to optimization of water and fertilizer use efficiency. Soon, the first and most important obligation for the use of protected cultivation technology is for its large-scale use for raising disease and virus-free vigorous planting material in all kinds of vegetable crops and secondly to use the technology for hybrid seed production of vegetables and thirdly production of fresh food for better economic viability in the country and mainly in a cluster approach. Moreover, for the sustainability of the technology, it is of utmost significance to develop considerable skilled manpower in the form of rural youths in two sets, one set for designing, fabrication and installation and thereafter maintenance of the protected structures and the other set for the entire crop production management system under protected conditions. Technology's success depends solely on the profit it can produce for farmers. Hence, given the strength of protected cultivation technologies, there is immense scope for increasing farmers' income in different regions by promoting protected farming innovatively (Singh 2019)²⁴.



Figure 4. A greenhouse with planting bags indicating protected cultivation and nursery raising

3. Entrepreneurship through insect pheromones

Production and usage of pheromone dispensers and traps (Figure 5) are highly economical compared to other biopesticides because the dispensers and traps can be procured from different local vendors. The initial investment for the pheromone production unit will be low, maybe \$4000-5000 for the equipment and civil structures (Binosundar 2019)²⁵. Several farmer groups can produce the lures after due training from the experts. The quality of the pheromone is essential for the sustainable use of pheromone technology; both the quality of pheromone components such as exact blend ratio and exact quantity is to be maintained. State governments can identify such laboratories with the facilities and expertise for testing the pheromones and designate them as referral laboratories. This will ensure quality pheromones are available for Indian farmers (Bakthavatsalam & Subaharan 2022)²⁶. Using pheromones as a component of integrated pest management (IPM) is necessary to ensure pesticide-residue-free agricultural and horticultural produce. The technologies available with the different inventors should reach the commercial producers in time for proper upscaling of their products and ensure more areas under pheromone use [26]. The global agriculture pheromone market is estimated to be USD 2.9 billion and projected to reach USD 6.1 Billion in 2026 (Binosundar 2019)²⁵. The high cost of cultivation, proposed ban of insecticides, resistance development to insecticides and drive for

organic cultivation coupled with the advancement in the synthesis of pheromones, dispensing methods and awareness amongst the farmers and developmental officials are the factors responsible for the high pheromone market (Bakthavatsalam 2016)²⁷.

The pheromone production unit may not need a large workspace, a room with 5x4 m for the impregnation unit, 5X5 m unit for the drying and packaging unit. However, if the pheromones are to be synthesized, a separate synthesis unit of 7x5 m is required with all facilities needed for an organic laboratory. The production units must be located in an industrial area and away from residential colonies. All the production units must have fume hood facilities to ward off the chemical vapours. The state or central governments must complete necessary permits and other statutes, and the production units must be registered as MSME units. Equipment includes a fume hood, gas chromatography with FID (optional) for quality maintenance, glassware for handling organic chemistry, and glassware such as pipettes, conical flasks, funnels, and packaging units. A refrigerator or freezer chemical storage unit (one) is essential for storing the pheromone compounds. A skilled organic chemistry graduate is essential to produce pheromone septa and other adsorbents, in addition to one or two unskilled workers needed for cleaning, impregnating pheromone septa, washing of glass wares and other works (Bakthavatsalam & Subaharan 2022)²⁶.



Figure 5. Some of the commonly used dispensers: rubber septa; plywood pieces and plastic vials (Bakthavatsalam & Subaharan 2022)²⁶

