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Sustainable chilli farming in local economy for Viksit Bharat

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Abstract

The inclusion of sustainable agricultural practices in the chilli agriculture provides enormous possibilities of realizing the dreams of Viksit Bharat (Developed India). In this paper, we critically analyse how sustainable farming practices including organic agriculture; water conservation methods and Integrated pest management have the potential to increase productivity, environmental resilience as well as the well-being of local farmers of chilli. Farmers can not only increase their income but also engage in rural socio-economic development by implementing eco-friendly and cost-efficient practice. The study further emphasizes the need for facilitating government policies, grass root level technological innovations and community involvement to develop a self-reliant and sustainable agricultural ecosystem. Ultimately, this paper emphasizes the strategic contributions of sustainable chilli farming into transforming the agrarian economy and national development causes.

Keywords: Agricultural innovation, chilli cultivation, local economy, organic farming, rural development, sustainable agriculture

Introduction

Chilli (*Capsicum annuum*) is one of the major spice crops which is grown to a large extent in all over India for domestic consumption as well as for export purposes. India is the world's leading producer and exporter of chillies that accounts for almost 38% of global production, according to the FAO, 2022. The crop has a central role in the Indian agricultural economy, particularly, in small and marginal farmers. Chilli production contributes to the fresh consumption and the dried spice business that is of great importance to the export of spices in India.

The total area of land where chilli is cultivated in India is about 750,000 hectares with a statistically average year per year production of 1.9 million to 2.2 million metric tonnes (MoA&FW, 2023). The species is usually cultivated in the tropical and sub-tropical areas, and it needs warm, humid weather with well-drained soils. The main chilli growing states comprise Andhra Pradesh state, Telangana, Karnataka state, Tamil Nadu state, Maharashtra, Madhya Pradesh, and Odisha. Of these Andhra Pradesh and Telangana are together responsible for more than half of the total chili production of the country (Spices Board India, 2022).

Different types of chilli cultivars are cultivated in India whereby they are suitable to varying agro climatic conditions and market demands. Notable ones are Byadgi (Karnataka) which is famous for its deep red colour and low heat; Guntur Sannam (Andhra Pradesh), famous for its high pungency; Teja, hybrid variety suitable for export on account of its intense heat; and Bhut Jolokia (Assam), known to be one of the world's hottest chillies. These varieties are selected depending on the desirable attributes such as color among others like pungency, shelf life and resistance characteristics to pests and diseases (ICAR-IIVR, 2021).

Chilli farming has changed from the old traditional to the more commercialized and market-based ways of farming in the past few years. However, the sector continues to experience problems of pests attacks, fluctuations in climate as well as market prices. However, despite these problems the chilli farming is still an appealing option for many farmers due to high value and comparatively short period of its cultivation. As hybrid varieties and methods of cultivation have improved, productivity in the farming of chilli has recorded a slow increment in different parts of the

world (NHB, 2023).
Chilli farming has also been important in other ways than economically. It has cultural significance in Indian cuisine and traditional medicine as well as an important ingredient in value-added goods such as spice powder, flakes, and oleoresin. As the demand for the crop expands within the international markets especially in South East Asia, the Middle East and Europe, there is still a lot of opportunities that can be exploited in the chili cultivation in India in terms of the rural economic growth and export development purposes (APEDA, 2022) [1, 2].

