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## Global Advances in Microbial Technology & Bioengineering: Driving Innovations in Health, Agriculture and Environmental Sustainability

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**UNIVERSITI MALAYSIA KELANTAN,**
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OP 58

# Effect of Endocrine Disrupting Chemicals on Female Reproductive Health

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**Abstract:**

Recently, there has been an increase in reproductive problems and birth defects. Due to increasing contamination of the environment by toxic compounds such as endocrine disrupting chemicals (EDCs) is one of the major causes of reproductive problems. An Endocrine Disrupting Chemical refers to any substance that alters the normal function of the endocrine system in human. These chemicals are ubiquitous in the environment, obtained from both natural sources and human-made activities. Major sources of EDC pollutants include phthalates, Bisphenol A, triclosan, parabens, polychlorinated biphenyls, polyfluoroalkyl compounds, pesticides, plastics, and heavy metals, which are commonly found in the pharmaceutical, chemicals used in cosmetics, food preservatives, dyes, and packaging. These EDCs have been connected to problems in females such as irregular menstrual cycles, polycystic ovary syndrome, endometriosis, altered oogenesis, decreased oocyte quality, delayed puberty, onset of breast cancer in young women, and disruptions in hormonal milieu, induction of oxidative stress, fibroids in uterus, difficulty in conceiving, pregnancy abnormalities and complications in delivery. Due to various problems raised by EDCs, it became necessary to study relation between EDCs and female reproduction is crucial for understanding the complex interactions between environmental factors and health issues. This review presented the impact of EDCs on female health. Further, we discussed integration of nutritional therapy through dietary supplementation and good lifestyle could be needed to mitigate the effects of EDCs on female reproductive health and improving fertility outcomes.

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# ROLE OF SUSTAINABLE AGRICULTURAL PRACTICES IN INDIA FOR PROMOTING ECO-FRIENDLY FARMING

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**Abstract:**

Indian agriculture sector is facing the challenges like soil degradation, water scarcity, climate change and over usage of synthetic chemicals. Sustainable agriculture practices combining traditional wisdom with modern scientific approaches, is crucial for food security, environmental conservation and economic stability. Key practices include organic farming, crop rotation, conservation tillage, integrated pest management, agroforestry and precision farming are essential to mitigate the aforementioned challenges in agriculture. Government initiatives like the Paramparagat Krishi Vikas Yojana (PKVY) and the National Mission for Sustainable Agriculture (NMSA) have been instrumental to promote eco-friendly farming. However, challenges like small land holdings and lack of awareness persist, necessitating policy interventions and improved infrastructure facilities. Sustainable agricultural practices in India play a crucial role in preserving soil health, conserving water, reducing chemical use, promoting biodiversity, and mitigating climate change. These practices help maintain ecological balance, reduce water wastage, and promote sustainable agriculture. However, challenges in promoting sustainable practices include lack of awareness and education, high initial costs, limited access to technology, dependence on traditional farming methods, market access and profitability, inadequate government policy and support, climate and weather variability, and pest and disease management.

To promote eco-friendly farming in India, it is essential to address these challenges through concerted efforts from the government, non-governmental organizations, agricultural scientists, and farmers themselves. By reducing the use of synthetic chemicals, promoting organic farming, and reducing dependency on traditional practices, India can achieve long-term agricultural productivity and environmental balance.

Key words: PKVY, NMSA, Sustainable agriculture practices.

