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Sustainable Agriculture Development

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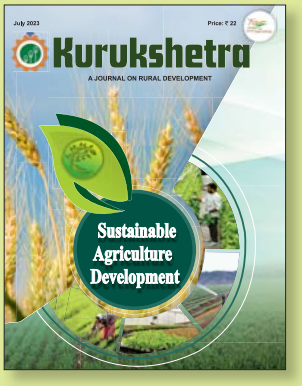

CHIEF EDITOR
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EDITOR
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JOINT DIRECTOR (PRODUCTION)
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COVER DESIGN
Rajender Kumar

EDITORIAL OFFICE
Room No. 653,
Publications Division,
Soochna Bhawan, C.G.O. Complex,
Lodhi Road, New Delhi-110003
Phone : 011-24362859
Email : kurukshetrajournal@gmail.com

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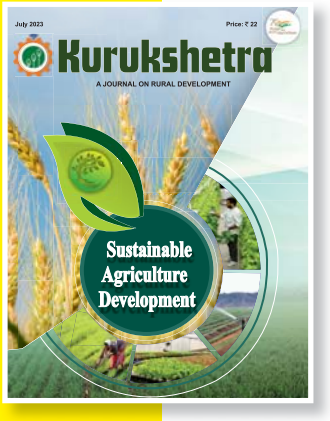

Editorial

One of the key industries driving the Indian economy is Agriculture. The contribution of the agriculture industry to employment and GDP (Gross domestic product) in India's economy evidently reflects the sector's significance. For Indian agriculture to remain viable over the long term, sustainable agricultural practises are necessary. In fact, agriculture determines the fate of a nation like India, where two-thirds of the population still relies on agriculture for a living in rural areas despite the country's long-term trend towards urbanisation. The Government has implemented a number of reforms, plans, schemes, and policies aimed at boosting farmer incomes and promoting sustainable agriculture and farmer prosperity.

The article *'Technologies for Sustainable Agriculture Development'* discusses about several initiatives by the Government to promote sustainable agriculture practices and the significance of adopting technologies in developing sustainable farming systems that promote environmental, social, and economic sustainability. The author further writes that for the Indian farmers to adopt contemporary farming methods and practises, technical knowledge dissemination needs to be improved.

This issue also attempts to comprehend about a renewed focus on millets that has the potential to produce positive externalities, such as increased income for growers, improved nourishment for citizens, and environmental sustainability. The author in the article *'Millets Future of Sustainable Agriculture'* writes about how Indian millets have registered respectable demand in international markets and the trinity that underpins the current campaign to promote millets: nutrient enrichment, an environmentally friendly cropping plan, and financial reasons.

The author of the article *'Climate Sustainable Agriculture'* deliberates about the initiatives taken by the Government to lessen the potential damage to crop production from deteriorating climate conditions and emphasises on finding ways to sustainable agriculture through Climate-Smart Agriculture. The areas of agriculture in terms of sustainability related to 'dryland farming' and 'organic farming' have also been discussed extensively by the authors in this issue.

There is no doubt that Sustainable agricultural methods have the potential to increase crop quality, lower production costs, and increase agricultural productivity. Additionally, it might encourage the creation of safer and better foods, which is good for everyone's health. This issue of Kurukshetra aims to present an extended discussion regarding the agricultural sustainability and we hope that the knowledge provided by subject matter specialists will help our readers to better comprehend the development of sustainable agriculture in India.

Technologies for Sustainable Agriculture Development

Farmers can develop sustainable farming systems that promote environmental, social, and economic sustainability by adopting advanced technologies. However, it is essential to note that technology is not a silver bullet and must be implemented with other sustainable farming practices, such as soil conservation, crop rotation, and integrated pest management, to achieve sustainable farming systems.

Dr Neeraj Sinha
Naman Agrawal
Rajeev Kumar

Agriculture is the backbone of the Indian economy, employing more than half of the country's population. On the other hand, traditional agricultural practices in India are frequently unsustainable and can negatively affect the environment and human health. Sustainable agricultural practices are required to ensure the long-term viability of agriculture in India.

According to the World Bank, as of 2020, 42.1% of the Indian population was employed in agriculture. While the industry and services sectors contribute more than 80% of the gross value added in the country, they employ 54.4% of the workforce. Agriculture, which accounted for 18.29% of GVA in 2019–20, still employs 45.6% of the workforce, indicating that a significant portion of the Indian population relies on agriculture for their livelihoods. However, over the years, the percentage of the population employed in agriculture has gradually declined as the country has diversified its economy and developed other sectors, such as

The authors are Senior Advisor, Specialist and Young Professional, NITI Aayog.
Email: naman.agrawal@nic.in and mrrjvkmr.aim@nic.in

services and manufacturing. In 2000, the percentage of the population employed in agriculture was 60.5%, showing a significant shift away from agriculture in recent years.

Gross Domestic Product (GDP) Growth Rate in India

Per capita GDP measures the average economic output per person in a given country or region. The agriculture sector's contribution to per capita GDP in India has declined over the years as the country has diversified its economy and developed other sectors such as services and manufacturing. The Ministry of Statistics & Programme Implementation (MoSPI) estimates that the GVA of agriculture and related sectors was 20.2% in 2020–21, 19.8% in 2021–22, and again decreased to 18.3% in 2022–23.

In recent years, there has been a shift in economic power and focus on the growing economies of the BRIC countries: Brazil, Russia, India, and China. The BRIC countries' GDP growth rate is far greater than that of traditionally strong economies such as the United States and Germany. While the United States has the world's largest economy by almost any measure, China has the second-largest share of global GDP, with India racing Japan for third place. Despite the global recession in 2008 and 2009, India managed to maintain impressive GDP growth rates, especially given that most of the world experienced negative growth in at least one of those years.

While the agriculture sector's contribution to India's per capita GDP has declined over time, it remains an essential sector of the economy, particularly regarding employment and livelihoods. Several initiatives, including the Pradhan Mantri Fasal Bima Yojana, the Pradhan Mantri Krishi Sinchayee Yojana, and the National Agriculture Market (e-NAM) platform, have been launched by the Government to promote the development of the agriculture sector. These initiatives aim to increase farmer productivity, reduce risks, and increase income in India. According to the survey, the Pradhan Mantri Fasal Bima Yojana (PMFBY) is a watershed initiative that provides farmers with a comprehensive risk solution at the lowest uniform premium across the country. Year after year, the PMFBY receives around 5.5 crore farmer applications.

Sustainable agriculture is a farming method that considers the soil, the environment, and the community's long-term health. It is critical to meet rising food demand while protecting natural resources for future generations. As the world has become more aware of the importance of environmental preservation, sustainable agriculture has received significant attention in recent years. Sustainable agriculture produces food, fibre, or other plant or animal products while preserving the environment, public health, human communities, and animal welfare. Natural resources such as soil, water, and air are conserved and regenerated for future generations through these practices.

As a developing country, India is vital in achieving sustainable agriculture globally. Agriculture provides a living for more than 58% of India's population. The country has made significant strides in increasing agricultural output, but much more work remains to achieve sustainable agricultural practices. One of the most significant challenges confronting Indian farmers is declining soil fertility due to the excessive use of chemical fertilisers, pesticides, and intensive farming practices.

Adopting sustainable agriculture practices in India is critical for the long-term sustainability of the agriculture sector. The Indian Government and various organisations have launched several initiatives to promote sustainable agriculture practices. For example, the government launched the National Food Security Mission, the Pradhan Mantri Fasal Bima Yojana, and the Soil Health Card Scheme to improve agricultural practices and financially assist farmers.

Adopting technologies can be crucial in developing sustainable farming systems that promote environmental, social, and economic sustainability.

Here are some ways in which technology can help in sustainable farming:

Precision Farming: It involves sensors, GPS mapping, and data analytics to monitor and optimise crop performance. By using precision farming techniques, farmers can reduce the use of fertilisers and pesticides, improve water management, and increase yields. Precision farming is a relatively new concept in India, and its adoption varies by state depending on various factors such as the availability of technology, agricultural practices, and Government policies.

Agroforestry: Agroforestry is a land-use integrated management system that combines trees and shrubs with crops and livestock to create a more sustainable and productive farming system. This approach can provide various benefits, including soil conservation, biodiversity conservation, and carbon sequestration.

Vertical Farming: It cultivates crops in stacked layers, usually under controlled conditions. Vertical farming can potentially increase local food production while reducing water consumption and optimising resource utilisation, making it an appealing option for Indian urban agriculture. This method can reduce the need for pesticides and herbicides while increasing crop yields and lowering transportation costs.

Hydroponics: Hydroponics is gaining traction in various Indian states as a sustainable farming method that allows for efficient water and nutrient use, year-round cultivation, and reduced dependence on traditional agricultural practices. Hydroponics involves growing plants in nutrient-rich water without soil. This approach can reduce water use, increase yields, and allow for year-round crop production. It can potentially revolutionise how we grow food in India, especially in urban areas with limited space and resources.

Renewable Energy-based: Renewable energy technologies, such as solar and wind power, can be used to power farming operations. This approach can reduce greenhouse gas emissions and dependence on fossil fuels.

Robotics and Automation-based: Robotics and automation technologies can help reduce labour costs, improve crop yields, and reduce the use of fertilisers and pesticides.

Gaps Identified in Adopting Sustainable Agriculture Development

Adopting sustainable agriculture development practices is critical to the long-term viability of the agriculture sector in India. However, several gaps have been identified in adopting sustainable agriculture practices in the country. Here are some of the significant gaps:

1. **Lack of Awareness and Knowledge:** One of the main barriers to adopting sustainable agriculture practices is farmers' lack of awareness and knowledge. Many farmers must know the benefits of sustainable agriculture practices or how to implement them effectively.

2. **Limited Access to Finance:** Sustainable agriculture practices often require significant infrastructure and technology investments. However, many tiny and marginal farmers need more access to finance to make these investments.

3. **Inadequate Policy and Regulatory Framework:** Adopting sustainable agriculture practices is not always supported by India's policy, and the regulatory framework does not always support adopting sustainable agriculture practices. For example, farmers may need more incentives to adopt sustainable practices, or regulations may prohibit certain sustainable practices. The National Mission for Sustainable Agriculture receives only 0.8% of the Ministry of Agriculture and Farmers Welfare (MoAFW) budget, indicating a significant opportunity to support sustainable agriculture further.

4. **Limited Research and Development:** There is a need for more research and development in sustainable agriculture practices that are appropriate for the Indian context. There is also a need for more investment in disseminating research findings and developing extension services to help farmers adopt these practices.

5. **Lack of Infrastructure and Technical Support:** Adopting sustainable agriculture practices often requires significant infrastructure and technical support. However, many farmers need access to these resources, particularly in remote rural areas.

6. **Low Productivity:** Agriculture in India is characterised by low productivity, a significant impediment to its growth and development. The yield per hectare for most crops in India is significantly lower than the global average, and several factors contribute to this, such as low levels of mechanisation, inadequate irrigation facilities, and poor soil health.

7. **Fragmented Landholdings:** The average landholding size in India is small, which makes it difficult for farmers to adopt modern farming techniques and technologies. Fragmented landholdings also make it difficult for farmers to access credit and other support services.

8. **Lack of Market Access:** The lack of access to markets is a significant challenge for farmers in India, tiny and marginal farmers. Many farmers are forced to sell their produce to intermediaries at low prices, as they cannot access direct markets. This results in lower incomes for farmers and higher food prices for consumers.

9. **Inadequate Infrastructure:** Inadequate infrastructure, such as rural roads, storage facilities, and cold chains, is a significant challenge for the agriculture sector in India. This makes it difficult for farmers to transport their produce to markets, store it safely, and sell it later.

10. **Climate Change:** Climate change poses significant challenges to the agriculture sector in India, particularly in terms of water availability, pest and disease management, and crop yields. The changing weather patterns, including erratic rainfall and rising temperatures, affect crop productivity and increase farmers' vulnerability.

Women are particularly susceptible. The Global Food Security Index (GFSI) score for sustainability and adaptation decreases as gender inequality increases. The GFSI demonstrates that a lack of access to fresh, clean water and land resources and a lack of political commitment to adaptation and sustainable agricultural practices are all factors associated with gender inequality. Identifying numerous additional gaps in India's agricultural sector presents severe obstacles to developing a resilient and sustainable agriculture sector. A multifaceted approach will be necessary to close these gaps, necessitating investments in R&D, regulatory and policy reforms, and creating infrastructure and extension services to encourage adopting sustainable agricultural practices. The Indian government has launched several programmes to support sustainable agricultural practices, including the Paramparagat Krishi Vikas Yojana, the Soil Health Card Scheme, the Rashtriya Krishi Vikas Yojana, the Pradhan Mantri Fasal Bima Yojana, the Pradhan Mantri Krishi Sinchayee Yojana, and the National Agriculture Market (e-NAM) platform.

Improving Dissemination of Technological Information to Farmers

Improving the dissemination of technical information to farmers is critical for adopting modern farming techniques and practices in India. According to a survey conducted by the National Sample Survey Organisation, only 6% of farmers in India have access to information on modern agricultural practices. To address this issue, the Government of India has

Farmers benefit from sustainable agriculture by preserving the environment, ensuring food security, and improving their livelihoods. Sustainable agriculture practices have the potential to boost agricultural productivity, reduce production costs, and enhance the quality of crops. It may also promote the production of healthier and safer foods, which is beneficial to public health.

launched several initiatives, such as the Kisan Call Centre and the mKisan portal, which provide farmers with information on a wide range of agricultural topics, including weather forecasting, market prices, and pest and disease management. The Kisan Call Centre had received over 21 million calls from farmers across India, indicating the importance of such initiatives in improving the dissemination of technological information to farmers.

India has had a National Mission for Sustainable Agriculture (NMSA) to promote sustainable agriculture since 2014-15. It is divided into several programmes focusing on agroforestry, rainfed areas, water and soil health management, climate impacts, and adaptation. Aside from NMSA, the Pradhan Mantri Krishi Sinchayee Yojana encourages precision farming techniques like micro-irrigation, and the Integrated Watershed Management Programme encourages rainwater harvesting.

Some Agri Tech Startup Case Studies

Sustainable agriculture is critical to agriculture's long-term viability in India. While the country has made strides towards adopting sustainable agricultural practices, there is still room for advancement. The Government, farmers, and other stakeholders must work together to promote and implement sustainable agricultural practices in the country. Finally, sustainable agriculture is critical for the agriculture sector's and the environment's long-term viability. While India has made some progress towards adopting sustainable agricultural practices, much work still needs to be done. The Government and various organisations must collaborate to promote and implement sustainable agriculture practices in the country. India can ensure food security while improving farmer livelihoods and contributing to global efforts to create a more sustainable future by implementing sustainable agriculture practices.

AgriApp Technologies Pvt. Ltd. is an IT, ICT, and IoT-enabled technology company intending to bring technology to the agriculture and food sector. We work on precision and predictive agriculture while building a strong Agri-Ecosystem to benefit farmers, the economy and ecology. AgriApp works to fill the gap between farmers and the right kind of strategic information, thus making the farmers ready for high-efficiency technology-enabled agriculture production and marketing.

Khetee promotes agroecological farming through the agroforestry model, which first sets a farmer's prosperity and the environment. Khetee has created a one-of-a-kind fellowship programme for farmers and aspiring farmers to help them build agroecological model farms. Khetee is constructing a model farm in Lakhisarai's Durdih village. Farmers from all over the state come to our farm to gain experience and knowledge. Khetee organises training programmes for farmers regularly to help them build their capacity in regenerative farming. Khetee is aiming for systemic change in how agriculture is practised, its relationship with the market, and the policies surrounding it.

Instinct Earth Aqua-Scaping Private Limited is a Private Limited Company based firm engaged as the foremost Manufacturer of Clay Ball, Indoor Vertical Plant, Artificial Potted Plant, Artificial Vertical Garden Wall, Vermicompost Fertilisers, Hydroponic Machine, etc. They are also a Service Provider of Green Wall Installation Services, Gardening Services, and Vertical Garden Landscaping Services.

Aumsat provides precision-driven, satellite-based, AI-enabled hydrological analysis for locating, predicting, and forecasting groundwater resources. Unlike conventional costly and time-consuming methods

used in groundwater exploration, Startup services can help detect groundwater zones at a high precision rate without physically being present on the field, thereby saving cost economically and logistically by 75%.

Pudhuvai Green Gas Chemicals Fertilisers Private Limited is a clean & renewable Bioenergy startup producing organic waste agri-raw materials. Methane and Hydrogen will be produced as a by-product of the process, utilised commercially to provide a green fuel. Many by-products will also be produced, namely solid and liquid Bio-fertilisers, CO_2, Sodium Silicate, Precipitated Silica & $CaCO_3$, and Monosulfur, which will be used commercially.