4. Agripreneurship through entomopathogenic nematodes

Indian Council of Agricultural Research developed soil-dwelling beneficial organisms, *i.e.*, entomopathogenic nematodes (EPN) for biological pest management considering localized needs. Globally, four decades ago EPNs were well-recognized as effective and commercially viable biocontrol agents for pest management suiting agribusiness leading to the availability of EPN. During the late 80s, though Hyderabad, India-based venture had started work on importing and supplying EPN in aqueous formulations, which could not sustain in the market and was recalled entirely from the business. Significantly, the factors contributing to the failure were a lack of local production systems, limited awareness and demand amongst farming communities and researchers about the product (EPN); ecological suitability of exotic strains of EPN;

limited shelf-life and unsuitable formulation; lack of validation in the field against pests, etc. Subsequently, research, awareness and innovations rapidly increased worldwide during the next three decades and pan India. Currently, EPNs are available as commercial products across the board in the Americas, Europe, Australia, China, Japan *etc.* (Nagesh et al. 2022)²⁸. During the last two decades, Bengaluru, India-based ICAR-National Bureau of Agriculturally Important Insect Resources successfully addressed the challenge of evolving EPN technologies and transforming them into commercially viable propositions. Such innovations led to an annual production of 1000 metric tonnes of EPN with an area of about 30,000 ha in different crops of economic significance (Figure 6), in different states, mitigating the use of soil insecticides and contamination of soil and water bodies (Nagesh et al. 2020)²⁹.

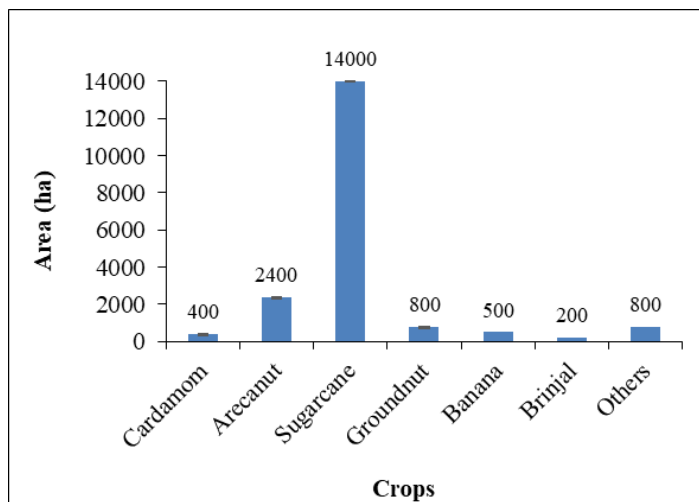


Figure 6. Crop-wise adoption of EPN technology across the country (2016-17) (Nagesh et al. 2022)²⁸

5. Entrepreneurship in honeybees' production and small-scale honey processing plants

Beekeeping includes rearing bees scientifically to produce honey and other bee products such as beeswax, bee venom, propolis and royal jelly. Not only this, but beekeepers can also sell bee colonies for money and also help pollinate crops. Beekeeping is entrepreneurship based on agri-horticulture which is an attractive and highly profitable option for rural youth and agriculture graduates (Singh et al. 2022a)³⁰. It does not require sophisticated technology, high capital investment or infrastructure. It fits well with the integrated agricultural program as a joint venture to grow the economy of the farming community. Beekeeping is now one of the leading Agri-business in India. Due to the different climatic conditions in India, many flowers help in beekeeping (Haldhar et al. 2022b)³¹. Commercial beekeeping is taking place in India because of the vast forest that includes nectar and pollen in its grasslands. It is known that 160 million hectares of land are cultivated in India where 55 million hectares of land is under entomophilous plants that require cross-pollination of bees or other pollen. Honeybee rearing is still part of the small industry and needs more scientific support and infrastructure provided for the industry. It is essential to recognize the need for Indian honey in domestic and international markets and explore new ways to increase productivity to meet growing demand (Haldhar et al. 2022b)³¹. The beekeeping industry also plays a significant role in providing nutritious food to a sufficient number of people. According to the National Agricultural Commission, India requires at least 200 million bee colonies to pollinate and increase the production of 12 main crops that need insect pollination. This will employ 21.5 million people and produce 10 million tons of honey. It also regulates migration from rural to urban areas, increases national income, stabilizes industrial development in rural areas and reduces pressure on urban areas (Haldhar et al. 2021a)³².