## I. Introduction

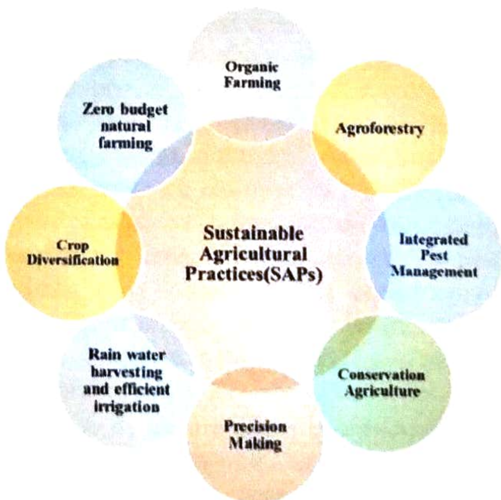
Nearly half of India's workforce is employed in agriculture, which continues to be the foundation of the country's economy, accounting for 16–18% of GDP. However, environmental deterioration has been caused by conventional farming methods,excessive use of chemical fertilizers, and water-intensive practices[1]. Eco- friendly farming methods are incorporated into sustainable agriculture to increase output while protecting natural resources for coming generations. Sustainable agricultural practices in India play a critical role in promoting eco-friendly farming by encouraging methods that maintain environmental balance, enhance soil health, conserve water, and reduce dependence on harmful chemicals. By integrating these sustainable practices, India can continue to enhance food security, reduce environmental degradation, and improve the livelihoods of farmers[2]. Eco-friendly farming practices help to create a balanced relationship between agricultural development and environmental stewardship, securing the health of both people and the planet for future generations. These practices are supported by both government initiatives and non-governmental organizations (NGOs), but the challenge remains in scaling them due to limited awareness, resources, and access to technology among small-scale farmers.

In order to address the issues of food security and climate change, numerous specialists and international organizations have advocated for the implementation of sustainable agricultural practices, or SAPs. Support for the Sustainable Development Goals around the world has concentrated on initiatives to expand the use of SAPs in developing nations where the resilience of natural resources is threatened by population and income growth. The factors influencing smallholder farmers' decisions to adopt SAPs (better seed, fertilizer, and soil and water conservation) as well as the effects of adoption on farm income and food security. The lowered coping strategy score and household dietary diversity are indicators of food security[3]. Findings indicate that farmers need the development of new technologies and practices that improve food yield, are affordable and practical for farmers, and do not negatively impact environmental goods and services is at the heart of concerns regarding sustainability in agricultural systems. It is also recognized that sustainability in agricultural systems addresses a number of broader economic, social, and environmental issues and integrates the ideas of resilience and persistence[4].

Indigenous cultures worldwide have evolved farming and land management strategies known as indigenous sustainable agriculture practices. These methods put the health of the land, biodiversity, and community well-being first and are based on cultural traditions, local knowledge, and spiritual beliefs. Indigenous farming methods promote harmony between people and nature, in contrast to traditional industrial farming, which frequently depletes ecosystems and abuses land resources[5]. Many people are looking to indigenous knowledge for sustainable solutions as the world deals with issues including soil degradation, climate change, and biodiversity loss.

## II. Key Sustainable Agricultural Practices in India

Sustainable agricultural practices in India aim to promote environmental health, economic viability, and social equity. Here are some key practices:

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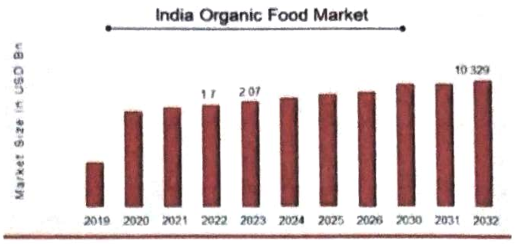
Here's how these practices contribute to eco-friendly farming.

**1. Organic Farming**

In India, organic farming is growing quickly. Farmers have taken to it, particularly in areas where chemical fertilizer use is minimal. Organic farming eliminates synthetic fertilizers and pesticides, relying on bio fertilizers, compost, and crop rotation. Customers are gravitating toward organic products as a result of growing understanding of the health risks associated with chemical-based farming. With a sizable percentage of its agricultural area devoted to organic farming, India is one of the world's top producers of organic goods. The National Programme for Organic Production (NPOP) promotes organic farming in India, with states like Sikkim achieving 100% organic certification. The future of organic farming in India looks promising, with an increasing number of farmers adopting organic practices, rising consumer demand, and government support. However, for the sector to grow further, more investments in research, infrastructure, and farmer education will be necessary[6].