Sense it Out is a deep-tech startup that brings technology solutions to specific climate change problems in Agriculture. Their product SICCA (Sensor-based Intelligent Crop Centric Automation), uses indigenously developed sensor technology that makes irrigation management more competent, reliable, and efficient. It is an IoT-based solution that optimises water usage using innovative soil sensor technology and scalable LoRa technology, making it suitable for small and large farms.

Conclusion

Farmers can develop sustainable farming systems that promote environmental, social, and economic sustainability by adopting advanced technologies. However, it is essential to note that technology is not a silver bullet and must be implemented with other sustainable farming practices, such as soil conservation, crop rotation, and integrated pest management, to achieve sustainable farming systems. Farmers in India have adopted various sustainable agricultural practices to ensure agriculture's long-term sustainability. Crop rotation involves alternating crops in a specific field over time. This practice promotes soil health and fertility while decreasing the likelihood of pest infestations and diseases.

Organic farming methods are another sustainable agricultural practice. To produce crops without synthetic chemicals, organic farming relies on natural processes and techniques such as crop rotation, intercropping, and natural fertilisers. Organic farming has numerous advantages, including producing healthy and nutritious food, reducing soil erosion, and water resource conservation. When comparing India to global data, sustainable agriculture has gained much traction. According to the Food and Agriculture Organization (FAO) report, sustainable agriculture practices have increased in developed countries such as Australia, Canada, the United States, and several European nations. Furthermore, the report highlights the increasing popularity of sustainable agriculture practices in developing countries such as China, Brazil, and South Africa.

Furthermore, improved crop varieties, rainwater harvesting, and drip irrigation systems are examples of sustainable agricultural practices in India. These practices not only increase crop yields but also ensure the efficient use of natural resources. Despite adopting sustainable farming practices in India, the country faces numerous challenges in ensuring long-term sustainability. For example, indiscriminate pesticide and fertiliser use persists in many parts of the country, resulting in soil degradation and water pollution. Furthermore, climate change poses a significant threat to India's agricultural sustainability. Numerous climate-related disasters, such as floods and droughts, have occurred in the country, resulting in crop failures and the loss of livelihoods for many farmers.

Farmers benefit from sustainable agriculture by preserving the environment, ensuring food security, and improving their livelihoods. Sustainable agriculture practices have the potential to boost agricultural productivity, reduce production costs, and enhance the quality of crops. It may also promote the production of healthier and safer foods, which is beneficial to public health. ❑

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Climate Sustainable Agriculture

Agriculture in coming years and decades is sure to face formidable challenges for the simple reason that climate change and its inherent impacts are a reality now. The challenge aggravates multiple times as the world would need an increase of around 70% by 2050 in its food production to feed its ever increasing population. So, the world needs to find ways to sustainable agriculture and the answer lies in Climate Smart Agriculture (CSA).

Bhuwan Bhaskar

Multiple studies by the Indian Government and various global institutions have proved beyond any doubt that, with an increasing population, the question of food security is going to be one of the biggest challenges facing humanity. According to the Food and Agriculture Organization (FAO) data, the relative rates of increase in yield for major cereal crops are decreasing. The food security challenge will only become more difficult, as the world will need to produce about 70 per cent more food by 2050 to feed an estimated 9 billion people, while the population is projected to reach 11 billion in 2100 (UN Population Division report). Rising temperatures due to global warming have already started eating up the yield of food grains and other agricultural crops. It has been predicted that the temperature will rise 2–5°C in the future climate by 2100 (IPCC, 2014). The interesting fact about the relationship between global warming and agriculture is that they are interdependent.

Global Warming Challenge

The situation for agri-production is a two-way challenge: first, to shield the production from the

The author is a Commentator on contemporary issues related to Indian economy and agriculture.
Email: bhaskarbhuwan@gmail.com

effects of global warming, and second, to increase the production for a larger population in the years to come despite the symptoms of global warming.

It is evaluated that without the use of CO_2 fertilisation, efficient solutions, and genetic transformation, each 1°C rise in the global mean temperature reduces global maize yield by 7.4%, wheat yield by 6.0%, rice yield by 6.2%, and soybean yield by 3.1%. An increase in the average temperature of 2°C could lead to 20–40% reductions in cereal grain output, notably in Asia and Africa. The fifth assessment report (AR5) by the Intergovernmental Panel on Climate Change (IPCC, 2018) predicts that the temperature will increase by 2.5–5.8°C before 2100. With such an increase, the damage to crops can only be imagined. Numerous food crops such as rice, wheat, soybeans, maize, cotton, sorghum, and tomatoes are tremendously vulnerable to high temperatures. The maximum threshold temperature for various crops differs. However, high temperatures above 35°C can cause damage to rice crops. Evident injuries were observed due to high temperatures in different developmental stages. Recent studies have revealed that sorghum pistils and pearl millet are both similarly sensitive to high temperatures. High temperatures during grain filling have a significant effect on sunflower seeds and oil constituents. In addition, it also reduces the linoleic acid content of numerous oilseed oils. It also reduces the oil content and seed yield, and speeds up seed maturity, which influences erucic acid over seed development.

Producing crops with the least impact from deteriorating climate conditions is easier said than done. It is, in fact, a very complex process that needs a thorough overhaul of the whole production cycle in agriculture. In fact, agriculture is as much responsible for the rapid deterioration of normal weather conditions as it is for being negatively impacted by global warming. According to IPCC, 2013, agriculture, forestry, and the change of land-use, account for as much as 25% of human-induced GHG emissions. Agriculture is one of the main sources of methane and nitrous oxide emissions. Besides its contribution to global warming, farming has other detrimental effects on the environment. Agriculture is often the reason for deforestation and a change in land use, from natural ecosystems that take up and store carbon dioxide (CO_2) from the atmosphere to farmland.

So, when a 360-degree solution is envisaged for sustainable agriculture, it must also take care of saving the environment from agriculture along with saving agriculture from the environment. In other words, the world needs to find ways to sustainable agriculture and the answer lies in Climate-Smart Agriculture (CSA).

What is Climate-Smart Agriculture (CSA)

As defined by the World Bank, 'Climate-smart agriculture (CSA) is an integrated approach to managing landscapes—cropland, livestock, forests and fisheries, that address the interlinked challenges of food security and climate change.' A range of agricultural practices that transform agricultural systems to support food security in the face of climate change have been collectively known by the name CSA. Basically, the CSA targets three outcomes simultaneously:

1. Increased productivity

A 2020 World Bank report found that nearly 690 million people—or 8.9 per cent of the global population—are hungry, up by nearly 60 million from 2015 onwards. Saving this population from hunger in the first place and providing them with necessary nutrition are the two major dimensions of increasing the productivity of agricultural produce.

2. Enhanced resilience

Developing crops that could sustain extreme weather conditions like drought, flooding, etc., and sustain against pests, diseases, and other climate-related risks and shocks; and improve capacity to adapt and grow in the face of longer-term stresses like shortened seasons and erratic weather patterns are the major objectives under enhancing resilience.

3. Reduced emissions

As discussed in the above section, agriculture is responsible for global warming on a large scale. So, for climate-smart agriculture, it is imperative to find ways to reduce emissions for each kilo of food produced, avoid deforestation, and identify ways to absorb carbon out of the atmosphere.

Climate-Smart Crop Production Practices and Technologies

The Food and Agriculture Organization (FAO) says in its 2011 report that it is impossible to harvest good crops with bad seeds. Therefore, for the success of any climate-smart agriculture, it is very important to develop and follow smart management practices and technologies. These practices and technologies must be able to address the problems of production as well as emissions in agriculture. Most of these practices prevent soil damage that releases carbon and water into the atmosphere, promote soil and water conservation; and increase productivity. The Organization has laid down a fairly elaborative system of such practices and technologies to be followed by the countries for climate-smart crop production.

The varieties being bred to resist the detrimental effects of climate change should be resistant to the climate-related phenomena and should be able to thrive on limited resources so that their own regressive impact on the atmosphere could be curtailed significantly. Drought, floods, extreme heat waves, extreme cold conditions, and salinity are the most common manifestations of global warming for which crop varieties are being bred. There are other impacts too, like increasing pest attacks, higher frequencies of frosts at the seedling and/or pollination stages, high temperatures at the grain-filling stage, heavy rains that compress the soil, and alternate light rains and hot temperatures that stimulate seed germination but prevent the establishment of seedlings. Climate-smart crops have to take care of all these situations in order to secure food for the world population. But it is important to note that only developing such varieties is not enough to secure the food production for the world population or the livelihood of farmers. It needs to lay down an efficient process of the production of such seedlings on a commercial level and develop channels of distribution for them among farmers. The seed delivery system involves multiple other stages too, for example, multiplication, processing, storage, and marketing, apart from development and distribution.

Use of quality seeds and planting materials of well-adapted crops and varieties: To effectively implement a climate-smart agriculture strategy, there are some components that are recommended by FAO:

1 Conservation of plant genetic resources for food and agriculture

To address the challenges posed by climate change, there is an increasingly urgent need for the investment of greater resources and efforts in safeguarding the widest possible diversity of plant genetic resources for food and agriculture in their natural habitats, on farms and in gene banks.

2 Crop variant development

Two approaches need to be adopted for the development of climate-resistant varieties. First, the range should be as wide as possible. More diverse will be the portfolio of varieties of an extensive range of crops, more likely will be the chances for the production systems to adapt to climate change. The second approach should be to involve farmers in the process from the beginning. The farmers' perspective contributes to the decisions about which varieties are proposed for official release and registration. Participatory plant breeding is an effective way to achieve demand-driven crop improvements for adaptation to climate change.

3 Seed production and delivery

For the success of any strategy in climate-smart agriculture, the affirmative participation of the farmers is a must. To ensure the same, it is very important that the problem of global warming be seen from the farmers' livelihood perspective too. Farmers must be convinced to use climate-resistant varieties. This can only be done by gaining their trust that the new variety will meet their needs.

Biodiversity Management

All major grain crops, including maize, wheat, rice, and most other crops, are often grown in monoculture systems that require significant investments in pesticides and herbicides. Any crop variety is never found alone in one field. Carl Folke, in his 2006 research paper, successfully proved that when agricultural ecosystems are simplified, whole functional groups of species are removed, and their capacity to respond to changes and provide ecosystem services is compromised. In a

cropping system, greater diversity of crops and other living organisms is an important criterion for ensuring farm resilience, economic stability, and profitability.

Integrated Pest Management

Climate change will affect the spread and establishment of a wide range of insect pests, diseases, and weeds. Integrated Pest Management is an ecosystem approach to crop production and protection. It is based on the careful consideration of all available pest management techniques. Integrated pest management involves the use of appropriate measures to discourage the development of pest populations, and keep pesticides and other interventions to levels that are economically justified, reduce or minimise risks to human health and the environment, and disrupt the agricultural ecosystem as little as possible. The ability to make good decisions in the field is crucial for effective integrated pest management. Integrated pest management is valid in a variety of different and evolving farming conditions. Independent of how climate change will affect agricultural ecosystems, farmers who understand integrated pest management principles will be better equipped to cope with the effects of climate change and develop sound and location-specific adaptation strategies (M. Allara et al., 2012).

Improved Water Use and Management

Water is a scarce resource these days. The water table across regions is depleting, and in many areas, the groundwater has become unusable due to its salinity. The situation is going to worsen in the future with climate change phenomena. Climate change, which will increase crop evapotranspiration, change the quantity of rainfall and rainfall patterns, and lead to greater variations in river runoff and groundwater recharge, will affect both rainfed and irrigated agriculture. The impacts of climate change on water resources used for agriculture must be situated in a wider context. Responses to address these impacts need to consider the other pressures that are affecting water resources, such as the increasing demand and competition for water by all sectors and the degradation of water quality. So, to achieve sustainability in agriculture, water resource management comes on top. This can be achieved through measures that conserve soil and water, with deficit irrigation that can maximise crop yields per volume of water applied; and/or more efficient irrigation technologies that can reduce unproductive evaporation losses. The integration of climate change into the planning and design of investments can considerably reduce the risks to the water infrastructure used for agriculture.

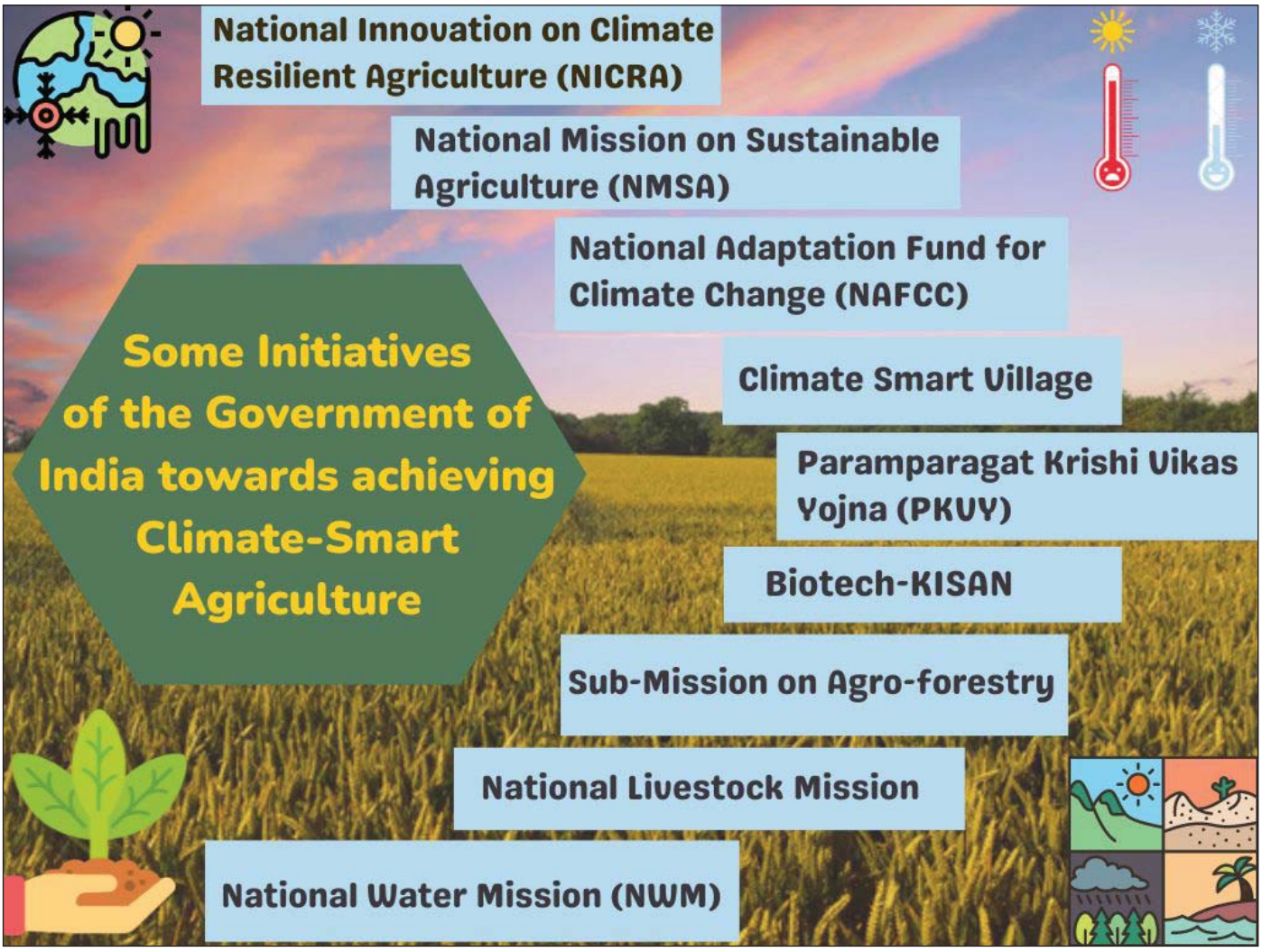
Sustainable Soil and Land Management

Integrated landscape planning and management are instrumental for achieving climate-smart agriculture. It is an umbrella for natural resource management that recognises the value of various ecosystem services to multiple stakeholders, and the different values that can lead stakeholders to pursue different land-use objectives or livelihood strategies. Soil protection can be achieved by practising direct seeding in combination with the sustainable management of crop residues within a broader framework of integrated soil fertility management. The most cost-effective management strategies for sustainable intensification of crop production involve achieving a balanced cycling of nutrients through the production system and protecting the soil on the field. Nutrient cycling refers to the movement and exchange of organic and inorganic matter into the production of crops.