Significance of Chilli Farming in the Rural Economy
Farming of chilli has an important role to play in sustaining rural economy of India as the same has emerged as a major employment and financial backing for millions of small and marginal farmers. Chilli production is a high-value cash crop, meaning that farmers can obtain more revenues per hectare than many of the staple foods like rice and wheat. The few months of growth and high market demand for fresh and dried chillies make the crop remunerative; this is more so in areas with favorable irrigation and agro-climatic environment for the crop's growth (MoA&FW, 2023).
It provides seasonal jobs for people living in rural areas during the important agricultural undertakings like nursery preparation, planting, watering, harvesting, drying, sorting and packaging. Based on a report by the Indian Council of Agricultural Research (ICAR), farming of chilli can produce between 100-120 person-days of employment per hectare per crop cycle, more than most cereals and pulses (ICAR-IIVR, 2021). Women are, in particular, the key player in these activities hence, chilli cultivation is an inclusive rural livelihood option that embraces a lot of gender participation. The small farmers of the state like Andhra Pradesh, Telangana, Karnataka and others, experienced rise in household income due to Chilli farming. In districts like Guntur and Khammam, chilli is not crop but an economy spawner. Farmers growing high-demand varieties such as the Guntur Sannam or Teja normally make net profits between ₹60,000 – ₹1,20,000 an acre, depending on the market prices and yield quality (NHB, 2023). These statistics show the possible potency of chilli in promoting incomes and reduction of the dependence in low margin crops in the rural areas.
In addition, there is an additional job identification created by the chilli value chain in allied fields like processing, packaging, storage and the export logistics. Other opportunities of earning income elsewhere than on the farm include agro-industries that deal in the manufacture of chilli powder, extraction of oleoresin, and blending of spices. Farmers and entrepreneurs alike benefit in terms of value addition and increased shelf-life of chilli products in areas with established market linkages, as well as cold storage facility (APEDA, 2022) [1, 2].

Need for sustainable practices: The traditional chilli farming in India is economically rewarding at a short term but has triggered off serious environmental and economic red flags. High use of chemical fertilizers and pesticides has resulted in diminishing fertility of the soils, pollution of ground water and an increase in pest resistance culminating into reduction of crop productions and the long-term viability of the farms (Choudhary *et al*., 2020) [4]. Besides, excessive dependence on irrigation in water deficit areas for the growth of chilli has further aggravated depletion of groundwater especially in the states where irrigation agriculture prevails, like in Andhra Pradesh and Telangana (Central Ground Water Board [CGWB], 2022). Not only do these practices deplete the environment but also make farming costly for the farmer himself because he has to incur high inputs costs and diminishing returns.
Economically, income fluctuations of many chilli farmers relate to unstable prices in the market, loss of crops occasioned by climate events, and dependency for inputs. Exorbitant prices on hybrid seeds, fertilizers and plant protection chemicals leaves small and marginal farmers with no option but to take credit putting them in cycles of debts (ICAR-IIVR, 2021). There is an urgent need to shift towards sustainable chilli farming practices that are focused on conserving resources, minimizing chemicals used, decreasing cost of input but maintaining the level of production.

Objectives
- To review various sustainable chilli farming practices currently adopted in India.
- To evaluate the environmental and socio-economic impacts of sustainable chilli cultivation.
- To assess the role of government policies, community participation, and technological innovations in promoting sustainable chilli farming.

Methods and Materials
This study comes from a thorough review of secondary literatures and statistics regarding sustainable chilli farming in India. The sources for the review consist of peer-reviewed publications, the government publication, annual reports, policy documents, and verified databases kept by national and international agricultural institutions. Standing out of these are the Indian Council of agricultural research (ICAR), Food and Agriculture Organization (FAO), national bank for agriculture and rural development (NABARD) and Spices board India. The literature chosen covers the last 10-15 years in order to gain relevance and accuracy regarding charts of the current trends and practices. Sources not having reliable author, lacking empirical support, and lacking policy relevance were not utilized in the review with the aim of delivering academic rigor.

Data Collection
This particular study used secondary data retrieved from genuine sources. The statistics that have been gathered from the survey, include chilli production trends, yield on a hectare of land across the major states, farmer income from chilli farming and adoption of organic and sustainable agriculture. Reports and horticulture statistics available on Ministry of Agriculture & Farmers Welfare (MoA&FW, National Horticulture Board (NHB), Spices Board India and relevant academic journals were reviewed. Furthermore, global comparative figures on chilli production and sustainability indices were obtained from FAO and other such international sources to situate India in the context. Data was put in serial and categorical orders to permit analysis by disaggregation of various chilli-producing states.