In 2023, the organic food market in India was estimated to be worth USD 1.7 billion. The organic food market is expected to expand at a compound annual growth rate (CAGR) of 22.20% from 2024 to 2032, from USD 2.07 billion in 2024 to USD 10.329 billion. Growing awareness of the health benefits of organic food products, the health risks associated with chemical pesticides and fertilizers, and the increasing investments made by Indian corporate firms in agribusinesses, agritech, and organic farming are some of the main factors propelling the organic food market in India.




Courtesy:
https://www.marketresearchfuture.com/reports/india-organic-food-market-20704

**2. Conservation Agriculture**

This approach includes minimal tillage, crop rotation, and residue management to improve soil health. It reduces soil erosion and enhances water retention, making it a viable alternative in rain fed regions. Long-term agricultural productivity can be supported by healthier soils that have less soil erosion, improved moisture retention, and increased soil organic matter[7]. More varied cropping systems preserve or even boost plant and soil biodiversity, which can aid in pest management and enhance ecosystem services. Techniques like keeping soil cover and reducing tillage can greatly increase the soil's capacity to retain water, which is especially advantageous in regions that are prone to drought. Conservation agriculture lowers greenhouse gas emissions by storing carbon in the soil. Additionally, it makes crops more resilient to the effects of climate change by enhancing their capacity to withstand harsh weather conditions like droughts and floods[8]. When conservation agriculture was first adopted. Farmers may need to invest in new equipment (such as no-till drills) or technology in order to make the switch to conservation agriculture, and there may be a learning curve involved in implementing new methods[9].

Farmers' adoption of conservation activities may be constrained by their lack of understanding of these methods. To get past these obstacles, education and training are crucial.

Since many farmers are used to conventional farming methods, it can be challenging to alter them, particularly if the advantages of conservation agriculture aren't immediately obvious.

No-till systems may occasionally result in a rise in weeds or pests that require alternative methods of control, such as selective herbicides or integrated pest management[10].

**3. Agro forestry**

Agro forestry integrates trees and crops on the same land, improving biodiversity, soil fertility, and carbon sequestration. The National Agro forestry Policy (2014) supports farmers in adopting this system. A lot of trees, especially leguminous ones, fix nitrogen in the soil, making it more fertile[11]. Additionally, tree litter enriches the soil by adding organic stuff. Numerous plant, insect, and animal species are supported by agro forestry systems. Agro forestry increases ecological stability and creates wildlife habitats by diversifying land use. Tree roots aid in soil stabilization and lessen erosion brought on by water and wind. Additionally, trees serve as organic water filters, lowering the amount of contaminants that enter adjacent waterways[12]. By storing carbon, trees help lower atmospheric concentrations of carbon dioxide. Additionally, agro forestry systems can boost climate change resilience by enhancing soil moisture retention. Purchasing trees, fences, or irrigation systems are just a few of the substantial up-front expenses that may be necessary to set up an agro forestry system[13].

**4. Integrated Pest Management (IPM)**

IPM uses biological control methods, resistant crop varieties, and cultural practices to reduce pesticide dependency. This approach minimizes environmental harm while controlling pest outbreaks. Integrated Pest Management (IPM) is a holistic method to managing pest populations while minimizing the impact on the environment, human health, and non-target species[14]. It incorporates a number of tactics based on the biology, behavior, and interactions of pests with the environment. Instead of attempting to remove pests entirely, IPM aims to maintain populations at levels that do not result in substantial harm. Prevention is the process of altering the environment to make it less conducive to pests. Examples of this include crop rotation in agriculture, adequate sanitation, and sealing access sites. Assessing pest levels and deciding if intervention is required is made easier by routinely keeping an eye on pest populations using sampling, traps, or inspections[15]. Accurately identifying the pest is essential because it enables more efficient and safe control methods. This entail changing methods, including planting resistant crop types or changing irrigation techniques to lessen the number of insect habitats. Utilizing diseases, parasites, or natural predators to manage pests is known as biological control. To control aphids, for instance, ladybugs can be released. This covers methods such as hand-picking pests from plants or setting up obstacles or traps[16].