Sustainable Mechanisation

The availability of appropriate machinery to carry out sustainable crop management practices increases productivity per unit of land. It also increases efficiency in the various production and processing operations and in the production, extraction, and transport of agricultural inputs, including coal and oil. Tractor-operated tillage is the single most energy-consuming operation in crop production. Using smaller tractors, making fewer passes across the field, and reducing working hours, when combined with conservation agriculture, reduce carbon dioxide emissions, minimise soil disturbance, and curtail soil erosion and degradation that are common in tillage-based crop systems (Lal, 2016). The timely availability of agricultural equipment, such as drills, harvesters, and threshers, permits producers to plant, harvest, and process crops in an efficient manner. This increases yields and reduces post-harvest losses. Precision farming equipment, along with controlled release and deep placement technologies, make it possible to accurately match production inputs with plant needs. This improves efficiency in the use of inputs and reduces direct and indirect greenhouse gas emissions.

Climate Smart Agriculture in India



In India, the countrywide decline in major crop yields due to climate change effects between 2010 and 2039 could be as high as 9%, worsening further with time. The loss can be up to 35% for rice, 20 per cent for wheat, 50% for sorghum, 13% for barley, and 60% for maize, depending on the location and future climatic scenario, according to a reference note uploaded on the Loksabha website. The Productivity of most crops is likely to decrease 10-40% by 2100 due to increase in temperature, rainfall variability, and decreases in irrigation water. The major impacts of climate change will be on rainfed or un-irrigated crops, which are cultivated on nearly 60% of cropland. A temperature rise of 0.5 degree Celsius in winter is projected to reduce rainfed wheat yield by 0.45 tonnes per hectare in India. The Government of India's economic survey (2018) estimated that the annual loss of US$ 9-10 billion was due to the adverse effects of climate change.

To mitigate the impending impact, the Government has taken many initiatives, some of which are as follows: *(source: reference note from Parliament Library And Reference, Research, Documentation And Information Service):*

National Innovation on Climate Resilient Agriculture (NICRA): This is a network project of the Indian Council of Agricultural Research (ICAR) launched in February 2011 with an outlay of Rs. 350 crore. The project aims to enhance the resilience of Indian agriculture, covering crops, livestock, and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies.

National Mission on Sustainable Agriculture (NMSA): The Government is implementing the National Action Plan on Climate Change (NAPCC) which provides the overarching framework for climate actions, through

national missions in specific areas. The NMSA works through adoption of sustainable development pathway by progressively shifting to environment friendly technologies, adoption of energy efficient equipments, conservation of natural resources, integrated farming, etc. Besides, the NMSA aims at promoting location-specific improved agronomic practices through soil health management, enhanced water use efficiency, judicious use of chemicals, and crop diversification.

National Adaptation Fund for Climate Change (NAFCC): It was established to meet the cost of adaptation to climate change for the State and Union Territories of India that are particularly vulnerable to the adverse effects of climate change. This Scheme was implemented during 2015-16 mainly for supporting concrete adaptation activities dealing with mitigating the adverse effects of global climate change in various sectors including agriculture. Under the NAFCC, various projects have been sanctioned in different states, i.e., Punjab, Himachal Pradesh, Odisha, Manipur, Tamil Nadu, Kerala, Mizoram, Chhattisgarh, J&K, Meghalaya, Telangana, Andhra Pradesh, etc.

Climate Smart Village (CSV): It is an institutional approach to test, implement, modify, and promote CSA at the local level and to enhance farmers' abilities to adapt to climate change. CSVs were piloted in two states of India: Karnal district of Haryana state and Vaishali district of Bihar state, which later spread into the districts of Punjab, Andhra Pradesh, and Karnataka.

Paramparagat Krishi Vikas Yojna (PKVY): It is an extended component of Soil Health Management (SHM) launched in 2015 under NMSA with the objective of supporting and promoting organic farming through adoption of organic village by cluster approach, which in turn results in improvement of soil health.

Biotech-KISAN: It is a scientist-farmer partnership scheme launched in 2017 for agriculture innovation with an objective to connect science laboratories with the farmers to find out innovative solutions and technologies to be applied at farm level. Under this scheme, so far 146 Biotech-KISAN Hubs have been established covering all 15 agroclimatic zones and 110 aspirational districts in the country.

Sub-Mission on Agro-forestry: This Mission was launched during 2016-17 with the objective of planting trees on farm bunds. Agro-forestry has the potential to bring sustainability in agriculture and also achieving the optimum productivity by mitigating the impact of climate change.

National Livestock Mission: This Mission was initiated by the Ministry of Agriculture and Farmers' Welfare and got commenced from 2014-15 focusing mainly on livestock development through sustainable approach ultimately protecting the natural environment, ensuring bio-security, conserving animal bio-diversity and farmers' livelihood.

National Water Mission (NWM): A Mission was launched to ensure Integrated Water Resource Management (IWRM) for conserving the water sources and minimising its wastage and to optimise Water Use Efficiency (WUE) by 20 per cent including agriculture sector.

The Government of India has aggressively embarked upon the process of evaluating the climate change impact on agriculture supplemented by strong interventions. District-level risk assessment of the Indian agriculture to climate change (572 rural districts) have been prepared. ICAR along with NARS has developed District Agriculture Contingency Plans for 650 districts in India and is being updated regularly. Climate-resilient villages have been developed, one in each of 151 climatically vulnerable districts under the NICRA Project and location-specific technologies have been demonstrated in these districts. The fertiliser policies in India have grown positively by enhancing crop production and productivity. The additional food grain production of 13.66 Mt using fertilisers avoided the conversion of 11.48 million hectares of forest land to cropland, thereby, reducing 2013 Mt of GHGs emissions. Neem coated urea has also reduced fertiliser input cost, improved nutrient use efficiency and reduced GHGs from fertiliser nutrient sources. There has been a sincere effort to promote Zero Budget Natural farming (ZBNF) across India. It offers a commercially viable and environment friendly alternative and offer better climatic adaptation compared to conventional agriculture. Area under agro-forestry is on upward trend towards more carbon fixation and reduced GHGs. ❑

Dryland Farming

Dryland farming is challenging with many constraints, but with the understanding of local climate and soil conditions, the selection of suitable crops, and the use of appropriate technologies, dryland farmers can produce bountiful crops even in the driest conditions. By adopting a suitable integrated farming model, dryland farmers can grow multiple crops in a single season with extra horticultural or livestock production.

Dr. Jagdeep Saxena

India is a land of great variability in climatic conditions and patterns due to its unique geographical location. Hence, characteristically different farming systems and cropping patterns evolved in different agro-climatic zones of the country. Dryland farming is one such practice which has assumed especial importance in view of the looming crisis of global warming and climate change. In recent years, dryland farming has emerged as a prominent path to ensure sustainable food security despite an increasing population and growing pressure on natural resources. Dryland farming refers to the cultivation of crops under natural rainfall conditions without or very scanty irrigation. Dryland areas are characterised by low rainfall within a range of 375 mm to 1125 mm, which are unevenly distributed, highly erratic, and uncertain. The dependency on rainfall makes these areas less productive and economically fragile, increasing their vulnerability to environmental stresses and shocks. These areas have generally poor or degraded soils with

The author is a Former Chief Editor, Indian Council of Agricultural Research. Email: jagdeepsaxena@yahoo.com

low water holding capacities and multiple nutrient deficiencies. The distribution of rainfall during the crop period is usually lopsided, with crops receiving a high amount of rain when it is not required and lack of it when they need it most. Dryland areas are often more prone to drought and drought-like conditions due to poor and weak structure of soil and depleting ground water tables. When monsoon sets in late, the sowing of crops is delayed resulting in poor yields. Similarly, when monsoon rains retract early, the crop is exposed to drought-like condition during critical stages of growth, which reduces crop yields. The soils of drylands are generally deficient in major nutrients such as nitrogen and phosphorus. Thus, in common parlance, drylands are not only thirsty but hungry as well! Huge variations in temperature not only affect crop growth and yields but also deteriorate quality of produce in most of the cases. In dryland areas, land holdings are generally small (less than two hectares), fragmented, and scattered, which makes farming less remunerative and difficult as well. Further, frequent crop failures coupled with a lack of market facilities and weak infrastructure ultimately lead to poor economic conditions of farmers. Agrarian distress is very common in dryland areas.

Distribution and Contributions

In India, terms like dry farming, dryland farming, and rainfed farming are often used interchangeably, but technically they are a bit different depending on the quantum of rainfall. Dry farming is practised in areas where the annual rainfall is less than 750 mm and the crop growing season is less than 200 days. It is generally practised in arid regions of the country. Cultivation receiving rainfall in the range of 750 mm to 1150 mm is known as 'dryland farming'. Crops in areas of semi-arid regions of the country are included under this category. Rainfed farming is a practice of crop cultivation without irrigation in areas receiving rainfall in the range of around 1150 mm. Most of its cultivation area falls in the humid and sub-humid regions of the country. In all these areas, irrigation facilities do not exist, and even protective or life saving irrigation is not possible. As per estimates, nearly 40 per cent of the net sown area in India will remain rainfed even after realising the full potential of irrigation. Of the 141 million hectares of estimated crop area in the country, close to 80 million hectares is under dryland farming, which is 52 per cent of the total cultivated land. Despite struggling with issues of scanty resources, environmental stress, and low productivity, the dryland agriculture is producing nearly 44 per cent of the total food grains in the country.

Geographically, dryland agriculture area in India includes the north western Rajasthan, the plateau region of central India, the alluvial plains of Ganga-Yamuna river basin, the central highlands of Gujarat, Maharashtra, and Madhya Pradesh, the shadow regions of Deccan in Maharashtra, the Deccan Plateau of Andhra Pradesh, and the Tamil Nadu highlands. However, the area under drylands is currently showing a declining trend and is expected to be stabilised by 2050 at around 75 million hectares. Globally, nearly 41 per cent of the earth's land surface is covered by drylands, of which 72 per cent are in the developing world and the rest, 28 per cent fall in developed / industrialised nations. Various definitions and criteria float around as estimates of the extent and intensity of rainfed areas in the country.

A recent report of the National Rainfed Area Authority (2020) identified and categorised 168 districts as 'very high' rainfed districts requiring interventions of drought-proofing on an urgent basis. Another 168 districts are categorised as high, 167 as medium, and 167 as low rainfed districts. In total, NRAA categorised 670 districts on an all India basis, of which 11 states have a high share of rainfed areas. These states are Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, and Uttar Pradesh. The estimates of rainfed areas vary significantly across the states. There are a few states which have a higher rainfed area as percentage of their net cropped area; so naturally, these are the states that suffer from vagaries of droughts with more than 20 per cent probability. There are 10 states that have more than 40 per cent of their net sown area under rainfed conditions. Among these, Assam comes under assured rainfall zone (2,579 mm per year), but has 87 per cent of its net sown area as rain dependent, and so is the case with Odisha. The rest of states have a large share of net sown area under rainfed conditions. States like Maharashtra, Karnataka, Andhra Pradesh, Gujarat, and Rajasthan are the most climatically vulnerable regions.

Despite various developmental efforts, agriculture remains the mainstay of the economy in dryland areas. Hence, the Government of India has launched many

schemes and programmes to increase per hectare productivity, production, and marketing facilities, along with the development of infrastructure. There is a vast scope to increase the productivity of dryland agriculture from the current average of 1.2 tonnes per hectare to 2.0 tonnes per hectare. According to experts, this potential can easily be achieved by inclusion of new technologies, diversification of crops, adoption of drought-tolerant varieties, and implementation of moisture retention techniques in the field.

Major dry farming crops include millets, now called nutri-cereals, oilseeds, pulses, maize, cereals, and cotton. Sorghum (Jowar), Pearl Millet (Bajra), and Finger Millet (Ragi) are most commonly grown millets in drylands, while other millet species are also cultivated across rainfed areas. Almost 80 per cent of Sorghum and Maize, 90 per cent of Pearl millet, 75 per cent of oilseeds, and approximately 95 per cent of pulses are obtained from dryland agriculture. Contributions to wheat and rice production are also important, because 33 per cent of wheat and 66 per cent of rice are still rainfed. Apart from contributing to food security, drylands also give a boost to the textile sector by contributing more than 70 per cent cotton to industries. Millets are traditional and staple crops of dryland, and they are the most popular due to their specific attributes which suit these regions. Millets, now also called *Shri Anna* are annual, short-duration (75 to 120 days) rainfed crops that grow well on shallow, low-fertility soils. Millets have a very low water requirement and can be grown even under extremely high temperatures and low rainfall. These crops are resistant to drought, resistant to most pests and diseases, and need minimum care. In nutshell, millets are eco-friendly and climate resilient crops. In the continuing 'International year of Millets', the Government of India is promoting and supporting production, processing, marketing, and export of millets and millet products, which will further help expansion of millets in rainfed regions. Marginal lands in rainfed regions offer potential for fodder production to feed the cattle population, which is an integral component of the farming ecosystem in arid regions.

Oilseeds are major crops in rainfed regions, grown mainly with low levels of input usage. Oilseed crops are mostly cultivated on marginal lands by resource-poor small farmers in biotically stressed conditions. This results in low productivity, poor quality and lower profit margins to farmers. To improve the condition, the latest production technologies and drought-tolerant varieties were introduced in drylands under a special programme on mustard and rapeseed during Rabi season. Consequently, India has registered a compound annual growth rate of 7.7 per cent in vegetable oil production from 2015-16 to 2020-21. The improvement in production of oilseeds in rainfed regions will save valuable foreign exchange reserves, as India is still importing oilseeds to meet domestic demand. The dryland pulses help the small holder farmers in arid and semi-arid regions withstand weather variability. Pulses are also called climate smart crops because they require less water' survive weather fluctuations, improve soil health and provide more nutrition per drop. Pulses in rainfed regions are ideal for on-farm diversification. As an intercrop with cereals and other crops, pulses bring in extra income for farmers and at the same time increase the yield of the main crop. To enhance the production and productivity of cotton in rainfed regions, several improved varieties have been developed exclusively for drylands, along with their own customised production technologies.

The introduction of crop diversification and integrated farming systems in dryland regions has brought many changes in terms of area and yield. The area which was initially under Pearl Millet and Sorghum was replaced by more remunerative crops. A shift of pulse growing area from one agro-climatic zone to another was recorded due to many climatic and socio-economic factors. The area under Cotton and Maize increased drastically, mainly due to the increased irrigation facilities provided for these crops.

Strategies and Schemes

Dryland farming is characterised by long spells of drought, high temperatures, and other climatic adversities which can lead to partial or complete crop failure. To mitigate the risk of crop failure, scientists have developed various techniques, which are being extended and demonstrated to farmers for quick adoption. Agronomic approaches have been developed basically to conserve soil and water, in

order to achieve maximum productivity. Selection of proper cropping system suitable to the area is one of the key strategies in drylands, which becomes more remunerative with proper management of sowing time. Similarly, proper tillage, fertiliser management, proper weed control, and adoption of plant protection measures also contribute towards enhancing productivity. The selection of drought-tolerant or resistant varieties is another key technique as these varieties can withstand long periods of drought better than other varieties. Improvement of soil condition can be achieved by planting cover crops which are known to slow erosion, improve soil health, enhance water availability, help control pests and diseases, and bring a host of other benefits as well. Cover crops are plants that are planted to cover the soil rather than for the purpose of being harvested. There are evidences that growing cover crops increases resilience in the face of drought conditions and erratic rainfall.

Mulching is a common dryland technique to conserve moisture in the soil by preventing evaporation. Mulch is a material, generally straw, leaves, or plastic, that is spread over the soil's surface to prevent its natural exposure to sunlight. Mulch also helps to keep the roots of plants cooler, which can help them survive during periods of drought. Shelterbelts and windbreaks are other common water conservation techniques prevalent in dryland farming. These are rows of trees and shrubs planted on the ridge or around the field to provide wind. They not only help reduce evaporation but also protect crops from damage by strong winds. Weed control is an important strategy in dryland farming because, if left unchecked, weeds can compete with crops for water. Crop rotation in the field on a yearly basis helps prevent soil depletion and maintain fertility. Deep tillage and contour ploughing allow water to penetrate deeper into the ground. Some engineering approaches, such as contouring and compartmental bunding, preserve moisture and prevent soil erosion in dryland areas. Check dams and farm ponds are common water harvesting structures in rainfed regions that help provide life-saving irrigation during long dry spells.