Most beekeepers followed the manual honey processing method to process the harvested honey from the aviary. The honey is heated in a water bath up to 45 °C. It is then sieved in a closed mesh cloth to remove debris, pollen, wax particles, dust etc. Then heating is

repeated at 65 °C in a water bath and maintained for 10 minutes. It is then cooled and filtered in a mesh of muslin cloth and finally stored in stainless steel containers (Haldhar et al. 2021b)³³. For commercial honey processing (Figure 7), extracted amount of honey is passed through the filter, it allows the pure honey to pass through and all the impurities are collected in the filter. It is used for storing honey. Some impurities of bee waxes that have entered in honey are separated as honey tends to settle down. This is used for heating the honey for a certain period. It is used for further processing of honey after collection. Maintaining of natural aroma and taste of honey is very complex after extraction. Therefore, processing takes place to get a reasonable market price by applying collected honey into a processing tank. It controls the temperature that rises during pre-heating and collects pure honey. Packaging machines are used to pack the processed honey, which is appropriately sealed to avoid leaking. After packaging, appropriate labels are set on the packages to provide information regarding the brand, nutritional value and other helpful information (Haldhar et al. 2022b)³¹.



Figure 7. Honey processing plant for commercial production of honey

6. Entrepreneurship development through fruit and vegetable processing

India is the second-largest producer of overall fruits and vegetable production in the world, after China and one of the centres of origin of fruits and vegetables with a total production of 99.7 million metric tons of fruits and 191.77 million tons of vegetables during the year 2019-2020 (APEDA 2022)³⁴. In India, a substantial portion of net value added from agro-industries is derived from unregistered cottages and small units, and registered units' contributions are meagre. Generally, about 90% of total value added in food processing industries comes only from primary processing while secondary and tertiary processing accounts for a small proportion. In addition, by-product processing of primary fruits and vegetables has huge potential for industrial growth in rural areas (Dixit et al. 2014)³⁵. For the success of any industry, production should be carried on smoothly and

uninterruptedly. It can be only possible when purchasing the raw materials, machines and other equipment required for production is done effectively. In addition to this, they brought materials that need to be stored adequately to avoid wastage and decay. Moreover, the production department must see whether an efficient quality control process is adopted to test the quality of finished products. India's share in the 129 global markets is still nearly 1% only (Negi 2013)³⁶. Still, there is an

increasing acceptance of fruits and vegetables in the country, especially for pomegranates, mangoes, grapes, bananas, walnuts in fruits and onions, mushrooms, bitter gourd, okra, chillies and potatoes from vegetables (Figure 8). This may be due to concurrent developments in post-harvest management such as quality assurance, packaging, strict regulation, standard operating procedures, and cold chain infrastructure (Singh et al. 2022b)³⁷.



Figure 8. Equipment related to complete animal feed manufacturing plant (Singh et al. 2022b)³⁷

7. Entrepreneurship opportunities in nursery raising of horticultural crops

Cultivation of traditional fruit crops comprising tropical and subtropical fruits like mango, banana, pomegranate, pineapple, grape and citrus has the potential to afford sustainable livelihood to the petite landholders both under irrigated and rainfed conditions (Bana et al. 2013)³⁸. However, the appropriate availability of quality planting stuff for perennial horticulture crops and the absence of standardization and certification are critical issues in encouraging area expansion under these crops (Sarolia et al. 2018)³⁹. While several state governments have established nursery production facilities, a considerable gap exists in demand and supply. Because good quality planting material fetches a premium price, investing in a commercial nursery unit is viable and profitable. Apart from perennial horticulture crops, there is an increasing demand for nursery plants for decorative flowers and shrubby plants. Exclusive production of vegetable seedlings and supplying the same to farmers is also emerging as a profitable horticulture enterprise in major vegetable growing belts. Based on resources