**5. Precision Farming**

By using technology such as GPS, remote sensing, and soil sensors, precision farming optimizes resource use, ensuring efficient water and fertilizer application. It is being promoted through government initiatives like the Digital Agriculture Mission[17]. Precision farming, sometimes referred to as precision agriculture, is a cutting-edge approach to farming management that maximizes crop yields, minimizes waste, and improves overall agricultural practice efficiency through the use of technology[18]. Farmers may more accurately and efficiently apply resources (such water, fertilizer, herbicides, and seeds) by using data and technology to monitor, measure, and react to field variability. Fields are mapped out using Geographic Information Systems (GIS) technology, which also records data on variables like soil type, moisture content, and yield fluctuations throughout the field. This aids farmers in comprehending the unique requirements of every section of their property. This technology tracks the whereabouts of equipment and machines[19].

Farmers can track crop health, identify insect issues, and evaluate soil conditions in real time with the use of remote sensing equipment like drones and satellite pictures. Precision farming produces a lot of data, which may be interpreted using sophisticated analytics[19]. The most effective management techniques can be recommended by machine learning models, which can also forecast results like possible crop yields or disease risks. Farmers may increase agricultural yield by giving plants precisely the right amount of water, nutrients, and pesticides. Less waste and lower input costs result from more effective resource use. By minimizing excessive use of fertilizers, herbicides, and water all of which can lead to pollution and resource depletion precision farming helps to reduce its negative effects on the environment. By emphasizing the long-term well-being of the soil and ecosystem, it assists farmers in managing land in a more sustainable manner[20].

**6. Zero Budget Natural Farming (ZBNF)**

It involves using cow dung-based inputs and intercropping to maintain soil health without external fertilizers. The sustainable farming approach known as Zero Budget Natural Farming (ZBNF) places an emphasis on economical, environmentally friendly, and natural agricultural methods. ZBNF was created by Indian agricultural scientist Subhash Palekar with the intention of lowering farmers' reliance on outside inputs such as chemical fertilizers and pesticides. Rather, it emphasizes the utilization of natural resources and methods that are readily available in the area to preserve soil fertility and manage pests. Making farming both environmentally and financially feasible is the aim of ZBNF, especially for small-scale farmers. The main goal of "zero budget" is to reduce the cost of agricultural inputs. ZBNF uses organic farming inputs that are readily available in the area, including: Urine and cow manure are used to make biopesticides and natural fertilizers[21].

A) **Jeewamrutha:** A concoction comprising water, pulse flour, jaggery (unrefined sugar), cow manure, and cow urine. This improves soil health by nourishing the soil and encouraging microbial activity. In order to increase resilience and lessen the need for chemical interventions, biodiversity promotes the use of mixed cropping and multi-species farming[21].

By increasing microbial activity, ZBNF aims to preserve soil fertility. By nourishing the soil with organic matter and bacteria, ZBNF seeks to restore soil health in contrast to traditional techniques that gradually deplete the soil with chemical fertilizers. The strategy promotes the use of non-chemical, natural techniques to eradicate weeds and pests, like: Agni Astra: A natural biopesticide derived from garlic, neem, and other organic materials[22].