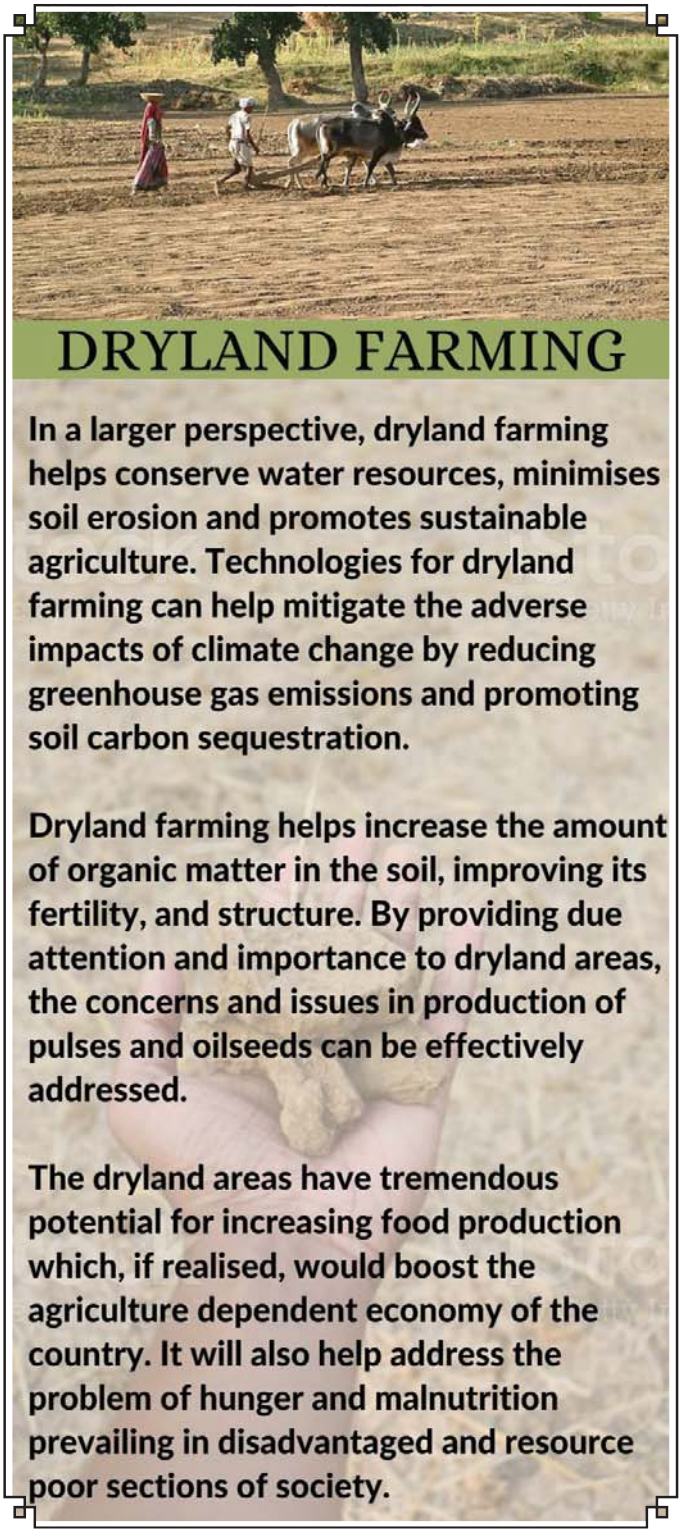
The success story of appropriate strategies, technologies, and innovations dates back to 1950s when the Government of India realised the significant role of dryland agriculture in Indian food production system; and decided to improve stability and productivity of drylands through R&D efforts. Various R&D centres at different dryland locations initiated work for developing appropriate soil and water conservation practices. Later, in 1970, the Indian Council of Agricultural Research (ICAR) launched the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) at Hyderabad, with 23 cooperating centres spread across the country. It marked the beginning of an era of location specific adaptive research in dryland agriculture. To further strengthen basic and adaptive research, ICAR established Central Research Institute for Dryland Agriculture (CRIDA) at Hyderabad in 1985. Since then, India has not looked back. Over the years, CRIDA has played a pioneering role in developing and disseminating improved rainfed farming technologies in different agro ecological regions of the county. Large number of technologies in rainwater management, watershed development, soil health management, cropping systems, etc., have been implemented in fields with impressive success rates. However, increasing climatic variability and climate change posed new challenges to dryland agriculture, which necessitated the development of adaptation and mitigation strategies. The ICAR launched a flagship network project called the National Innovations in Climate Resilient Agriculture (NICRA), primarily to develop and promote climate-resilient technologies in agriculture with a special focus on rainfed regions. The project also aims to address vulnerable areas of the country and help districts and regions prone to extreme weather conditions, most notably droughts, high temperatures, and heat waves. The NICRA project has developed several climate-resilient technologies which include climate resilient varieties of different crops, resilient intercropping systems, crop diversification with alternate crops, agro forestry systems, in-situ moisture conservation, farm pond, integrated framing systems, etc. Such technologies have been developed and popularised for wider adoption in various fields. Agricultural contingency plans for 650 districts have been made available online for policy makers to take decisions in the event of delayed monsoons and other extreme weather events. Climate resilient technologies are being demonstrated on farmers' fields in 151 clusters covering 446 villages.

The Government of India is implementing a scheme on rainfed area development under the National Mission for Sustainable Agriculture. The scheme focuses on integrated farming systems for enhancing productivity and minimising risks associated with climatic variability. Under this system, crops / cropping systems are integrated with activities such as horticulture, livestock, fishery, agro-forestry, apiculture, etc. The scheme aims to cover an area of 6.74 lakh hectare with appropriate and location-specific Integrated Farming Systems. Schemes such as Per Drop More Crop, Soil Health Card and the Paramparagat Krishi Vikas Yojana are also contributing in the improvement of dryland agriculture through their own components.

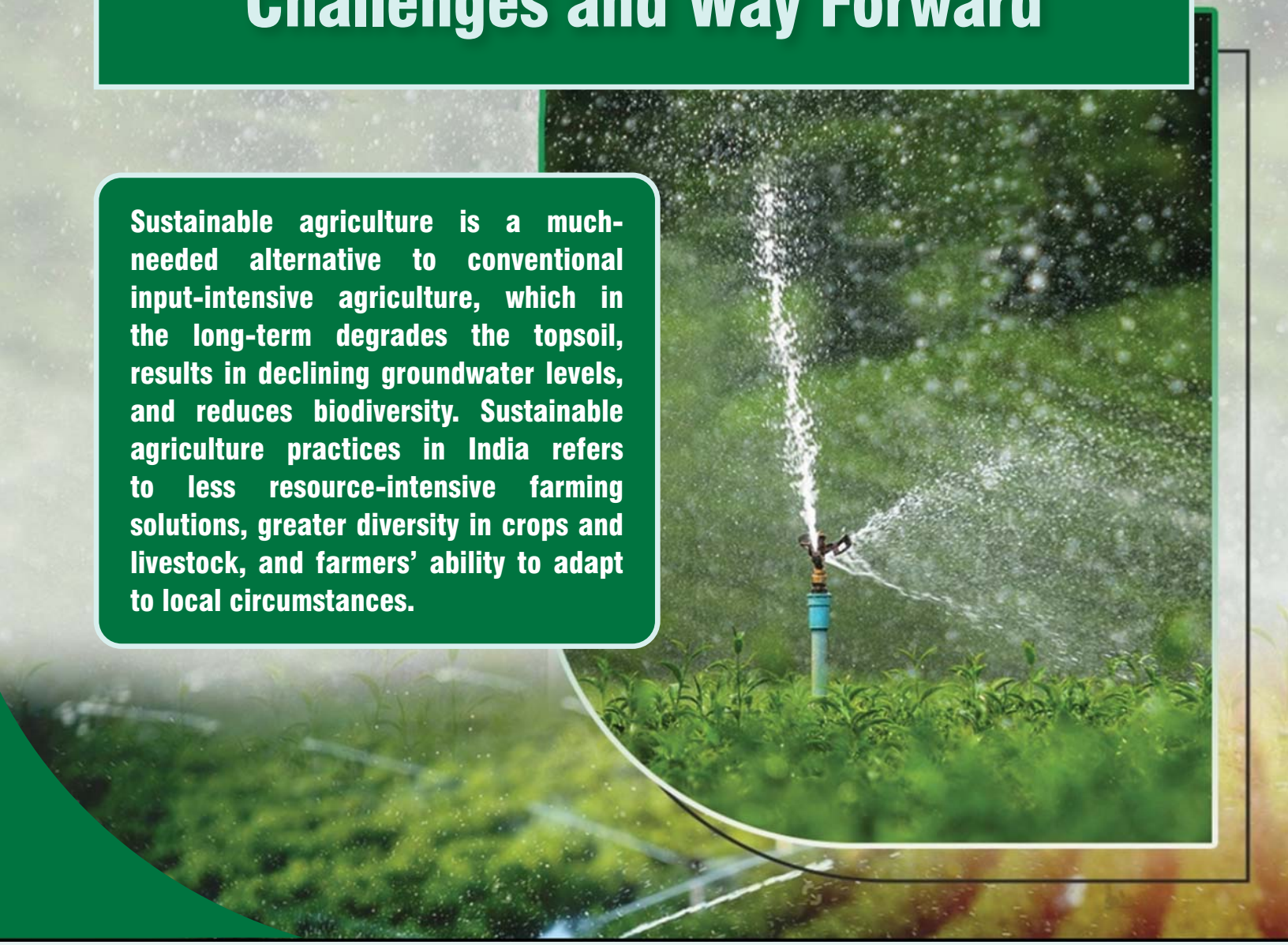
Way Forward

CRIDA has developed 'The Vision 2050', which outlines the future scenario, new and emerging challenges, the strength of the existing network, and strategies to meet short and long term goals. Location-specific research and its efficient delivery will be guiding principles to bring sustainability to the dryland agriculture system. The primary focus may be laid on rainwater harvesting and soil health management through intensive efforts and scaling up successful field experiences. Integrated farming modules for different production environments must be attempted on a priority basis for the risk-proofing of small and marginal farmers. As per the vision, cutting edge technologies such as remote sensing and GIS (Geographic Information System) applications will be exploited for natural resource characterisation and land-use planning. Nanotechnology based products and processes will also be developed for application in dryland agriculture. Several research strategies for improving resource efficiency in rainfed areas will be demonstrated on a large scale. Small farm mechanisation is another important area in this regard that needs early attention and addressal due to uneven monsoon patterns, drudgery, and an acute shortage of labour for agricultural operations. Energy efficiency and management, in conjunction with precision agriculture, need to be implemented in dryland areas for better productivity and profitability. In this regard, the use of solar power and other renewable sources needs to be promoted in dryland regions.

Dryland farming is challenging with many constraints, but with the understanding of local climate and soil conditions, the selection of suitable crops, and the use of appropriate technologies, dryland farmers can produce bountiful crops even in the driest conditions. By adopting a suitable integrated farming model, dryland farmers can grow multiple crops in a single season with extra horticultural or livestock production. ❑



Sustainable Agriculture
Challenges and Way Forward



Sustainable agriculture is a much-needed alternative to conventional input-intensive agriculture, which in the long-term degrades the topsoil, results in declining groundwater levels, and reduces biodiversity. Sustainable agriculture practices in India refers to less resource-intensive farming solutions, greater diversity in crops and livestock, and farmers' ability to adapt to local circumstances.

Dr. Namrata Singh Panwar

In the era of extreme fitness consciousness, the popularity of organic food is at its peak right now. The major organic food brands claim that they follow sustainable agriculture practices (SAPs) to grow healthy crops that ensure a chemical-contamination-free diet for the people. But here it is very important to understand that SAPs are not mere marketing techniques; they are the only solution in the world for the sustainable and healthy growth of future generations.

Sustainable agriculture is the type of agricultural practice that focuses on the moderate utilisation of unreplenishable resources while keeping nature and future generations in mind. This concept advocates switching to renewable energy sources, sparing land

The author is working as Assistant Professor Economics with the Government of Uttarakhand and previously worked as consultant in NITI Aayog. Email: panwar.namrata@gmail.com

use, and eliminating pollution from nature . According to the definition of FAO-

"Sustainable agricultural development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such development conserves land, water, plant, and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable"

According to this definition, sustainable agriculture practices have five major principles:

Therefore, for the successful application of sustainable agriculture practices in any country, the administration of that country should be open enough to embrace these five principles.

Apart from these principles, Sustainable agriculture practices are based on three basic pillars:

- **Economy:** This ensures the growth and profitability of the business for the farmers through the efficient use of viable resources.
- **Society:** This pillar ensures enough food for the world's growing population and fair employment and compensation opportunities for the local community.
- **Environment:** This pillar ensures the environment's protection through ecologically sound farming practices and less use of replenishable resources.

Thus, in order to assure the benefits of such practices, proper coordination among these pillars is highly necessary. In the absence of any of these pillars, the community will not be able to successfully implement these practices in the practical arena. But now, the question is, why will the community want to use these practices, and what are the benefits of these practices?

It is widely known that the current agricultural practices may have increased our yield but they are not at all sustainable. They are harsh on the land, endanger the local species, and pollute the water and air resources. Therefore, they cannot be the long-term solution for the food requirements of our increasing population. Hence, sustainable agriculture practices are our only way out.

These practices protect natural ecosystems, help in maintaining soil integrity by preventing soil erosion and nutrient depletion, support biodiversity and create close-to-natural conditions for livestock, reduce water pollution and air contamination, and save non-renewable resources.

On the economic front, these practices ensure food security in the long run by increasing production in a sustainable manner, decreasing the burden on the farmer by reducing the cost of production, and making them self-reliant by reducing their dependency on fossil fuels.

As far as society is concerned, they promote equality as they are less expensive in comparison to other agricultural practices. They are also a boon for general public health as the implementation of these practices results in less chemical contamination, healthier crops, and minimised environmental pollution.

Some Major Sustainable Agriculture Practices:

- **Crop Rotation and Crop Diversity:** Crop Rotation is basically ditching the practice of monoculture, which degrades the soil and makes the yield more susceptible to pests. Planting a variety of crops can have many benefits, including healthier soil and improved pest control. Crop diversity practices include intercropping and complex multiyear crop rotations.
- **Water and Energy-efficient Irrigation Techniques:** Sustainable water use in agriculture is carried out through planting less water-consuming crop species and implementing smart irrigation

techniques. For example, drip irrigation practice is much more water efficient than flood irrigation. Also, the use of solar power in pumping the water can reduce the dependence of farmers on petroleum and diesel.

- **Reducing or Eliminating Tillage:** Traditional ploughing prepares fields for planting and prevents weed problems, but it can cause soil loss. No-till or reduced-till methods, which involve inserting seeds directly into undisturbed soil, can reduce erosion and improve soil health.
- **Integrating Livestock and Crops:** The proper integration of crops and livestock serves two purposes: livestock can feed on the by-products of the farms, and crops can receive abundantly rich natural fertiliser and manure. A vast number of studies have proved that smart integration of crop and animal production can make farms more efficient and profitable.
- **Adopting Agroforestry:** Planting trees along with the crops not only conserves the soil cover and local water resources but also provides an additional source of income to the farmers.
- **Grow the Cover Crops:** By sowing cover crops off-season, farmers can protect their fields from soil erosion and soil degradation. These cover crops can build up organic matter, which acts as green manure for the crops and thus reduces the expenditure on fertilisers. Besides, cover cropping tackles weeds and retains soil moisture. Flowering cover crops naturally support the populations of bees and other pollinators and also act as an additional source of income for farmers.
- **Integrated Pest Management system:** This system aims at long-term protection of crop cover on farms by mitigating pest attacks. It reduces pest infestations by applying different agronomic techniques, which may include crop rotation, planting pest-resistant species, or pre-treated seeds. The major benefits of this system are reducing the exposure of farmers to chemicals, saving soil from harsh elements like pesticides, and, reducing water, air, and soil pollution.
- Other methods include urban agriculture, polyculture, biofuels, etc.

Sustainable Agriculture and Use of Technology

Technological development and the rate of innovation have always influenced the stability and sustainability of agricultural production. Technology in the field of agriculture has affected the productivity of agriculture and thus acts as the backbone of sustainable agriculture. Technological advancement in agriculture involves-

- Development of nutrients,
- Development of Pest control methods,
- Development of agriculture-related machinery and equipment,
- Development of genetically modified crops providing greater nutritional efficiency (more calories per yield, or more yield),
- Manipulation of natural pest control agents,
- Discovering efficient farm management techniques that focus on whole-farm productivity over time,
- The use of computational technology, combined with geographical location devices and remote sensing advancements will help the genetically modified seeds provide site-specific solutions,
- The Use of environment modelling along with risk management algorithms will assist farmers in combating the uncertainties related to drought, floods, etc.

Thus, in short, we can say that technologies not only help in monitoring the ongoing farm process but also help in managing the future of crops. Sustainability includes achieving continuous food production, the welfare of food producers, and the preservation of nonrenewable resources. Technology is the only link that can really connect all three objectives together.