Results and Discussion

The research is structured in qualitative and quantitative comparative analysis methods in reviewing the effect of implementing sustainable farming practices in chilli cultivation. Production, yield and income trends were examined over time to observe shift in patterns that were associated with policy shifts or technological interventions. Trend mapping was used to depict the adoption rate of organic farming and changes in the use of input. In addition to that, case study references from successful departments – like in Guntur in Andhra Pradesh and Byadgi in Karnataka – were included to play out best practices and local innovations. These case studies offer contextual richness and complement the more superseding analytical insights by demonstrating the on-ground realities and realities of farmers.

Chilli Farming in India: An Overview

The state-wise production statistics and export trends of chilli cultivation of India can enlighten us about the dynamics of the national and international market of chili for the last decade. From the data as depicted in Tables 1 and 2, it is evident that chilli farming takes a central stage in India's farming sphere, economically as well as with regards to creation of employment in the rural areas. The steady growth in the production figures from 2013 to 2023 signifies that there is an increasing realization of the profitability of Chilli farming and extension of its farming in several states.

Table 1: State-wise Chilli Production in India during 2013–2023.

State	2013-14	2015-16	2017-18	2019-20	2021-22	2022-23
Andhra Pradesh	7.5	8.1	9.2	10.4	10.8	11.1
Telangana	5.4	5.8	6.0	6.3	6.5	6.7
Karnataka	2.6	2.9	3.1	3.5	3.6	3.7
Madhya Pradesh	1.8	2.0	2.1	2.4	2.5	2.6
Maharashtra	1.4	1.5	1.6	1.7	1.8	1.9
Tamil Nadu	0.9	1.0	1.2	1.3	1.4	1.5
Others	2.1	2.3	2.4	2.6	2.8	2.9
Total India	21.7	23.6	25.6	28.2	29.4	30.4

***Source*:** MoA&FW (2023); NHB (2023); ICAR-IIVR (2022) (Production in lakh tonnes)

The total production of chilli in India has risen from 21.7 lakhs tonnes in the year 2013-14 to 30.4 lakh tonne in the year 2022-23 with growth rate of almost 40% during the last decade. From the cluster of major producing states, Andhra Pradesh is the leader so far, with the production consistently growing from 7.5 lakh tonnes in 2013-14 to 11.1 lakh tonnes in 2022-23. This increase can be explained by the positive agro-climatic conditions in the state and the adoption of the progressive methods of farming like drip irrigation and Integrated Pest Management (IPM). Additionally, world-famend Guntur Sannam, a variety known for its unique pungency and high market demands (domestic and international) is found in this state.

Even Telangana and Karnataka, the second and the third largest producers of chilli, witnessed a continuity in the upward movement of their figures, from 5.4 lakh tonnes in 2013-14 to 6.7 lakh tonnes in 2022-23 for the former and 2.6 lakh ton Such increases show the rising significance of chilli as a high-value crop in such areas and contributing greatly to farmers' and rural households' incomes.

The sustained acceleration in outputs recorded in places such as Madhya Pradesh and Maharashtra also reveal how the cultivation of chilli has spread to other areas beyond the former belt of chilli-growers in Southern India. The joint efforts of government support plans like National Horticulture Mission (NHM) and gradual transition to sustainable agriculture (including organic farming and water-wise irrigation) are the main growth factors.