B) **Bijamrita:** A seed treatment that shields seeds from pests and fungal diseases by combining organic components such as cow urine and dung. To guarantee that farming is viable even in regions with scarce water supplies, ZBNF encourages mulching, rainwater collection, and other water-conserving techniques. Water efficiency and waste reduction are the main priorities. By encouraging farmers to produce their own inputs, such as organic seeds, fertilizers, and insecticides, ZBNF helps them become less dependent on costly commercial goods and outside markets[23]. By emphasizing soil health, water management, and local ecosystems, ZBNF promotes methods that assist farming systems in adapting to shifting climatic conditions, such as droughts or floods. Farmers can greatly lower input costs and increase profitability by utilizing natural resources that are sourced locally[23].

## 7. Rainwater Harvesting and Efficient Irrigation

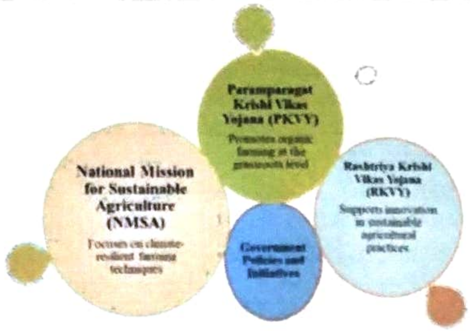
Micro-irrigation techniques like drip and sprinkler irrigation help conserve water, particularly in drought-prone areas. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) supports farmers in adopting these methods. Two essential techniques that assist preserve water, guarantee its sustainable use, and boost agricultural output are rainwater harvesting (RWH) and efficient irrigation, particularly in areas with unpredictable rainfall patterns or water scarcity[24].

The technique of gathering and storing rainwater for use in home, industrial, or agricultural settings later on is known as rainwater harvesting ( RWH). RWH is essential for increasing water availability in agriculture, particularly in arid and semi-arid areas with scarce surface and groundwater supplies. In order to ensure that crops receive enough moisture while reducing waste and preserving water, efficient irrigation systems concentrate on maximizing the use of water for agricultural purposes[24]. In regions with limited water resources, effective irrigation is crucial and can greatly aid in water conservation. One of the most effective irrigation techniques is drip irrigation, which uses a system of emitters, pipes, and tubes to transport water straight to the plant's root zone. Minimizes runoff and evaporation to cut down on water waste, ensures that water is delivered precisely where and when it is needed, which increases water use efficiency. Can be applied to a variety of crops, but it works best with high-value crops including vegetables, fruits, and row crops[25].

## 8. Crop Diversification

Shifting from monoculture to multi-cropping systems reduces soil exhaustion, pest attacks, and market risks. Pulses, millet's, and oil seeds are being encouraged as alternative crops for sustainability. Farmers who plant a range of crops are less susceptible to weather extremes, crop failures, and price swings. For instance, alternative crops may flourish in the event of a pest outbreak or drought, offering a fallback revenue stream. The root systems and nutritional needs of various crops vary[26]. Crop diversity and rotation lessen the accumulation of pests and illnesses linked to monoculture and help stop the loss of particular nutrients from the soil. Peas and beans are examples of leguminous crops that can fix nitrogen in the soil, increasing soil fertility. Crop diversification aids farmers in adjusting to the shifting climate. Certain crops might be more resilient to drought, while others might be more resilient to intense rains or temperature changes. This flexibility is particularly crucial in areas with erratic or severe weather patterns.

Access to many market outlets is made possible by crop diversity. Profitability can be increased by farmers selling directly to marketplaces, consumers, or processors. Additionally, some crops could serve export markets or specialized markets. Managing several crops successfully calls for distinct sets of abilities and expertise.




Certain crops might need specific handling and storage, or they might not have established market access. Finding consumers for their varied crops can be difficult for farmers, particularly if they are niche or lesser-known goods. Setting up varied farming systems can have higher upfront expenditures, particularly if new machinery, seeds, or irrigation systems are needed. Over time, farmers may incur more costs to sustain a variety of crops[26].

In a varied system, controlling weeds and pests can be more challenging. The farmer must use integrated pest management (IPM) techniques to control pests across a variety of crops without endangering the environment because different crops may attract different pests.