Sustainable Agriculture in India: Facts, the National Mission for Sustainable Agriculture, Challenges and Recommendations-

Sustainable agriculture is a much-needed alternative to conventional input-intensive agriculture, which in the long-term degrades the topsoil, results in declining groundwater levels, and reduces biodiversity. It is vital to ensure India's nutrition security in a climate-constrained world.

Sustainable agriculture practices in India refers to less resource-intensive farming solutions, greater diversity in crops and livestock, and farmers' ability to adapt to local circumstances. But still in India, the coverage of Sustainable Agriculture practices is very low. According to resources,

- Only 5 (crop rotation; agroforestry; rainwater harvesting; mulching and precision) Sustainable Agriculture practices scale beyond 5 per cent of the net sown area.
- Most SAPs are being adopted by less than five million (or four per cent) of all Indian farmers. Many are practiced by less than one per cent.
- Crop rotation is the most popular SAPs in India, covering around 30 million hectares (Mha) of land and approximately 15 million farmers.
- Agroforestry, mainly popular among large cultivators, and rainwater harvesting have relatively high coverage - 25 Mha and 20-27 Mha, respectively.
- Organic farming currently covers only 2.8 Mha — or 2% of India's net sown area of 140 Mha.
- Natural farming is India's fastest-growing sustainable agricultural practice and has been adopted by around 800,000 farmers.
- Integrated Pest Management (IPM) has achieved a coverage area of 5 Mha after decades of sustained promotion.
- The impact and coverage of practices like floating farming, permaculture, etc. is insignificant.

Therefore, in order to increase the coverage of SAPs, in 2014-15, the Government of India launched the National Mission for Sustainable Agriculture. This has been formulated for enhancing agricultural productivity, especially in rainfed areas focusing on integrated farming, water use efficiency, soil health management, and synergising resource conservation. The main objective of the mission are-

1. To make agriculture more productive, sustainable, remunerative, and climate resilient by promoting location-specific Integrated/Composite Farming Systems.
2. To adopt comprehensive soil health management practices based on soil fertility maps, soil test-based application of macro & micro nutrients, judicious use of fertilisers, etc.
3. To optimise utilisation of water resources through efficient water management to expand coverage for achieving 'More Crop Per Drop'.
4. To develop capacity of farmers & stakeholders, in conjunction with other on-going Missions e.g. the National Mission on Agriculture Extension & Technology, the National Food Security Mission, the National Initiative for Climate Resilient Agriculture (NICRA), etc., in the domain of climate change adaptation and mitigation measures.
5. To pilot models in select blocks for improving the productivity of rainfed farming by mainstreaming rainfed technologies and by leveraging resources from other schemes/Missions like the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), Integrated Watershed Management Programme (IWMP), Rashtriya Krishi Vikas Yojana (RKVY), etc.

Based on the above objectives, NMSA has been divided into 4 major components-

1. **Rainfed Area Development (RAD)-** It develops an area-based approach for the development and conservation of natural resources along with farming systems and thus implements practices that will regulate soil nutrients based on soil health cards, and the development of farming lands. Under it, new property resources are developed which would be common, like a bank for grains, fodder, shredders for biomass, and a combined marketing initiative.

2. **On-Farm Water Management (OFWM)-** The primary focus of this is the optimum utilisation of water by promoting advanced on-farm water conservation equipment and technologies. It emphasises efficient harvesting and management of rainwater.

3. **Soil Health Management-** It promotes sustainable practices that preserve the health of soil based on a specific location and the type of crops that could be grown in those locations with the help of various techniques like management of residue, organic farming by making new maps with details on soil fertility and linking them with macro- and micro-management of nutrients, optimum land use, the right utilisation of fertilisers, and reducing the degradation and erosion of soil.

Despite all these efforts, the coverage of Sustainable Agriculture Practices has improved very little. Some of the major challenges/ roadblocks faced are-

- The budgetary allocation to NMSA is less. It is only 0.8 per cent of the Ministry of Agriculture and Farmers' Welfare's total budget.
- Most of the SAPs are knowledge-intensive techniques whose proper adoption requires proper knowledge exchange among the segregated Indian farmers.
- Capacity building among the different types of farmers is again the major challenge faced by government authorities. According to reports, the civil society organisations that can help in capacity building are concentrated cumulated mainly in three states- Maharashtra, Rajasthan, and Madhya Pradesh.
- SAPs are not protected by any set of guidelines or policies from the Government. Out of all, only organic farming can gain some attention from policymakers.
- Since SAPs are niche, the mechanisation for various input preparations, weed removal, or even harvesting in a mixed cropping field is not mainstream yet. Hence, SAPs are labour-intensive, which may hinder their adoption by medium to large farmers.
- The awareness is low among farmers around climate-resilient farm practices. Farmers don't want to know how their action can affect climate conditions, but they want to know how the adoption of SAPs can benefit them.

Based on the above context, some key recommendations for the successful adoption of sustainable agriculture practices in India are-

Rainfed areas should be focused on as the area of primary gain because they are already performing low-resource agriculture.

Authorities should prepare the full taxonomy for sustainable agriculture in India. It includes policies, guidelines, and legal frameworks.

Proper focus should be kept on knowledge exchange and capacity building among farmers and agriculture extension workers.

Authorities should extend short-term transition support to farmers liable to be adversely impacted by a large-scale transition to sustainable agriculture.

Financial support should be provided for research in the field of sustainable agriculture.

Use of technology in this field in India is negligible. In order to support the formalisation of agrotech, a proper system should be made for the leveraging of data and technology.

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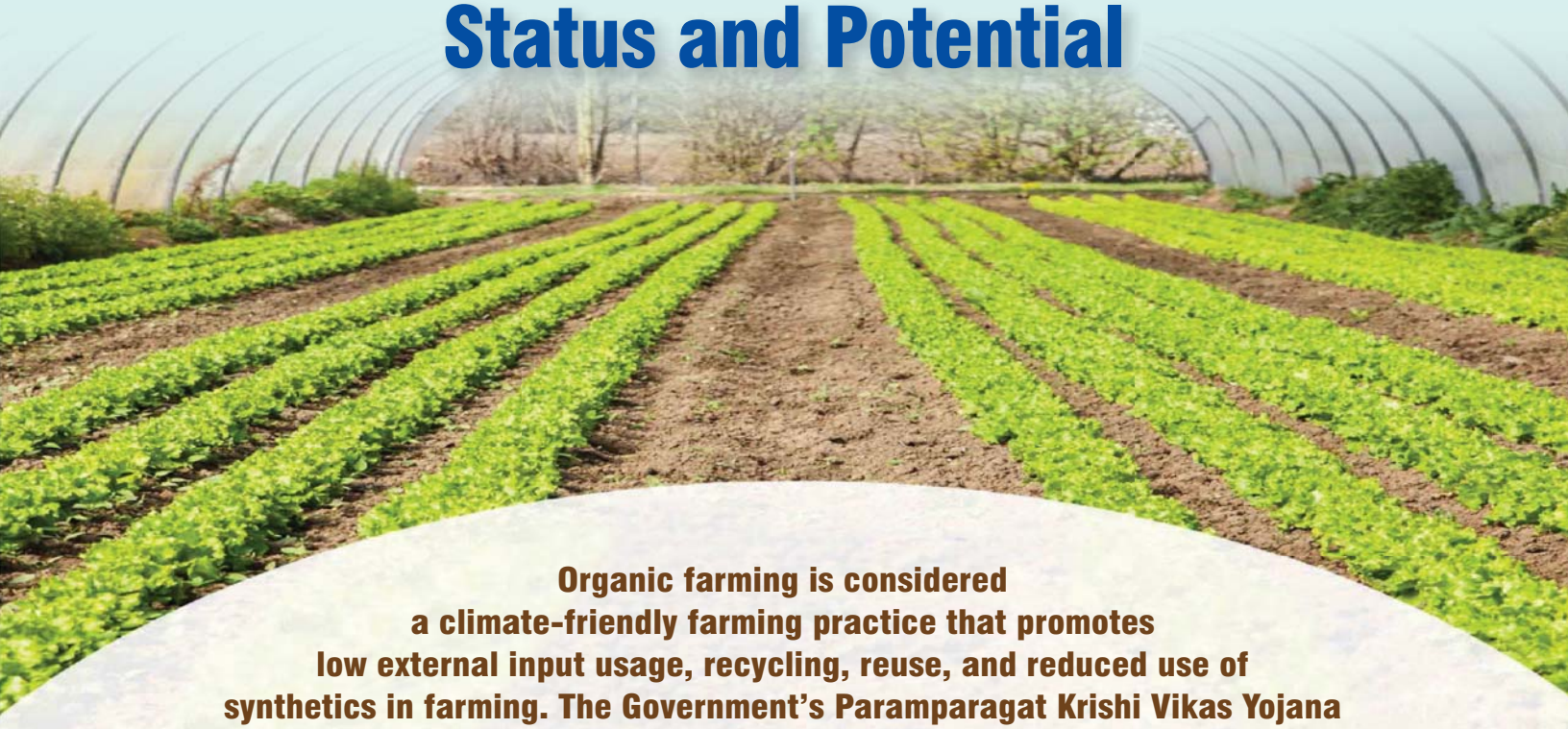
Organic Farming
Status and Potential



Organic farming is considered a climate-friendly farming practice that promotes low external input usage, recycling, reuse, and reduced use of synthetics in farming. The Government's Paramparagat Krishi Vikas Yojana (PKVY) and Mission Organic Value Chain Development for North Eastern Region (MOVCDNER) schemes have led to significant increase in organic agriculture acreage.

B S Purkyastha

From groundwater pollution to the overuse of fertilisers degrading soil fertility to the overload of pesticides in foodgrains, India has witnessed how measures to increase crop yield in the immediate term can harm farm productivity in the long term. Punjab and Haryana, known for their critical role in making the Green Revolution of the 1960s and 1970s a stupendous success and thus helping India transform from a foodgrain-scarce country to a foodgrain-surplus country, have borne the brunt of this excessive use of fertilisers and pesticides. Investigations carried out under the All India Coordinated Research Project on 'Long Term Fertiliser Experiments' over five decades at fixed sites have indicated that continuous use of nitrogenous fertiliser alone has a deleterious effect on soil health and crop productivity, showing deficiencies of other major and micronutrients. Even with recommended doses of NPK and more, deficiency of micro and secondary nutrients has become a yield-limiting factor over the years. Deficient nutrients may also affect plant growth and cause plant physiological disorders. There is also the possibility of nitrate contamination in groundwater above the permissible limit of 10 mg NO3-N/L due to excessive or overuse of nitrogenous fertilisers, particularly in light textured soils, which has consequences for human or animal health, if used for drinking purpose.

The Government of India had thus launched a National Mission on Soil Health Card to promote soil test-based, balanced, and judicious fertiliser application in the country. Similarly, the Government

The author is a Freelance Journalist. Email: ideainks2020@gmail.com

has been promoting organic farming since 2015-16 through the schemes of Paramparagat Krishi Vikas Yojana (PKVY) and Mission Organic Value Chain Development for the North Eastern Region (MOVCDNER). Both schemes stress on end-to-end support for farmers engaged in organic farming, i.e., from production to processing, certification, marketing, and post harvest management support, including processing. PKVY is being implemented in all the states other than the North Eastern (NE) states, while the MOVCDNER scheme is implemented exclusively in the NE states.

The Covid-19 pandemic has changed the perception of food, with the spotlight now on safety and healthy food to build a strong immune system. It is time to talk about nutritional security, not just food security (which consists of only carbohydrates). Organically grown foods generally contain higher levels of antioxidants, certain micronutrients, no harmful chemicals, pesticides, fertilisers, are better tasting, and most importantly, aid in the sustainability of the planet and in maintaining ecological balance. Thus, organic farming needs to be adopted on a large scale to have a far-reaching impact on the health of our citizens as well as on the health of our soil.

Organic Farming: India and the World

The National Standard of Organic Production (NSOP) has defined organic agriculture as 'a system of farm design and management to create an ecosystem that can achieve sustainable productivity without the use of artificial off-farm inputs such as chemical fertilisers and pesticides.' Organic farming is considered a climate-friendly farming practice that promotes low external input usage, recycling, reuse, and reduced use of synthetics in farming. The Indian Council of Agriculture Research (ICAR), under its All India Network Programme on Organic Farming, has developed a package of practices for organic production in cropping and farming systems mode.

Organic agriculture is practised in 187 countries, and 72.3 million hectares of agricultural land were managed organically by at least 3.1 million farmers worldwide, according to the 2021 FiBL survey, with the most organic agricultural land in Australia (35.69 m hectares), followed by Argentina (3.63 m hectares), and Spain (2.35 m hectares). The global sales of organic food and drinks reached more than 106 billion euros in 2019. On this global map, India holds a unique position among the 187 countries practising organic agriculture. India is home to 30% of total organic producers in the world: 27, 59,660 total farmers (11, 60,650 PGS and 15, 99,010 India Organic), 1703 total processors and 745 traders. However, organic farming is at a nascent stage in India. About 2.30 million hectares of farmland was under organic cultivation as of March 2019. This is two per cent of the 140.1 million ha net sown area in the country.

Increasing acreage

A dedicated drive by the Central Government and the individual States to promote organic farming has led to a relative increase in organic agricultural land throughout the country. A cumulative area of 29.41 lakh ha, 38.19 lakh ha, and 59.12 lakh ha has been brought under organic cultivation in the last three years (2019-20, 2020-21, and 2021-22) using organic manure and other organic inputs, which constitute 2.10%, 2.72%, and 4.22% of the cultivable land of 140 million ha. Since 2015-16, an area of 11.85 lakh ha has been brought under organic farming through the Paramparagat Krishi Vikas Yojana (PKVY) scheme, and the Government also intends to bring another 6.00 lakh ha area under organic farming through PKVY during the period from 2022-23 to 2025-26. Apart from this, Integrated Nutrient Management (INM) is prescribed for the entire cultivable land in the country and promotes the balanced use of fertilisers including chemical, organic, and bio-fertilisers.

A few states have taken the lead in improving organic farming coverage. Madhya Pradesh tops the list with 0.76 million ha of area under organic cultivation, which is over 27 per cent of India's total organic cultivation area. The top three states-Madhya Pradesh, Rajasthan, and Maharashtra-account for about half the area under organic cultivation. The top 10 states account for about 80 per cent of the total area under organic cultivation. During 2016, Sikkim achieved a remarkable distinction of converting its entire cultivable land (more than 75000 ha) under organic certification.

TABLE 1: State-wise and year-wise details of area (in ha) added to organic farming through PKVY scheme since 2015-16

S. No.	State	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	Andaman & Nicobar	1360	1360	1360	1360	1360	1360	1360
2	Andhra Pradesh	8660	8660	26000	106000	106000	206000	206000
3	Arunachal Pradesh	380	380	380	380	380	380	380
4	Assam	4400	4400	4400	4400	4400	4400	4400
5	Bihar	6540	6540	10600	10600	10600	24600	24600
6	Chhattisgarh	3760	3760	4000	24000	24000	109000	109000
7	Goa	80	80	80	10080	10080	10080	10080
8	Gujarat	2000	2000	2000	2000	2000	2000	2000
9	Haryana	400	400	400	400	400	400	400
10	Himachal Pradesh	2200	2200	4200	4200	5700	17700	17700
11	Jammu & Kashmir	560	560	560	560	560	560	560
12	Jharkhand	2000	2000	5540	5540	5540	8940	23940
13	Karnataka	10900	10900	10900	10900	20900	20900	20900
14	Kerala	2380	2380	12380	12380	12380	96380	96380
15	Lakshadweep	0	0	0	2700	2700	2700	2700
16	Madhya Pradesh	17600	17600	27600	76560	76560	175560	175560
17	Maharashtra	18640	18640	25160	25160	25160	25160	32160
18	Manipur	600	600	600	600	600	600	600
19	Meghalaya	900	900	900	900	900	900	900
20	Mizoram	680	680	680	680	680	680	680
21	Nagaland	480	480	480	480	480	480	480
22	Delhi	0	0	10000	10000	10000	10000	10000
23	Odisha	6400	6400	6400	20800	20800	44800	44800
24	Puducherry	0	0	160	160	160	160	160
25	Punjab	1000	1000	5000	5000	5000	5000	7000
26	Rajasthan	15100	15100	23000	123000	123000	123000	123000
27	Sikkim	3000	3000	3000	3000	3000	3000	3000
28	Tamil Nadu	2240	2240	2240	6240	6240	8240	8240
29	Telangana	6000	6000	13800	13800	13800	13800	13800
30	Tripura	1000	1000	1000	1000	1000	1000	1000
31	Uttar Pradesh	11500	11500	18800	32800	42800	78580	78580
32	Uttarakhand	11000	11000	12540	90540	90540	140540	140540
33	West Bengal	2400	2400	2400	2400	2400	2400	2400
34	Daman & Diu	0	0	1100	1100	1100	1100	1100
35	Dadar Nagar	0	0	10000	10000	10000	10000	10000
36	Chandigarh	0	0	0	1300	1300	1300	1300
37	Ladakh	0	0	0	0	0	0	10000
	Total	**144160**	**144160**	**247660**	**621020**	**642520**	**1151700**	**1185700**

Cumulative state-wise year under PKVY since 2015-16

SOURCE: Lok Sabha questions_annex_1711_AU2261-1.pdf

Salient features of PKVY and MOVCDNER schemes

Under PKVY, farmers of various states are provided financial assistance of Rs. 50000/ha for 3 years, whereas under MOVCDNER, an assistance of Rs. 46,575/ha for 3 years is provided for creation of FPO, support to farmers for organic inputs, quality seeds/ planting material, training, hand holding, and certification.