available and market demand an entrepreneur can choose from fruits, vegetables or flowers nursery or simultaneously start with two or more ventures. Besides this, startups may be initiated in online marketing of planting material. Therefore, enormous opportunities for entrepreneurship development through the nursery establishment of horticultural crops exist. Commercial nursery production is highly capital-intensive. The project components include capital investment items viz., the establishment of a mother plant garden, irrigation infrastructure, poly house, mist chamber, shade net area, fencing and other utilities. Considering the returns generation pattern, which instigates from the third year of establishment, capitalization of operational everyday expenditure (maintenance of mother plant garden, rootstock production, labour, etc.) for the initial three years (Gurjar & Gora 2022)⁴⁰. The commercial nursery activity may be categorized as presented in Figure 9.

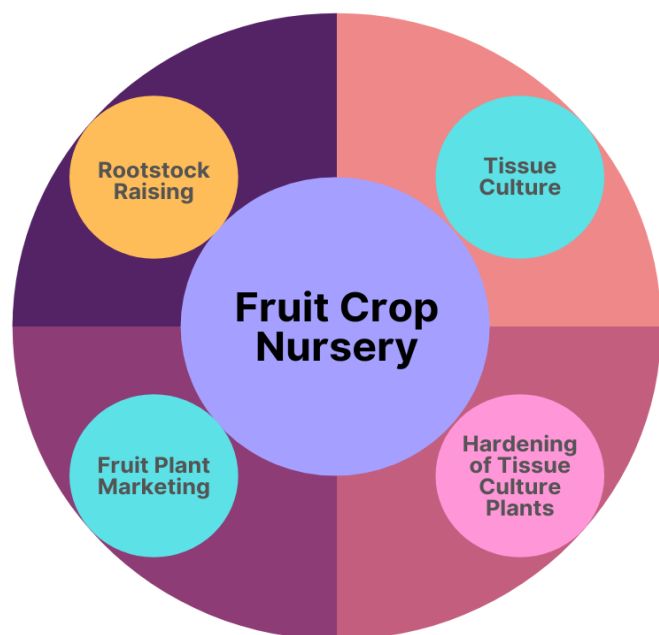


Figure 9. Opportunities of business in nursery raising of horticultural crops

8. Entrepreneurship development through botanical pesticides

Synthetic pesticides have led to unforeseen problems during their prologue]. Pesticide residues are found in food, water, and breast milk. WHO estimated that 25 million cases of pesticide poisoning are recorded yearly in developing countries (Haldhar et al. 2022c)⁴¹. Considering these disadvantages of synthetic pesticides, it is necessary to search for alternative ones such as botanical pesticides. These plant-based pesticides are an alternative solution to address the existing difficulties. In this context, botanical extractants are the most promising solution due to their broad spectrum of action, such as repellent, antifeedant, growth regulatory and oviposition deterrent. Botanical insecticides are an alternative solution to synthetic pesticides through which their non-phytotoxicity, biodegradability and rapid breakdown ability. The natural chemicals of essential oil have multiple modes of action, including antifeedant and repellent activities, moulting and respiration inhibition, growth and fecundity reduction and cuticle disruption. They can act as a contact, fumigant, repellent, antifeedant and oviposition inhibition toxicants (Haldhar et al. 2019)⁴². Furthermore, essential oils have been widely used in anti-parasitical, bactericidal, fungicidal, antiviral and insecticidal activities (Ahmed et al. 2020)⁴³. However, only a few plants (neem, lemongrass)-derived products have demonstrated their effectiveness against various insects. A small-scale biopesticides process from a neem plant is shown in Figure 10. More than 6000 species of various plants have been screened, and more than 2500 plants belonging to 235 families were found to possess biomolecules against various types of pests (Ali Saad Abdelatti & Hartbauer 2020)⁴⁴. Among those, important plant families are, *Apocyanaceae*, *Asteraceae*, *Euphorbiaceae*, *Fabaceae*, *Meliaceae* (maximum), *Myrtaceae*, *Ranunculaceae* and *Rosaceae*. Recently, botanical insecticides have emerged as a potential pest management tool instead of synthetic insecticides, and

organic crop producers in industrialized countries recognize these botanical insecticides. Hence, it is recommended to use botanical insecticides and promote and investigate in depth to find new sources of botanical insecticides (Haldhar et al. 2022c)⁴¹.