## III. Challenges in Implementing Sustainable Agriculture

### A)High Initial Costs:

Many sustainable practices require significant investment, which small farmers find difficult to afford. In agriculture, "high initial costs" refers to the substantial up-front expenditures that farmers must make in order to start and run their farms. For young farmers or those looking to grow their operations, these expenses may be a major obstacle. Long-term success in agriculture is possible, but starting or growing a business can require a significant amount of capital[27]. For farmers, buying or renting land can be one of the biggest expenses. The types of crops or livestock that can be effectively raised can be determined by the quality of the soil and the location, which can have a significant impact on land prices. Land is costly in many areas, and obtaining it could necessitate taking out loans or making long-term financial obligations. There are additional expenses associated with leasing land, especially if the lease is long-term if the leaseholder desires a cut of the profit or produce. Large-scale farming frequently requires farm machinery and equipment uch tractors, plows, harvesters, irrigation ystems, and seeders[28].

If farmers are cultivating high-value ommodities like fruits, vegetables, or ommercial cereals, the cost of seeds, specially premium or hybrid seeds, might e substantial. Pesticides and fertilizers, vhether organic or conventional, are dditional inputs that can mount up rapidly. Due to the lack of chemical alternatives, puts for organic farming can be even more ostly. Initial costs for livestock husbandry iclude feed, vaccinations, and medications. nstalling irrigation systems is a significant inancial commitment, especially in places vith erratic rainfall or water scarcity. nstalling sprinklers, surface irrigation, or a rip irrigation system can be very xpensive[29].

High wages or a lack of workers in ome areas can dramatically increase roduction costs. During peak seasons planting and harvesting), seasonal labor is equently needed, which raises the short-erm labor expenditures. Investments in echnology, including GPS units, soil ensors, drones, and farm management oftware, are necessary for the nplementation of precision farming nethods. Despite their potential to boost roduction and efficiency, these echnologies come with a high upfront cost. 'he cost is further increased by the fact that btaining data analytics, weather forecasts, r market information frequently requires urchasing specialist equipment or ubscribing to services. To safeguard their rops, machinery, and infrastructure from ests, disease outbreaks, and natural isasters, farmers frequently need to buy everal types of insurance[28]. For high-value rops in particular, this can be crucial. Depending on the type of farming, licenses nd permits may also be required (for organic certification, pesticide use, or water use). There are frequently fees and renewal costs for these permissions. To pay for their first investments, a lot of farmers depend on loans. Loan interest payments might result in substantial recurring expenses.

By strengthening soil health, lowering reliance on chemical inputs, and increasing water efficiency, techniques including organic farming, rainwater collection, and crop diversity can help lower long-term expenses[27]. As their business expands, farmers can gradually use data management software and precision farming instruments rather of making a large upfront investment in costly technology. New farmers can obtain the funds they require to pay for startup expenses through crowd funding, venture capital, or microfinance options[23].

### C) Market Constraints:

Organic and sustainable produce often lack proper marketing channels and certification processes. In Indian agriculture, "market constraints" refers to the different obstacles farmers encounter while attempting to sell their produce, which can make it more difficult for them to get fair pricing, increase their revenue, and establish economic sustainability[29]. These limitations result from a number of causes, including as supply chain inefficiencies, market access restrictions, intermediary dominance, and infrastructure bottlenecks. Farmers frequently have restricted access to local markets where they can sell their produce, particularly those in isolated rural locations. This lowers the profitability of their produce by causing spoiling and excessive shipping costs. Inadequate market infrastructure, such as cold storage facilities, packing facilities, and contemporary wholesale markets, is a problem in many rural locations. Postharvest losses result from this, and they are substantial in India, particularly for perishable commodities like fruits and vegetables[30].