Under PKVY, farmers are provided financial assistance of Rs. 50000/ha for 3 years out of which, Rs. 31000/ ha for 3 years is provided directly to farmers through DBT for on-farm and off-farm organic inputs.

Financial assistance of Rs. 20 lakh/ cluster of 1000 ha for 3 years is provided for value addition and infrastructure creation. Under the scheme, assistance is provided of Rs. 7500/ha for 3 years for training and capacity building whereas, Rs. 2700/ha for 3 years is provided for certification and residual analysis.

Since 2015-16, under PKVY, an area of 11.85 lakh ha has been covered under organic farming by developing 32384 clusters involving 16.19 lakh farmers. In addition, eight states - Madhya Pradesh, Uttarakhand, Tamil Nadu, Jharkhand, Maharashtra, Punjab, Chhattisgarh, and Tripura - developed their own brands for organic products. So far, Rs. 1793.80 crore has been released under the scheme.

Under MOVCDNER, there is provision of financial assistance of Rs. 10000/ha for 3 years for training, handholding, and ICS documentation, and farmers in the North Eastern states are provided assistance of Rs. 32500/ ha for 3 years for off-farm /on – farm organic inputs.

Under the scheme, need-based assistance is provided for various components: an Integrated Processing Unit at Rs. 600 lakh, Collection, aggregation, and grading unit at Rs. 10 lakh, Integrated Pack house at Rs. 37.50 lakh, Refrigerated vehicle at Rs. 18.75 lakh, Pre-cooling, cold stores, and ripening chambers at 18.75 lakh and Transportation / 4 wheeler at Rs. 6 lakh.

Since 2015-16, under MOVCDNER, 1.73 lakh ha of area has been covered under organic farming by developing 379 FPO/FPCs involving 1.89 lakh farmers. In addition, seven Northeastern states developed their own brands for organic products.

So far, Rs. 886.16 crore has been released under the scheme. Altogether, 367 collection, aggregation, and grading units, custom hiring centres and 74 processing and packing house entities have been created under FPO/FPCs and private ownership.

Apart from this, support is also provided for group/ FPO formation, training, certification, value addition, and marketing of their organic produce. Under PKVY assistance is provided of Rs. 15 lakh / 1000 ha cluster for 3 years facilitate farmers for direct marketing of their organic products to the buyers. In addition, assistance is provided of Rs. 53 lakh /1000 ha clusters for 3 years for branding, publicity, exhibition, trade fairs, and other marketing initiatives to support direct buying of organic products from farmers. Under MOVCDNER, there is provision of assistance of Rs. 25 lakh/ FPO/FPC of 500 farmers for 3 years for the marketing of certified organic products.

Global Organic Market & Exports from India

As per the latest report published by International Federation of Organic Agriculture Movement (IFOAM) Germany and FiBL Switzerland in 2022, the global organic market has been growing at a CAGR of 8.7% during last six years (2015-2020). In value terms, the market size has grown from US $ 84 billion in 2015 to

US $ 129 billion in 2020, suggesting that the demand of organic products has increased all over the world.

The promotion of exports of organic products is a continuous process. The Agricultural & Processed Food Products Export Development Authority (APEDA), a statutory organisation under the administrative control of Department of Commerce, has the mandate to promote export of agricultural and processed products, including organic products from the country.

India produced around 3430735.65 MT in 2021-22 of certified organic products, which includes Oil Seeds, fibre, Sugar cane, Cereals & Millets, Cotton, Pulses, Aromatic & Medicinal Plants, Tea, Coffee, Fruits, Spices, Dry Fruits, Vegetables, Processed foods, etc. Organic production is not limited to the edible sector but also produces organic cotton fiber, functional food products, etc. The organic food export realisation was around Rs. 5249.32 Crore (USD 771.96 million). Organic products are exported to USA, European Union, Canada, Great Britain, Switzerland, Turkey, Australia, Ecuador, Korea Republic, Vietnam, Japan, etc. In terms of export value realisation, processed foods including soya meal (61%) lead among the products, followed by Oilseeds (12.85%), Cereals, and millets (12.71%), Sugar (4.77%), Plantation crop products such as, Tea & Coffee (2.16 %), Spices and condiments (1.72%), Pulses (1.1%), and others.

The primary reason for India's relatively low share in world organic export is our huge domestic consumption base for agriculture products, including organic products, due to our large population base. According to IMARC report, Indian organic food market is expected to exhibit a CAGR of 25.25% during 2022-2027. The Government has been taking steps to increase India's share in global trade of organic products. International buyer-seller meets have also been organised in Northeastern States like Meghalaya, Assam, Nagaland, Arunachal Pradesh, and Sikkim to provide an impetus to organic exports from the region. Webinars and virtual buyer-seller meets have been organised to provide a platform for Indian organic exporters to interact with potential importers in various countries such as Japan, Australia, Malaysia, USA, European Union (EU), Canada, etc. However, there is a lot of scope to further promote organic food products exports from India. The government also intends to add 6.00 lakh ha area under organic agriculture through PKVY during the period from 2022-23 to 2025-26. This will further give a fillip to production of organic agriculture products, ensuring increasing availability of products for exports.

Organic agricultural products exported during last 3 years

S. No.	Year	Exported Qty (In MT)	Value (In Cr)	Value (In USD Million)
1.	2021-22	460320	5249.32	771.96
2.	2020-21	888179	7078.50	1040.96
3.	2019-20	638998	4686.00	689.10

SOURCE: APEDA

Moreover, to promote direct marketing of organic products from the farmers to the end consumers, a dedicated web portal- www.Jaivikkheti.in/ has been created to help farmers get a better price for their organic products. Altogether, 6.09 lakh farmers have been registered under Jaivikkheti portal.

Two types of organic certification systems have been developed for quality assurance of organic products - Third Party Certification by Accredited Certification Agency under the National Programme for Organic Production (NPOP) under the Ministry of Commerce and Industry for development of export market, and Participatory Guarantee System (PGS-India) under the Ministry of Agriculture and Farmers Welfare for meeting the demand of domestic market. ❑

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Millets
Future of Sustainable Agriculture

Millets have gained acceptance as nutri-cereals all over the world. These nutri-cereals have the potential to bring nutritional balance to our diet. Most millets have high contents of proteins, fibres, vitamins, and essential minerals and are an attractive gluten-free substitute for cereals. The need of the hour is to ensure the emergence of an appropriate supply-chain and value-chain from pre-production to processing and marketing. A challenge that needs to be addressed swiftly is the compliance of exports with sanitary and phytosanitary measures, which will lead to a global demand-pull for millets produced in India.

Dr. Ishita G. Tripathy

India has been the largest producer of millets globally. Three varieties of millet, viz., pearl millet (bajra), sorghum (jowar), and finger millet (ragi), constitute the largest share of India's total millet production. Out of these prime varieties of Indian millets, bajra and jowar together contribute about 19 per cent of the world's production. Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh, and Uttarakhand are the major millet-producing States in India. As per the Agricultural and Processed Food Products Export Development Authority (APEDA)'s report on millet production in India (www.apeda.gov.in), these ten states accounted for around 98 per cent of the production of millets in the country in 2020-21. Six states, viz.,Gujarat, Haryana, Karnataka, Maharashtra, Rajasthan, and Uttar Pradesh, account for more than 83 per cent share of the country's total production of millets.

The importance of millets is underscored by the United Nations' Food and Agricultural Organization, FAO Stat 2021, which indicates that out of the total area in the world under millets production and the total millet production in the world, India constitutes 19 per cent and 20 per cent, respectively. Further, average productivity in India is higher at 1,239 kilogram per hectare (kg/ha), compared to the world average of 1,229 kg/ha.

Dr MS Swaminathan-led Green Revolution brought modern technology to Indian agriculture. The movement advocated the use of high-yielding varieties of seeds with improved chemical-fertigation, mechanisation,

The author is an officer of the Indian Economic Service and Additional Development Commissioner, Ministry of MSME.
Email: igtripathy@gmail.com

and agronomic practices aimed at achieving self-sufficiency for the country's foodgrain production. The focus of the Green Revolution on high yielding variety seeds of rice and wheat changed India's status from a food-deficient country to one of the foodgrain-surplus nations of the world. Though the Green Revolution achieved its prime objective of making India self-sufficient in foodgrains, the approach somehow could not accord concurrent importance to the production and propagation of millets. Consequently, the proportion of millets in our food basket diminished over the years.

Millets consist of various small-seeded plants, including pearl, sorghum, foxtail, finger, barnyard, etc., and are also interchangeably referred to as nutri-cereals, super-foods, and *Shree Anna*. Nutritional enrichment, an 'environment friendly' cropping pattern, and remunerative considerations comprise the trinity that forms the foundation of the recent drive to promote millets. In this context, this article focuses on these three important aspects of millets and the steps taken by the Government of India to promote millets, against the backdrop of 2018 having been the National Year of Millets, and 2023 being declared as the International Year of Millets.

Nutritional Value of Millets

Nutritional imbalances can have a long-term adverse impact on health and may leave people grappling with medical concerns. Malnourishment can manifest in the form of stunting in children, anaemia in adolescents, diabetes and obesity in adults, etc., and imposes serious challenges in leveraging the economic potential of a nation. In this context, millets have been tested and tried for enhancing the nutritional sensitivity of people. Millets have gained acceptance as nutri-cereals all over the world. These nutri-cereals have the potential to bring nutritional balance to our diet. Most millets have high contents of proteins, fibres, vitamins, and essential minerals and are an attractive gluten-free substitute for cereals. As indicated in Table 1, millets can provide nutritional security. Some nutritional benefits of millets include low absorption of fats and low glycemic indices.

Table 1: Nutritional Profile of Millets and Cereals (per 100 g)

Grains	Energy (kcal)	Protein (g)	Carbohydrate (g)	Starch (g)	Fat (g)	Dietary Fibre (g)	Minerals (g)
Sorghum	334	10.4	67.6	59	1.9	10.2	1.6
Pearl millet	363	11.6	61.7	55	5	11.4	2.3
Finger millet	320	7.3	66.8	62	1.3	11.1	2.7
Proso millet	341	12.5	70.0	-	1.1	-	1.9
Foxtail millet	331	12.3	60.0	-	4.3	-	3.3
Kodo millet	353	8.3	66.1	64	1.4	6.3	2.6
Little millet	329	8.7	65.5	56	5.3	6.3	1.7
Barnyard millet	307	11.6	65.5	-	5.8	-	4.7
Maize	334	11.5	64.7	59	3.6	12.2	1.5
Wheat	321	11.8	64.7	56	1.5	11.2	1.5
Rice	353	6.8	74.8	71	0.5	4.4	0.6

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8871339/#B3-foods-11-00499

Environmentally Sustainable

A renewed focus is being laid on enhancing the production of millets, considering the high nutritional value of the products. These cereals have the required capacity to reduce overdependence on more commonly raised water-guzzling crops like rice, boosting diverse diets, and ensuring food security for all. Millets can be grown in varied landforms and climatic conditions,

thereby ensuring environmental adaptability. They are resistant to drought and most pests. Mixed cropping patterns, especially in dryland areas, work well to retain soil fertility. Irrigation requirements for some millets are relatively lower than those for paddy and wheat. For example, while rice requires temperature above 25 degrees with an annual rainfall of above 100 cm, bajra requires 40 to 60 cm of annual rainfall, and jowar can be grown even in areas with less than 20 cm of annual rainfall. Moreover, millets as compared to rice and wheat require a shorter duration between sowing and harvesting. For example, on an average, millets may require 60 to 90 days, while other cereals may require 100 to 200 days, thereby making the former more ideal for adopting crop rotation. Thus, production of millets can contribute a lot to the global efforts of addressing the challenges related to mitigation and adaptation to climate change.

Pricing of Millets

The Minimum Support Prices (MSP) for crops, including ragi, jowar, and bajra, are fixed by the Government of India. Assured prices ensure assured income for millet growers, thereby reducing risks and removing information asymmetry. From 2014-15 to 2023-24, while the MSP for paddy increased 1.6 times, those for jowar, bajra and ragi increased by 2.1, 2.0 and 2.5 times, respectively (Table-2). Evidently, the return over cost is the highest in the case of bajra.

Table-2: Minimum Support Price for Millets

Crop	MSP 2014-15	MSP 2022-23	MSP 2023-24	Cost* of production 2022-23	Increase in MSP (Absolute)	Return over cost (in per cent)
Paddy	1,360	2,040	2,183	1,455	143	50
Jowar	1,530	2,970	3,180	2,120	210	50
Bajra	1,250	2,350	2,500	1,371	150	82
Ragi	1,550	3,578	3,846	2,564	268	50

* refers to cost incurred on hired human labour, bullock/machine labour, rent paid for leased in land, expenses incurred on use of material inputs like seeds, fertilisers, manure, irrigation charges, depreciation on implements and farm buildings, interest on working capital, diesel/electricity for operation of pump sets, etc., miscellaneous expenses and imputed value of family labour.

Source: PIB, 07.06.2023.(https://pib.gov.in/PressReleseDetailm.aspx?PRID=1930443)

Promoting Millets Production

The area under cultivation of millets in India has ranged between 12.3 and 15.5 million hectares from 2013-14 to 2021-22. In 2022-23, India's production of millets was 159 lakh ton, as per advance estimates. The production target fixed by the Government for 2022-23 was 205 lakh ton . In terms of total production of millets, the figures increased from 137 lakh ton in 2018-19 to 160 in 2021-22, with a productivity enhancement from 1,163 kg/ha to 1,239 kg/ha over the same period. Table-3 provides the details of area under cultivation and production of select millets from 2013-14 to 2021-22.

Table-3: Area and Production of Millets, 2013-14 to 2021-22

Millets	Area/ Production	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Bajra	Area ('000 hectares)	7,811	7,318	7,129	7,459	7,481	7,105	7,543	7,652	6,841
	Production ('000 tonnes)	9,250	9,184	8,067	9,730	9,209	8,664	10,363	10,863	9,781
Jowar	Area ('000 hectares)	5,793	6,161	6,077	5,642	5,024	4,093	4,824	4,378	3,801
	Production ('000 tonnes)	5,542	5,445	4,238	4,568	4,803	3,475	4,772	4,812	4,151
Ragi	Area ('000 hectares)	1,194	1,208	1,138	1,016	1,194	891	1,004	1,158	1,218
	Production ('000 tonnes)	1,983	2,061	1,822	1,385	1,985	1,239	1,755	1,998	1,701

Source: Lok Sabha Unstarred Question No. 2447 answered on 15.03.2023

In India, millets are grown across various States. Table-4 presents the States where the area cultivated under millets and its production were the largest in 2021-22.

Table-4: Largest Area cultivated under Millets and Highest Millet Production in 2021-22

States	Bajra	Jowar	Ragi
Area ('000 hectares)	Rajasthan (3,736)	Maharashtra (1,649)	Karnataka (846)
Production ('000 tonnes)	Rajasthan (3,740)	Maharashtra (1,558)	Karnataka (1,127)

Source: Lok Sabha Unstarred Question No. 2447 answered on 15.03.2023

Awareness to Boost Millet Consumption

Despite there being evidence of the cultivation of millets as far back as ancient civilisations of Harappa and Mesopotamia, the consumption of millets has not really taken off. Consequently, to promote the consumption of millets, the Government of India has taken a number of diverse steps, which range from augmenting productivity to ensuring nutritional enhancement; from encouraging value addition to entrepreneurship development, and from bolstering the value chain to crop diversification. These include inter-State and advance subsidy, encouraging procurement and distribution under the Targeted Public Distribution System, the Pradhan Mantri Poshan Shakti Nirman, Integrated Child Development Services, implementing a Sub-Mission on Nutri-Cereals (Millets) under National Food Security Mission, issuing directives regarding promoting millets in canteens of Central Public Sector Enterprises, inclusion of millets in mid-day meals, promoting value-added millet products, organising Global Millets Conference in New Delhi in March 2023, facilitating buyer-seller meets, organising promotional campaigns, designing innovative ready-to-eat and ready-to-serve processed millet products, inclusion of millets in 'One District One Product', accentuating the role of media in promotion of millets, etc. Further, Budget 2023-24 had announced that the Indian Institute of Millet Research in Hyderabad will be supported as the Centre of Excellence for sharing best practices, research, and technologies at the international level.