Figure 10. Local or small scale biopesticides from neem plant (Haldhar et al. 2022c)⁴¹

9. Entrepreneurship in mushroom cultivation

Mushrooms are the fruiting bodies produced by some fungi but not each fruit bodies are true mushrooms. Puffballs and morels are suitable for eating fruit bodies, sometimes called “mushrooms” (Singh 2014)⁴⁵. The utility of this visible part of some fungi is to generate and disperse the most significant number of spores in the shortest possible time. Spores produce new individuals after passing away on the wind and landing in a superior place for growth. It is rich in protein, fibre and amino acids (Verhees et al. 2021)¹⁸. Mushroom is a 100% vegetarian food and is suitable for patients of diabetes and joint pains. Pickles, papad, soup powder, health powder, capsule, health drinks and pakodas can be made using mushrooms (Shakywar 2022)⁴⁶. It has no cholesterol and helps in purifying blood. The mushroom house can be constructed with bamboo frames, angle iron or concrete and tokopatta (Figure 11). Air vents on the upper walls and side walls are provided for ventilation. Sheds are built in an east-west direction to avoid the sun's direct effect and reduce the temperature inside the house. The walls may be covered with plastic or foam sheets to increase the relative humidity to 80-85% in the production house. The top covering with chicken mesh prevents entry of rats, squirrels, snakes etc. The shed's floor is filled with sand to a uniform height of 15 cm. Racks are built to accommodate mushroom beds; the inner side of the shed is covered with jute gunny bags. Water is sprinkled twice daily on

the floor and gunny bags to maintain the required temperature and relative humidity. Mushroom entrepreneurship is a perfect opportunity for agriculture graduates because they already have sufficient knowledge of cultivation aspects. Hence, they can start mushroom cultivation with low investment and less space, grow excellent quality mushrooms, and solve the problem of nutritional security and economic prosperity (Shakywar 2022)⁴⁶. In developing countries like India,

planning and implementation for developing entrepreneurial programs are essential for raising the living standard of most of the backward regions because of their over-dependence on agriculture for employment (Uplaonkar & Biradar 2015)⁴⁷. Thus, entrepreneurship development appears to be the greatest substitute for employment opportunities, returns generation, poverty decline and improvement in nutrition, health, and overall food security in the national economy.



Figure 11. The mushroom bed kept inside the dark place in the mushroom house (Shakywar 2022)⁴⁶

10. Entrepreneurship through vermicomposting

Vermicompost has revolutionized vegetable farming and kitchen gardening throughout the globe in the past few decades. Moreover, in the organic farming system, vermicompost has shown the best results compared to other inputs and vermicomposting is also relatively easy (Figure 12). Thus, vermicompost is ideal organic manure for better growth and yield of plants owing to its higher nutritional value and other quality described than traditional composts. The earthworms' casting is nutritive organic manure prosperous in humus, macronutrients (N-P-K), micronutrients, helpful microbes, antibiotics, enzymes, growth hormones, etc. As per studies, applying vermicompost as organic manure in soil built-up organic carbon improves nutrient status, cation exchange capacity, microbial activities, microbial biomass, enzymatic activities, soil structure, soil aggregation and improves soil water retention capacity (Choudhary & Suri 2018)⁴⁸. The earthworms' castings

also have pest-nauseating attributes—this help in promoting plant growth and sustaining soil health. Complying with vermicompost in crops may reduce the cost of chemical fertilizer input [56]. Vermicompost is an excellent option to develop entrepreneurship among unemployed rural resource-poor youth. The central and state governments encourage the unemployed youth to plan businesses and set up low-cost vermicompost units for micro-entrepreneur development. The setup of commercial units provides the scope of employment to other youth. Expert scientists consistently try to train youth on this aspect and guide them practically to start vermicompost businesses. There is a lot of marketing potential for this valuable input as the demand is increasing day by day due to the consciousness of the farmers towards the environment and health. Thus, one can quickly start this business and earn handsome returns with the guidance of experts over time (Choudhary & Suri 2018)⁴⁸.