In order to sell their produce in the market, Indian farmers frequently depend on middlemen, also known as commission agents. Farmers' incomes are decreased and prices are distorted as a result of middlemen control
by charging low rates and keeping a sizable percentage of the earnings, these intermediar ies commonly take advantage of farmers.
When it comes to pricing negotiations, small holder farmers, who comprise the bulk of In dia'sagricultural producers, have limited neg otiating leverage.

Because of this, individuals are susce ptible to being taken advantage of by interm ediaries, particularly when market acknowle dging the price discovery process. Price volatility and a lack of transparency in the agricultural supply chain are other effects of this[31]. The creation of a single national market has been hampered by the lack of consistency among states. For farmers, especially those with little expertise or awareness of regulatory needs, farming legislation, quality control standards, and certification procedures can be complex. Due to these complications, farmers may not be able to reach higher-value markets that demand certification or conformity to particular standards.

### D) Lack of Awareness and Training:

Farmers are at a disadvantage versus those that have access to better equipment and procedures since they are unable to fully utilize these technologies due to a lack of training programs. Lack of familiarity with government programs and subsidies. The National Mission on Sustainable Agriculture, Soil Health Management, and Pradhan Mantri Fasal Bima Yojana (crop insurance) are just a few of the many government initiatives, subsidies, and support programs in India that are designed to increase agricultural production[15]. However, because of the complicated application procedures and lack of information, many farmers are either unaware of these programs or find it impossible to access them. Farmers frequently lose out on chances to lower expenses or recoup from crop losses brought on by natural catastrophes if they are unaware of these financial assistance schemes. Market trends, pricing strategies, and market connections for their produce are frequently unknown to farmers[18]. Farmers are now receiving vital information on weather forecasts, market pricing, and farming methods through digital platforms including Kisan Call Centers, Krishi Vigyan Kendras (KVKs), and mobile apps like IFFCO Kisan and AgriApp. Increasing access to these platforms can greatly improve farmers' understanding. YouTube channels devoted to agricultural education, webinars, and online courses can also equip farmers with contemporary farming techniques.

## IV. Discussion :

In light of India's agricultural development, sustainable agriculture is an important concern. Since most people rely on agriculture for their living, addressing environmental, economic, and social issues requires a shift to sustainable farming methods. A more in-depth discussion about sustainable agriculture in India can be facilitated by the following discussion points:

Conventional farming practices that heavily rely on chemical pesticides, herbicides, and fertilizers have significant negative impacts on both the environment and human health. These chemicals are used to increase crop yields and control pests, but their overuse and improper application cause a range of issues that are not only damaging in the short term but also have long-lasting consequences like **Biodiversity Loss,** the widespread use of chemical pesticides and herbicides harms biodiversity in several ways by **Killing Non-Target Species**: While pesticides are intended to target specific pests, they often kill beneficial insects, including pollinators like bees and butterflies, as well as natural predators of pests. This disrupts local ecosystems and can lead to a decline in species diversity[6]. **Herbicide Resistance,** The overuse of herbicides can lead to the evolution of resistant weed species. These "super weeds" are harder to control, leading to even higher doses of herbicides being applied, further harming the environment. **Habitat Destruction,** as chemicals seep into soil and water, they damage the habitats of various animals, making it harder for certain species to thrive. The loss of these habitats leads to a reduction in overall biodiversity[10].

Farmers and agricultural workers who apply pesticides are at direct risk of exposure to these chemicals, leading to acute poisoning. Symptoms of poisoning can range from headaches and nausea to severe neurological or respiratory issues[12].Long-term exposure to pesticides has been linked to a variety of chronic health problems, including cancer, reproductive issues, hormone disruption, and developmental problems in children. People living in agricultural areas may also suffer from higher rates of these diseases due to pesticide drift or contamination of their environment.The environmental damage caused by chemical overuse creates a vicious cycle[17]. For instance, **Soil degradation** reduces crop yields over time, prompting farmers to apply even more fertilizers and pesticides to compensate. **Biodiversity loss** weakens natural ecosystems that could help control pests or support healthy soil. **Water pollution** further degrades ecosystems and damages public health, creating additional costs for society. The overuse of chemical inputs in conventional farming is unsustainable and has far-reaching consequences for the environment and human health[20]. To address these issues, there's an increasing push toward more sustainable agricultural practices, like organic farming, agroecology, and integrated pest management, which prioritize ecosystem health and minimize harmful chemical use.