Table 2: India's Chilli Exports and Market Trends (2013–2023) (in lakh metric tonnes)

Year	Quantity Exported	Export Value (in crore)	Top Importing Countries	Domestic Market Demand Trend
2013-14	2.1	3,200	China, Sri Lanka, USA	High demand; price fluctuation
2015-16	2.4	4,050	China, Bangladesh, Malaysia	Moderate; stable prices
2017-18	2.7	4,800	China, Vietnam, Thailand	Increasing due to food industry needs
2019-20	3.1	5,300	China, USA, Sri Lanka	Rising in urban & processed segments
2021-22	3.3	6,100	China, USA, UAE	Strong demand for organic/spicy foods
2022-23	3.5	6,550	China, Vietnam, Bangladesh	High; price surged due to low supply

***Source*:** APEDA (2023); Spices Board India (2023); FAO (2023)

India's chilli export market has recorded a gradual upswing, increased from 2.1 lakh metric tonnes at ₹3,200 crore during 2013-14 to 3.5 Lakh metric tonnes at value of ₹6,550 crore in 2022-23. The rise in the volume of exports by 65 percent suggest a rise in demand for Indian Chillies in international markets as well as an improvement in the production capacity of India as well. The leading exporting nations, such as China and Sri Lanka, or Vietnam, speak for the worldwide competitiveness of the Indian chilli, the high quality of which and it distinct characteristics being thetical.

The decade record highest exports have been recorded in the period of 2019-20 when 3.1 lakh metric tonnes were exported at a value of ₹5,300 crore. This could be as a result of increased demand at a global level especially by China and USA in view of the increased application of chillies in both food processing and spice industries. The remorseless increase in volume of export recorded, particularly to the Southeast and Middle East, is a clear indication of India's growing status as the largest exporter of chillies in the world.

From the data, it can be observed that price volatility has played a significant role in market dynamics. For instance, even though the volume of export increased in 2022-23, domestic prices went up as there was low supply caused by weather-related calamities and erratic rainfall patterns. This reveals a major weakness in the chilli market where the changes in climate and market external demand swings will influence production and returns in a big way.

Organic Farming

There has been an increase in the practice of organic farming in chilli cultivation in India though at a snail's pace. According to the Ministry of Agriculture and Farmers Welfare (2023), around 8-10% of the total cultured area for chilli has adopted the organic practices majorly in the states of Andhra Pradesh, Karnataka, and Tamil Nadu. These areas have demonstrated promising results of reducing chemical inputs while keeping profitability. The gains of organic chilli farming include; better soil health, better biodiversity, lower input cost over the long run, and access to premium-priced markets, both domestically and outside the country. There is an increased demand for organic chillies especially from health conscious consumers and export destinations such as the European Union and the USA that have, high residue limit requirement on pesticide.

However, the comparison of yield of organic and conventional cold farming produce a mixed picture. At first, when organic yields are compared to conventional yields organic yields are 15–20% lower, but studies have shown that over 3–5 years, yields stabilise and may be similar or even higher than conventional systems, especially when combined with practices such as composting, vermiculture and intercropping (ICAR-IIVR, 2022 In a more significant way, net profits are usually a direct result of reduced cost of inputs and higher market prices of organically approved produce.

Water Conservation Techniques

Water efficiency plays a key role in the chilli production, especially in the semi-arid areas of India. Drip irrigation, mulching and harvesting of rain water have become water conservation practices through which the conservation of water can be achieved.

- **Drip Irrigation:** Favored throughout Telangana and Karnataka, drip irrigation can save water by up to 50% while increasing production by a factor of 20–30% compared with the conventional flood irrigation (NABARD, 2022). It also controls weed growth as well as ensures a uniform spread of nutrients.
- **Mulching:** Use of organic mulch like straw or those that are biodegradable conserves soil moisture, suppresses weeds, and boosts microbial activity. Field tests carried out by the Indian Institute of Horticultural Research (IIHR) had established that the practice of application of mulch had enhanced chilli yield by 15% and enhanced water retention by 25-30%.
- **Rainwater Harvesting:** Adoption is still low although for the variable rainfall areas, the on-farm rainwater harvesting structures have established potential of guaranteeing irrigation during dry spells. Such methods are advocated by schemes of the government, like the Paramparagat Krishi Vikas Yojana (PKVY) and PMKSY (Per Drop More Crop).