A necessary pre-requisite for any of these steps to succeed is the creation of awareness about various aspects of millets. In this direction, a commemorative stamp and a commemorative coin have been released by the Government of India, and awareness programmes through the Food Corporation of India and the Central Warehousing Corporation. The Government's push has been to enhance both the demand for and the supply of millets and then work towards attaining an equilibrium. In this context, awareness generation among farmers becomes as crucial as awareness generation among consumers. While for consumers, nutritional aspects,

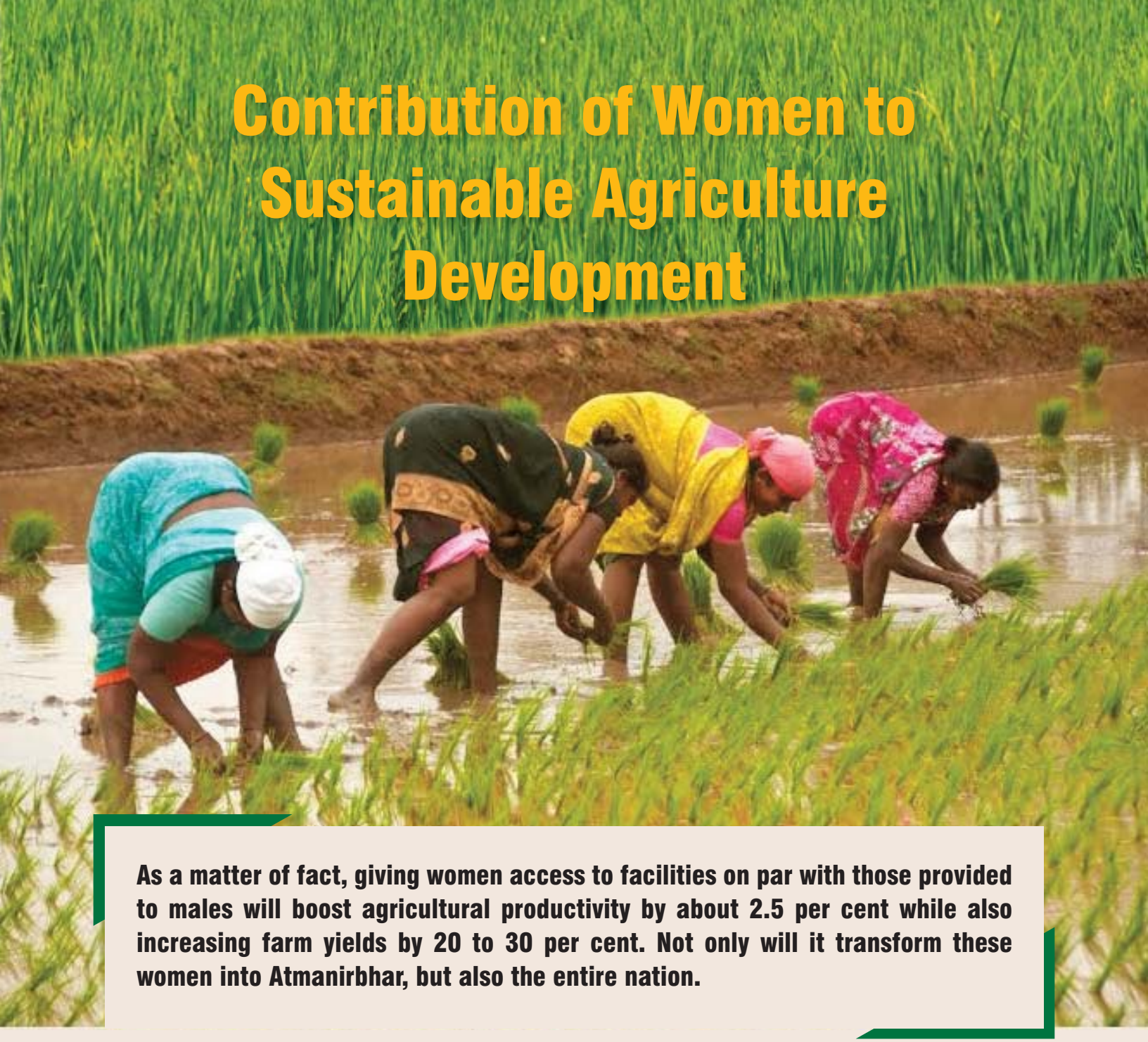
prices, and accessibility, including availability on Government e-Marketplace and e-commerce platforms, would be important determinants of demand, for other stakeholders, cropping pattern, access to technology and markets, availability of research and development, linkages with Farmer Producer Organisations, storage, constituents of the supply chain, etc., are of significance.

Concluding Remarks & Way Ahead

Indian millets have registered respectable demand in international markets. As pointed out by our Hon'ble Prime Minister, Indian millets have now become an acknowledged brand and are charting out the path of economic prosperity in their own way. The need of the hour is to ensure the emergence of an appropriate supply-chain and value-chain from pre-production to processing and marketing. To strengthen the supply chain emanating from India, APEDA has taken the lead by publishing e-catalogues, conducting capacity-building programmes, and promoting Indian millets through Business to Business (B2B) meetings during various international trade fairs. A challenge that needs to be addressed swiftly is the compliance of exports with sanitary and phytosanitary measures, which will lead to a global demand-pull for millets produced in India.

A focused approach on millets that has been adopted relies heavily on the flexibility of both producers and consumers to experiment. Such an approach is needed for surmounting agri-food related issues, ensuring higher production, along with enhanced productivity, meeting domestic demand, and being able to earn foreign exchange through exports. Effectively, the demand for millets is a function of its price; price of its substitute cereals; taste and preferences of the consumers, etc. The Government has adopted a policy of making millets available to the consumers. If this availability is coupled with considerations of affordability too, an assured market can be expected. A renewed emphasis on millets has the potential of generating positive externalities in the form of better nutrition for citizens, environmental sustainability, retention of soil fertility, and better incomes for the cultivators. ❑

Contribution of Women to Sustainable Agriculture Development



As a matter of fact, giving women access to facilities on par with those provided to males will boost agricultural productivity by about 2.5 per cent while also increasing farm yields by 20 to 30 per cent. Not only will it transform these women into Atmanirbhar, but also the entire nation.

Manjula Wadhwa

While it is a contentious issue that how the country would reap the benefits of the demographic dividend, the concept of the gender dividend, referring to the contribution of women to a country's growth process, can definitely foster the demographic dividend. While the demographic dividend comes from shifting age structures towards more productive ages, the gender dividend comes from taking steps that increase the volume of market (paid) work and the level of productivity of the female population. However, in the Indian context, the data shows a gradual declining trend in women's participation in the labour force.

Providing livelihood and employment to 45.6 per cent of the workforce in 2023 (Latest Periodic Labour Force Survey report) and contributing about 17.32 per cent of gross value added in 2022 (MoAFW 2022-23), our

The author is Deputy General Manager, NABARD, Uttar Pradesh. Email: m.wadhwa@nabard.org

Women play a substantial role in allied activities as well; they undertake a wide range of activities related to livestock production, vegetable cultivation, fish processing, and dairy production and maintenance. Beyond the farm, they play a meaningful role in land and water management and are most often the collectors of water, firewood and fodder.

agriculture sector remains the prime pulse for economic growth, poverty alleviation, and environmental sustainability, wherein rural women contribute significantly in three different ways depending on the socio-economic status of their family. They contribute as paid labourers, unpaid labourers doing labour on their own/family-owned land, and managers/ supervisors in agricultural production and post-harvest operations. Besides, they also play an important role in the maintenance of natural processes and ecosystem services and adopt an integrated perspective on farming system that emphasises sustainable agricultural practices and resource-use efficiency. This is further bolstered by their ability to respond to the barriers to farming with innovative strategies that emphasise smaller farm scales, diversified high value, and value added products and enterprises, unique marketing strategies, and sustainable practices.

Women play a substantial role in allied activities as well; they undertake a wide range of activities related to livestock production, vegetable cultivation, fish processing, and dairy production and maintenance. Beyond the farm, they play a meaningful role in land and water management and are most often the collectors of water, firewood and fodder. Given the extensive participation of women in all aspects of agricultural and allied activities, the mainstreaming of gender into the agriculture sector is a key strategy not only for the promotion of equality between men and women but also for sustainable agriculture and rural development. The United Nations Food and Agriculture Organization estimates that if women had the same access to productive resources as men, they could increase yields on their farms by 20-30% leading to higher agricultural output in developing countries and a dramatic reduction in hunger.

The social and cultural aspects of agriculture have been witnessing changing trends. Women's role has been growing with the 'feminisation of agriculture' as men are migrating to urban areas in search of productive employment, leaving women to manage the farmlands. Other factors include the rise of women-headed households and growth in the production of cash crops, which are labour-intensive and primarily managed by women. While the women are now de-facto playing multiple roles in managing farm and non-farm activities, particularly in the dryland areas, their typical work continues to be limited to less skilled jobs such as sowing, transplanting, weeding, and harvesting, and rearing livestock, among other things that fall within the broad framework of domestic life. The participation of women as unpaid subsistence labourers in agricultural work is also quite common. Though the number of women's tasks, both on farm and in non-farm activities, is increasing, it is often treated as an extension of their household works which in turn becomes a dual burden of domestic responsibilities.

Everybody knows what a farmer needs: freedom from debt, insurance to fall back on, and an assured price for his or her produce, to name only a few. Institutional

frameworks notwithstanding, the hard reality is that credit is available only to the landed, insurance is at the mercy of interpretation, while fair price lies somewhere between policy, intent, and politics. Some of the issues and challenges typically faced by rural women engaged in agriculture are listed below:-

Lack of Recognition of Women's Role: Women farmers in India work about 3,300 hours per crop season when fields are sown and harvested, more than double the 1,860 hours their male counterparts put in. Still, a bias has always persisted among development planners to not treat women as primary producers but only as consumers of social services. This unnoticed labour of women has led to the perpetuation of a cycle of drudgery, non-upgradation of skills, and non-participation in decision-making processes by rural women, to the detriment of development of the rural economy.

Skill Development: Researchers have revealed that owing to a lack of avenues for skill development, women are relegated to work long hours in low-skill farm activities that are time-consuming, labour-intensive, monotonous, and usually cause considerable physical and mental fatigue, and health problems. Further, with increasing mechanisation of agriculture, many women may be replaced from the production cycle unless skill development opportunities are created for them to learn to operate machinery. Moreover, an estimated 52-75 per cent of Indian women engaged in agriculture are illiterate, creating an education barrier that prevents them from participating in more skilled labour sectors.

Land Ownership and Records: However, only 13.9 per cent of the operational holdings are owned by women, which reflectsthe gender disparity in ownership. Moreover, there is a concentration of operational holdings (25.7 per cent) by women in the marginal and smallholding categories. The Hindu Succession Act (HSA) 1956, which took about 50 years to be modified in 2005, allows daughters equal rights in ancestral property, but the same is not true for agricultural land where state laws prevail. In some states, daughters and sisters are kept out of the inheritance lineage on the pretext of preventing further fragmentation of land. In other states, HSA applies but is easily circumvented. No doubt this is a complex socio-economic issue, but it is also a crippling problem for the female farmer.

Poor Credit: Microfinance and other credit facilities are largely inaccessible to women due to their lack of ownership of assets. Kisan Credit Card and other such credits are also not easily accessible to them. Rural financial institutions are often hesitant to accept female clients because they are unable to meet collateral requirements and are inexperienced borrowers.

Inequality in Market Access: Because of long-standing gender discrimination, Indian female farmers are significantly less mobile than men, which may limit their access to marketplaces.

Recognising the critical role of women as equal partners in sustainable development, the government has embarked upon various pro-women initiatives in a big way since 2007, and earmarked atleast 30% of benefits and resources for women under all beneficiary-oriented interventions. In this context, NABARD's SHG-Bank Linkage programme to solve the issue of access to credit of women farmers and self-help groups (SHGs) by relaxing the requirement of collateral for extending loans has definitely proved to be a remarkable milestone. The adoption of NABARD's Joint Liability Group (JLG) Ram Rahim model by Kerala's Kudumbshree accelerated the pace of empowerment among women farmers who undertook collective farming under the model.

With the thrust on sustainable agriculture growth, by way of strengthening community institutions, the National

Rural Livelihood Mission aims to empower poor women farmers to enhance participation, improve productivity, and pursue sustainable livelihoods through systematic investment in building knowledge, skills, and capacities. One of its sub-components, Mahila Kisan Sashaktikaran Pariyojana, has helped over 8.6 million SHG women access resources and services for enhanced agricultural productivity. Today, female farmers are being encouraged to take up leadership roles in Farmer Producer Organisations promoted by NABARD, SFAC, NCDC, and other government agencies. Recognising the multidimensional role of women at every stage in agriculture, the Government of India has started celebrating October 15 as Rashtriya Mahila Kisan Divas since 2016.

For skill development and capacity building amongst women farmers, various types of skill training are being imparted, including Support to State Extension Programmes for Extension Reforms (ATMA Scheme) under the Sub-Mission on Agriculture Extension (SMAE). Skill training courses in agriculture and allied areas (of a minimum duration of 200 hours) are also being conducted for women farmers through National Training Institutes, State Agricultural Management and Extension Training (SAMETIs), Krishi Vigyan Kendras (KVKs), and State Agricultural Universities (SAUs) across the country. The Pradhan Mantri Kaushal Vikas Yojana (PMKVY) implemented by the Ministry of Skill Development and Entrepreneurship, provides several short duration skill training programmes, viz., Short-Term Training (STT) and Recognition of Prior Learning (RPL), etc., for rural youth and women to earn their livelihood. Government schemes, viz., the DeenDayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY) is a placement linked skill development programme. The Prime Minister Mahila Shakti Kendra Yojana, launched by the Governmentin 2017, with a view to reach out to rural women and facilitate health, nutrition, skill development, employment, digital literacy, etc., has been further extended for the current FY 2023-24 also. The Biotech-Krishi Innovation Science Application Network (Biotech-KISAN) Programme was initiated by the Department of Biotechnology to provide scientific solutions to farmers in the north-east region to link available innovative agriculture technologies to the farm with the small and marginal farmers, especially women farmers of the region.

In addition, the well-being of women farmers is specifically addressed by the following programmes: the Mission for Integrated Development of Horticulture, the National Mission on Oilseed & Oil Palm, the National Mission on Sustainable Agriculture, the Sub-Mission for Seed and Planting Material, and the Sub-Mission on Agricultural Mechanisation.

In fact, the prime step for empowering women could be the conservation of the sex ratio percentage in the population and preventing female infanticides in the country. Towards this goal, Beti Bachao-Beti Padhao scheme has provided a significant mass mobilisation drive towards the elimination of gender discrimination and an improved sex ratio at birth. Similarly, the schemes like Sukanya Samriddhi Yojana, Pradhan Mantri Matru Vandana Yojana, Rashtriya Mahila Kosh, Swadhar Grih Scheme, Ujjawala Yojana, Women Helpline, and Gender Budgeting Scheme, implemented by the Central Government, are building confidence in Indian women, especially female farmers. The financial inclusion and financial literacy achieved by women farmers through the Pradhan Mantri Jan-Dhan Yojana (PMJDY), has helped them fight Covid-19 crisis, with uninterrupted access to financial aid for agricultural operations. Other initiatives like the Pradhan Mantri Mudra Yojana, Stand-up India scheme, and PM Employment Generation Programme

are other laudable steps taken by the Government towards the holistic empowerment of rural women, particularly, those in the agriculture sector. If we look at World Economic Forum's Global Gender Gap Index 2022, we find improvement of five places since 2021 on better performance in areas of economic participation and opportunity.

Collectivisation and investment in strong community institutions and human capital could hold the key to some of the problems faced by women in agriculture. Better access to credit, technology, and entrepreneurial abilities will further boost women's confidence and help them gain the recognition as farmers. It is high time the thrust is given on formation of more and more women FPOs under the Central Government's 10,000 FPO scheme. It will not only facilitate their access to resources FPO membership will also make it easier for women to register themselves in the local land records and establish themselves as farmers with access to and control over local resources. Likewise, in absence of modifications to tenancy laws by State Governments alternative solutions can be employed, like the issue of Loan Eligibility Card (LEC) by State Governments, as is being done in Andhra Pradesh.