Organic farming practices focus on soil health through composting, crop rotation, and the use of natural fertilizers like manure. These practices build up soil organic matter, improve soil structure, and encourage beneficial microbes. Healthier soils lead to better water retention, reducing the risk of erosion and nutrient depletion. Organic farming promotes biodiversity by maintaining a variety of plants, animals, and insects. It avoids the use of harmful pesticides and synthetic fertilizers that reduce biodiversity, especially by harming pollinators like bees and butterflies[13]. Diverse ecosystems are more resilient and can adapt to environmental changes better.Organic farming tends to emit fewer greenhouse gases due to practices like reduced fertilizer use and better soil management. Moreover, organic systems often sequester carbon in the soil, helping to mitigate climate change. India's organic farming industry has significant growth potential due to its favorable climate, increasing consumer demand for organic products, and government support. However, challenges such as limited awareness, high transition costs, and certification hurdles must be addressed to unlock the full potential of the organic sector[14]. With the right infrastructure, education, and support, organic farming can become a vital contributor to both the environment and human health in India.

Governments or agricultural organizations can provide resources, such as pest identification guides, biological control agents (e.g., ladybugs or predatory mites), and information on crop rotation planning. This enables farmers to implement IPM strategies effectively. To encourage adoption, financial subsidies or incentives can be offered to farmers who implement IPM techniques. Support in the form of grants for organic certification or sustainable farming practices can make IPM more appealing to farmers. Collaborating with agricultural research institutions and non-governmental organizations can provide farmers with the latest knowledge and best practices in IPM[16]. Research-based guidance on pest forecasting, pest-resistant crop varieties, and local biological control options can be shared. Governments can play a critical role by implementing policies that promote IPM, such as offering tax incentives for sustainable practices, creating markets for organic products, or encouraging the use of non-chemical pest control methods[19].

## V Conclusion :

To sum up, sustainable agriculture in India is not only essential, but also a means of guaranteeing long-term environmental health, farmer welfare, and food security. Farmers, legislators, researchers, and consumers must work together to achieve this. A more robust agricultural system that can endure the difficulties presented by climate change, market volatility, and resource depletion will result from the shift to more sustainable farming methods, which will also benefit farmers and the environment. India can attain a more sustainable, inclusive, and affluent agricultural future by raising awareness, implementing cutting-edge technologies, and setting up sufficient support networks.

Sustainable agriculture is essential for ensuring long-term food security, environmental conservation, and economic stability in India. While challenges exist, increased government support, technological advancements, and awareness programs can drive its adoption. Farmers need incentives, infrastructure, and education to transition toward sustainable practices successfully. A multi-stakeholder approach involving policymakers, researchers, and farmers can create a resilient agricultural system for future generations. Indigenous sustainable farming methods provide important insights into biodiversity, environmental stewardship, and resilience. Indigenous knowledge offers crucial insights into how we might farm in peace with nature, which is crucial as the globe faces increasing environmental difficulties. We can work towards a more just and sustainable food system that respects the earth and secures the welfare of future generations by reviving and integrating these methods into contemporary agriculture.The answers required to build a more resilient and sustainable agricultural future may be found in integrating these antiquated techniques into modern farming systems.

Sustainable agriculture practices in India aim to improve agriculture productivity while preserving natural resources but also contains lot of challenges like climatic conditions, sudden rain fall , insects improving tolerance to pesticides, cyclones, unavailability of advanced equipment like drones, poor irrigation facilities, lack of awareness on new genetically modified crop varieties.

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