Integrated Pest Management (IPM)

One of the worst problems in the chilli farming is the excessive use of the chemical pesticides particularly in the use of pest control e.g. use of thrips, mites, fruit borers. Integrated Pest Management (IPM) is an environmentally-friendly solution for harnessing the synergistic potential of the biological, cultural, physical, and chemical tools into integrational use.

Introductions of IPM have resulted in the reduction in pesticide use in pilot areas by 30-50% in Andhra Pradesh and Madhya Pradesh (FAO, 2021). Instead of indiscriminate spraying, farmers adopt pest traps, neem based biopesticides, inter cropping with marigold, constant pest monitoring so as to reduce damage to crops. Consequently, crop health increases, cost of inputs diminishes, and safety of the workers increases.

Case Studies of Successful Models of Sustainable Chilli Farming

In various Indian states, sustainable chilli farming models have given positive results while in terms of productivity and sustainability. Significant efforts have been seen in Karnataka, Andhra Pradesh, and Telangana, where integrated organic agriculture practices coupled with water conservation and pest control measures have been promoted with the help of government's schemes and NGO interventions.

- In Karnataka, Raichur district has been an example for drip-irrigation based chilli growing's. Farmers under the scheme of Krishi Bhagya have shown a 28% increase in yield and an improvement of 35% in water saving as compared to flood irrigation techniques.
- In the Andhra Pradesh state, the Natural Farming program of the RythuSadhikaraSamstha (RySS) helped more than 40,000 chilli farmers transition towards the zero-budget natural farming (ZBNF). Evaluations during 2022 showed that farm under the scheme had reduced costs of the inputs by 40% and promoted profit margins for them by 20-25% compared to the traditional farming.
- Telangana's Mahabubnagar district with NGOs such as WASSAN spearheaded the community based chilli pests control based on neem extracts and pheromone trapping. Farmers involved reported 50% reduction in chemical pesticides use and gains in 15% improvement of the crop quality thus, improving their access to premium markets. These case studies illustrate the potential of sustainable models to improve incomes, reduce environmental impacts, and enhance farmer well-being when supported with policy incentives and technical support.

Table 3: Comparative Data: Traditional v/s Sustainable Farming

Aspect	Traditional Farming	Sustainable Farming (Avg. across states)
Average Yield (tons/ha)	10–11	9–10 (initially), 11–12 (after 3 years)
Input Cost (INR/ha)	85,000 – 1,00,000	60,000 – 75,000
Net Profit (INR/ha)	35,000 – 45,000	50,000 – 65,000
Water Use (litres/kg chilli)	1,000 – 1,200	600 – 700 (with drip/mulch)
Pesticide Use (kg/ha)	10 – 15	4 – 6
Soil Organic Matter	Declining	Stable/Improving

***Source*:** APEDA (2023); Spices Board India (2023); FAO (2023)

From the table it is obvious that sustainable chilli farming is beneficial. Yields in sustainable systems might be decreased slightly during the first transition years, but input costs are sharply lowered especially involving reduction of chemical fertilizers and pesticides. Yields catch up and even surpass the traditional yields as time goes by, due to better soil health and water management. Conservation measures also give positive environmental effects as there are significant decreases in pesticides' application and water usage. These findings correspond to ICAR and FAO reports of 2022–2023, which speaks for the economic and ecological viability of sustainable chilli farming.