Figure 12. Processing of Vermicompost including sieving and packing (Kumar et al. 2022)⁴⁹

11. Entrepreneurship in fisheries and aquaculture

Fisheries and aquaculture are essential sectors putting up the primary source of protein for many people around the globe. India ranks third in fisheries production and

second in aquaculture, employing more than 145 million people nationwide. This sector contributed 1.07% of the total GDP of India in 2020. According to National Fisheries Development Board, Hyderabad, the sector

generates export earnings of \$4.4 billion. The sector comprises capture fisheries including inland and marine, aquaculture, gears, navigation, oceanography, aquarium and ornamental fish trade, fish breeding, fish processing, export and import of seafood, fisheries products and by-products, research and related activities. The rich biodiversity in India furnishes a greater opportunity for aquafarming fish, crustaceans, and aquatic plants for consumption and recreation purposes (Bisht et al. 2013)⁵⁰. The highly potential sector extends an enormous scope for developing fisheries through entrepreneurship and aquafarming. Research and development have uplifted the sector by introducing new technologies that bring critical inputs such as feed, improved breed, drugs and medicine, etc. involving several fish farmers, entrepreneurs, exporters, breeders, traders and modern fishermen. Being a high-potential area, the sector has been regarded as a central hub for employment generation and career opportunities in various fisheries sections (Wanglemba 2022)⁵¹. Aquaculture (Figure 13) is an underwater agriculture farming aquatic plants and animals for food and recreational purposes. It can be done in freshwater, brackish water and marine. It includes pond-based, cage-based, pen-based, raceway culture, bio-floc-based, recirculating aquaculture systems, aquaponics, etc. giving an immense scope in countless ways such as producing proteinaceous diet for a human, practical tools for recycling urban sewage, employment and income generation. Fish and fish products are the largest groups in agricultural export of India. Seafood composes 10% of the total export of India and nearly 20% of all agricultural exports (Ayyappan & Jena 2003)⁵². New technology in processing industries extends the scope for innovation, maximizing shelf life, increasing food safety and decreasing waste during processing hence a vast number of value-added products can be introduced (Nagarajarao 2016)⁵³.



Figure 13. An exemplary photo of a hatchery for fish rearing

Conclusions

Entrepreneurship in agriculture is essential in India because entrepreneurial skills could be stimulated by changing the social and business environment and directly influencing the farmers and their capacity. Hence, there is a need to reorient the focus of agriculture education in India to develop entrepreneurship skills

among youth. We have identified the main themes within agricultural entrepreneurship research and key technological aspects of this sector through which entrepreneurship scholars can learn more about entrepreneurship. We have systematically reviewed diverse technologies that have entrepreneurship potential in the agricultural sector, outlined the suggestions for scholars for revising and reorienting the focus of future research in the farm sector and included basic know-how about the suggested entrepreneurship pathways. Hence, the entrepreneurship options summarized and evaluated in this study will help agriculture graduates and rural youth start up and establish small-scale entrepreneurship, ultimately leading to the prosperity of the rural population and reducing unemployment issues.

Acknowledgements

The authors are thankful to Vice Chancellor, Central Agricultural University, Imphal, Manipur, India, for providing the facilities and advice required for experimentation, and to R. Swaminathan, Professor, Department of Entomology, MPUAT, Udaipur, India and Majeet Singh, Professor, SKRAU, Bikaner, India for critical discussion and suggestions.

Declaration of Interests

The authors have no conflict of interest to declare.

Data Sharing

All relevant data are within the manuscript.

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