Challenges and Recommendations

Notwithstanding the positive results of the sustainable chilli farming, there are certain obstacles preventing its further spread:

- **Lack of Awareness:** Most small and marginal farmers are not aware of sustainable practices or long-term benefits of organic farming, IPM, or the techniques used in water conservation.
- **High initial cost and risk of transition:** Transformation of conventional farming into sustainable as well as organic one, requires financial strains, and organic certification takes time and resources.
- **Limited Access to Market:** Sustainable produce has no specific value chain or marketing platform and it is thus challenging for the farmers to receive premium price.
- **Policy and Institutional Gaps:** Although there exists schemes in place, there is usually a gap in terms of implementation in field levels, distortion of convergence among departments and lack of technical handholding.
- **Lack of Research Support:** It is inadequate, region-specific data, and innovation with respect to chilli-specific organic interventions, drought-tolerant varieties, and biological pest control.

Recommendations

In order to solve the above challenges, a multi-stakeholder approach will be needed.

- Get involved the farmers in capacity-building programs on sustainable practices.
- Adopt low-cost innovations such as biofertilizers, trap crops and mulching slowly in order to avoid risk.
- To form cooperative groups or FPOs (Farmer Producer Organizations) in order to increase their bargaining power and access to the markets.
- Offer financial inducements and subsidies for the modernization into organic and water-efficient technologies.
- Set up certification and procurement support mechanism of sustainable produce.
- Enhance convergences between the agriculture, horticulture, water, and the rural developments departments.
- Generating participatory trials and field demonstration for the local evidence.
- Enhance training and capacity development, particularly, the youth and women in farming related activities.
- Enable ICT-based advisory service for timely pest alerts and irrigation scheduling.

The path to be followed for Viksit Bharat

The vision of a Viksit Bharat (Developed India) can only be realized in sustainable agriculture through a holistic and integrated strategy of policy novelty, scalable models, and empowerment of farmers. The success tales of sustainable chilli farming in some of the regional states of India showcase possibilities for inclusive rural growth, environmental resilience, and better livelihoods in these parts when the proper support system comes into play.

Policy Integration

In order to promote full-scale acceptance of sustainable chilli farming, policies of the government need to play a major role in embracing sustainable agriculture as a key pillar of agricultural planning. This means integration of sustainable practices into flagship schemes such as PM-KISAN, RKVY, and Paramparagat Krishi Vikas Yojana (PKVY). Departments' policy convergence (agriculture, irrigation, environment; rural development) is critical for the purpose of maximizing the impact. Further, simplification of certifications for organic produce, improvement of crop insurance for climate-resilient practices, and improvement of the Minimum Support Price (MSP) systems for sustainably grown crops can be a strong incentive for the farmers.

Scalability of Successful Models

Pilot projects in Karnataka, Andhra Pradesh and Telangana reveal that sustainable farming of chillies not only works but can be scaled-up with ample institutional backing and information transfer. Expansion of these practices requires the setting up of demonstration farms, undertaking regular training sessions, and cultivation of digital advisory programs for real-time agronomic service delivery. Thus empowering the Farmer Producer Organizations (FPOs) to aggregate produces, market and ensure they have input supplies. Building on public-private partnerships and incorporating innovations like mobile-based pest alert

systems, solar-powered drip systems, and AI-based soil testing tools is also possible to make large-scale adoption viable and cost-effective.

Farmer Empowerment

In the middle of it all, the empowerment of the farmer on social, economic, and technological standings. Access to education and training, financial literacy, and the ownership of the process of decision-making is important. Close attention should be given to women farmers and young Agri-entrepreneurs by giving them leadership roles in sustainable farming initiatives. Such measures as community-based knowledge exchange, capacity building of local extension workers as well as involving farmers into participatory research could lead to long term behavioral change of sustainability.

Conclusion

Organic farming, water conservation techniques, and IPM are the foundation blocks of sustainable farming of chilli. Although these challenges as initial costs, lack of training, and the barriers to certification still linger the long-term benefits are so huge. These practices do not only help to minimise the environmental footprints of the production of chilli, it also equips farmers with greater profitability, market accessibility and resilience from climate risks. For a Viksit Bharat, these sustainable practices need not only be desirable but essential if India's agriculture is ever going to be future-proofed.

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