As per existing priority sector guidelines, banks are mandated to finance up to 10% of ANBC to weaker sections, which includes financing small and marginal farmers (SF/MF), scheduled tribe/schedule caste (ST/SC), persons with disabilities, minorities, etc., including individual women up to Rs. 1.00 lakh. The overall target for women within priority sector and direct lending to agriculture are not specified. Inclusion of targets / sub-targets for women under priority sector lending and gender-disaggregated financial data is the need of the hour for any policy formulation, the absence of which only adds to the invisibilisation of women in agriculture.

Apart from the above, women also need direct access to information on improved agricultural practices and links to markets. In today's digital world, it is also important to think critically about the information and communication tools that can help women farmers who may not enjoy much physical mobility to reach out to markets, which are generally considered to be a male-centric arena.

To sum up, it is heartening to note that access to resources, technology, education, health facilities,

ownership rights, and skill development are improving agriculture productivity and helping to build an empowered nation. As a matter of fact, giving women access to facilities on par with those provided to males will boost agricultural productivity by about 2.5 per cent while also increasing farm yields by 20 to 30 per cent. Not only will it transform these women into Atmanirbhar, but also the entire nation. Recently, on 28 March 2023, the participation of farm women and women agripreneurs from all 23 districts of Punjab in the event 'Awareness on Agripreneurship cum Exhibition for Farm Women' organised by the Ministry of Agriculture and Farmers Welfare and the National Institute of Agricultural Extension Management (MANAGE), Hyderabad, in collaboration with PAMETI, Ludhiana, and the Department of Agriculture and Farmers Welfare, Punjab, evinces the increasing role of women in the sustainable agriculture development of India. So, it would be most apposite to say that if "Women hold up half the sky" and tend to half the earth is a trope, then we need to see beyond it with an abiding sense of fair play and justice. It is in the interest of the earth, and more particularly, Indian agriculture, which is considerably challenged by climate change, that the mahila kisan is given a fair chance to do what she does well. 2011 Nobel Prize Winner from Israel, Dan Shechtsman, has aptly said,

"Sustainable Agriculture Development requires human ingenuity and so women are the most important resource". ❑

Agriculture
Paving the Way for Sustainable Growth

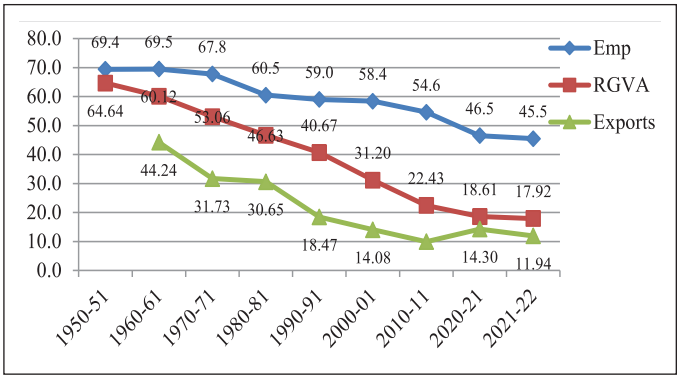
Agriculture continues to be the most crucial sector of Indian economy. Over the past seven decades, the country has experienced substantial growth in food grain production, outpacing population growth and resulting in a significant increase in per capita availability of foodgrains. The liberalisation of the economy has led to a transformation of the farm sector, shifting from traditional food crops to commercial and horticultural crops. Due to remarkable progress of this sector, India has emerged as the seventh largest exporter of agricultural products in the world.

Dr. H.L. Sharma

Agriculture has always been a crucial sector in the Indian economy. It, along with the allied sectors, plays a strategic role in the process of economic development by bolstering national income, output, employment, and foreign exchange earnings. The significance of this sector is brought out by the fact that more than 50 per cent of the total work force derives its sustenance through direct employment in agriculture, either as cultivators or as agricultural labourers. During the planned era of development in the country, there has been a tremendous increase in the production of agriculture and allied sectors. The real gross value added (RGVA) at constant prices by the primary sector (including agriculture, forestry, fishing, mining & quarrying) which was to the tune of Rs. 3,09,778 crore in 1950-51, went up to Rs. 24,37,680 crore in 2021-22, registering a compound growth rate of 2.91 per cent per annum. Though the share of the primary sector in real gross value added has steadily declined from 64.64 per cent in 1950-51 to 17.92 per cent in 2021-22, it is still remarkably high in view of the world average of 4 per cent of global GDP (Fig. 1). The share of the farm sector in employment generation has decelerated from 69.40 per cent in 1950-51 to 45.5 per cent in 2021-22 as per the NSSO's latest annual Periodic Labour Force Survey (PLFS) report for 2021-22. The contribution of agriculture and allied sectors to foreign exchange earnings has also declined from 44.24 per cent in 1960-61 to 11.94 per cent in 2021-22. Despite a fall in its share in national output and employment, the agriculture and allied sectors continue to serve as the primary source of livelihood for over half of the population of the country.

The author is Associate Professor of Economics, Govt. P.G. College Bilaspur. Email: hlsharmablp@gmail.com

Figure 1: Share of Agriculture & Allied Sector in Gross Value Addition, Employment and Exports (%)



Sources: (i) NSSO, Periodic LabourForce Survey 2021-22, February 2023.
(ii) Economic Survey 2022-23, Statistical Appendix, pp. 7-9, 112-118

Trends in Agricultural Production

Over the course of seven decades of planned economic development, India has achieved remarkable progress in the production of foodgrains. The major food crops in the country are cereals like rice, wheat, maize, jowar, bajra, etc., and pulses like gram, tur, moong beans, masur, peas, etc. Total foodgrain production in the country has increased significantly from 50.8 million tonnes in 1950-51 to 315.62 million tonnes in 2021-22, demonstrating an annual compound growth rate of 2.61 per cent (Table 1). Notably, while the production of cereals has surged by almost sevenfold, the production of pulses has increased merely by 3.25 times during the period under reference. (Fig. 2). India has emerged as the largest producer of pulses in the world despite modest growth in its production. It is noteworthy that India's foodgrain production has outpaced its population growth, with a compound growth rate of 2.61 per cent per annum as compared to the population growth rate of 1.95 per cent from 1951 to 2022. Consequently, the per capita per day availability of foodgrains has increased from 395 grams in 1951 to 514.5 grams in 2022.

Table 1: Trends in Agricultural Production

(quantity in million tonne)

Commodity	1950-51	1970-71	1990-91	1910-11	2020-21	2021-22	CAGR (%)
Foodgrains	50.8	108.4	176.4	244.5	310.74	315.62	2.61
Cereals	42.4	96.6	162.1	226.3	285.28	288.31	2.74
Pulses	8.4	11.8	14.3	18.2	25.46	27.3	1.67
Oilseeds	5.2	9.6	18.6	32.5	36.57	37.7	2.83
Sugarcane	57.1	126.4	241	342.4	405.4	431.8	2.89
Cotton@	3.04	4.8	9.8	33	35.25	31.2	3.33
Jute & Mesta#	3.3	6.2	9.2	10.6	9.35	10.32	1.62
Tea	0.28	0.4	0.7	1	1.4*	-	2.36
Coffee	-	0.1	0.2	0.3	0.3*	-	2.22
Rubber	-	0.1	0.3	0.8	0.7*	-	3.97
Potato	-	4.8	15.2	42.3	56.17	53.39	5.01
Milk	17	22	53.9	121.8	210.0	221.1	3.68
Egg (Million No)	1832	6172	21101	63024	122049	129600	6.18
Fish	0.75	1.76	3.84	8.4	14.7	16.2	4.42

@ Million Bales (170 kg each), # Million Bales (180 kg each), * Data for 2019-20

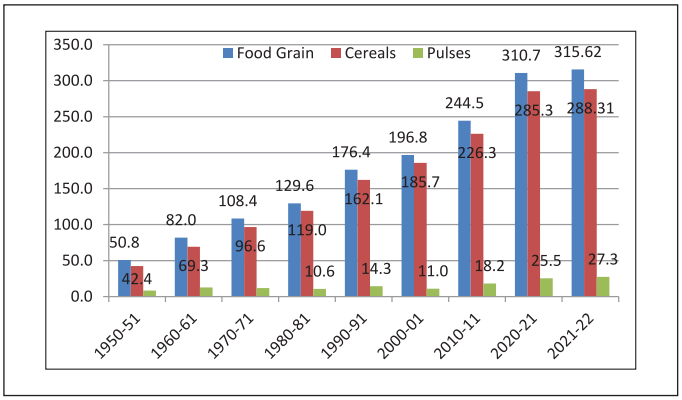
Source: Directorate of Economics & Statistics, Ministry of Agriculture and Farmers Welfare.

The major commercial crops in India are cotton, jute, tea, coffee, rubber, sugarcane, oil seeds, etc. It is evident from Table 1 that among commercial crops, potato witnessed the highest annual compound growth

rate of 5.01 per cent followed by rubber (3.97%) and cotton (3.33%) from 2050-51 to 2021-22. Oilseed production experienced an annual growth rate of 2.83 per cent, rising from 5.2 million tonnes to 37.7 million tonnes during the period under reference. Sugarcane production increased from 57.1 million tonnes to 431.8 million tonnes, yielding a growth rate of 2.89 per cent per annum. Furthermore, the cotton witnessed a growth rate of 3.33 per cent per annum, resulting in an increase in production from 3.04 million bales to 31.2 million bales in the same context.

Figure 2: Trends in Agriculture Production in India

(quantity in million tonne)



Sources: (i) Agricultural Statistics at a Glance, (Various Issues)
(ii) Economic Survey (Various Issues).

Trends in Horticultural Production

The wide varieties of soil and diverse agro-climatic conditions in the country, create favourable conditions for cultivating a vast array of horticultural products like fresh fruits, vegetables, root and tuber crops, flowers, aromatic and medicinal crops, spices, and plantation crops. This sector has experienced unprecedented growth over the past two decades. Total horticultural production in India has reached 342.33 million tonnes in 2021-22 as compared to 145.79 million tonnes in 2001-02, registering ACGR of 4.36 per cent during this period (Table 2). In fact, the production of horticulture crops in the country has continuously outpaced the production of foodgrains since 2012-13. Vegetables contribute significantly to India's horticultural production, accounting for nearly 60 per cent of the total output. In 2021-22, vegetable production reached 204.84 million tonnes, cultivated across 11.35 million hectares of land. Another significant component of the horticulture sector is fresh fruits, which constitute over 31 per cent of total horticultural production in India. The annual production of fresh fruits has reached an impressive level of 107.24 million tonnes, cultivated across 7.05 million hectares of land. India has also made remarkable progress in the production of flowers. Its annual production of loose and cut flowers reached 3.13 million tonnes in 2021-22. India has emerged as a prominent global producer of fruit and vegetables, securing the second position worldwide, just behind China. Notably, India holds the first rank in the world in the production of various fruits such as mango, banana, sapota, pomegranate, and aonla, along with vegetables like peas and okra. The country attains the second position in the world for the production of brinjal, cabbage, cauliflower, and onion. Furthermore, India boasts to be the largest producer, consumer, and exporter of spices and spice products. The total production of spices during 2021-22 stood at 10.81 million tonnes from an area of 4.49 million hectare, as per the third advance estimate of the Department of Agriculture, Co-operation and Farmers Welfare for 2021-22.

Table 2: Horticulture Vis-a -vis Foodgrain Production in India

(quantity in million tonne)

Year	Food Grain	Horticulture	Vegetables	Fruits	Other
2001-02	212.9	145.79	88.62	43.00	14.17
2005-06	208.6	182.8	111.40	55.36	16.04
2010-11	244.5	240.5	146.55	74.88	19.07
2015-16	251.6	286.2	169.06	90.18	26.95
2020-21	310.74	334.60	200.4	102.48	31.68
2021-22	315.62	342.33	204.84	107.24	30.25
CAGR (%)	1.99	4.36	4.28	4.68	3.87

Source: Agriculture Statistics at a Glance-2022.

Trends in Livestock Production

Livestock plays a vital role in the rural economy, contributing nearly 30 per cent to the overall agricultural and allied sector output in the country. Over the past two decades, India has consistently been the largest producer of milk in the world, with per capita availability of 427 grams per day as against the world average of 299 grams in 2022-23. India's contribution to global milk production stands at an impressive

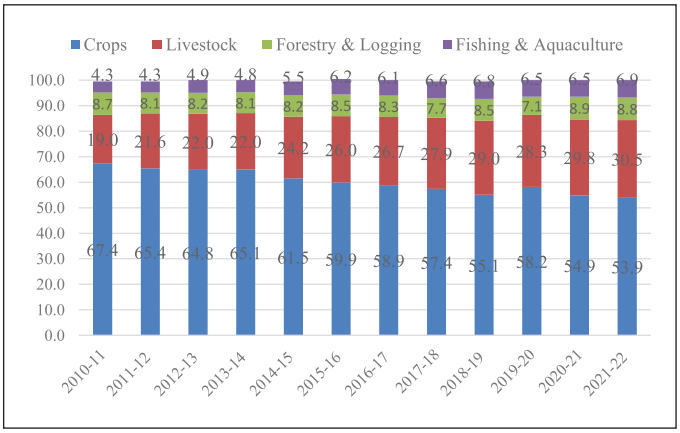
23 per cent. Total milk production in the country increased from 17 million tonnes in 1950-51 to 221 million tonnes in 2021-22, yielding an impressive growth rate of 3.68 per cent per annum (Table 1). Poultry production in India has also experienced remarkable progress, through the adoption of scientific farming practices and technological interventions. The egg production in the country has soared from 1,832 million to 1,29,600 million during the period from 1950-51 to 2021-22, showcasing an impressive annual compound growth rate of 6.18 per cent. As a result of robust performance of poultry farming in the country, India has become the third-largest producer of eggs globally, with the per capita availability of 95 eggs per year in 2020-21.

The aquaculture and fisheries sectors are also important sources of income and employment generation in India. It contributes more than 7 per cent to the total output of the agriculture and allied sectors. With its extensive coastline and diverse inland resources, India has emerged as the second-largest fish-producing country, accounting for 7.58 per cent of global production. In 1950-51, the total fish production in the country was 0.752 million tonnes, which has increased to 16.3 million tonnes in 2021-22, reflecting an annual compound growth rate (ACGR) of 4.42 per cent. The sector provides livelihood to about 16 million fishermen and fish farmers. The sector has been one of the major sources of foreign exchange earnings, with India being one of the leading seafood exporting nations in the world. During 2021-22, exports of fish and fish preparations stood at 1,398 thousand tonnes and valued at Rs. 57,910 crore. In order to foster sustainable development of fisheries sector, through the creation of additional infrastructure facilities, Fisheries and Aquaculture Infrastructure Development Fund (FIDF) with an impressive allocation of Rs. 7,522 crore was created in October 2018. The fund aims to elevate annual fish production to 20 million tonnes and generate over 9.40 lakh employment opportunities by 2022-23. Furthermore, on 10 September 2020, the Pradhan Mantri Matsya Sampada Yojana was launched, to bring about blue revolution through sustainable development of the fisheries sector. Under the scheme, total estimated investment of Rs. 20,050 crore is to be implemented over a period of 5 years from FY 2020-21 to FY 2024-25. The scheme sets an ambitious target to enhance the fish production to 22 million tons by 2024-25 and generate about 15 lakhs direct gainful employment opportunities.

Diversification of Agriculture

Agriculture & allied sectors consist of four major sub-sectors namely, crop sector, livestock, forestry, and fisheries. Over the past one decade, these sub-sectors have witnessed significant changes in their contribution to the total Value of Production (VoP) in agriculture. Fig. 3 reveals that the crop sector's contribution to GVA declined from 67.39 per cent in 2010-11 to 53.89 per cent in 2021-22, while the livestock sector's share in VoP shot up from 19.02 per cent to 30.47 per cent during the same period. Furthermore, the fishing and aquaculture sub-sector also experienced improvement in its contribution from 4.35 per cent to 6.86 per cent over the last decade. Within the crop sector, various categories have been included, such as field crops, plantation crops, horticultural crops, and narcotic crops. Notably, within the crop sector, there has been a shift towards the cultivation of commercial, plantation, and horticultural crops, including fruits, vegetables, spices, etc. The liberalisation of the Indian economy has created ample scope for the development of agricultural sector, driven by increased domestic and foreign demand.

Figure 3: Share of Different Sub-sectors in GVA by Agriculture (%)



Source: Monthly Bulletin, April 2022, Ministry of Agriculture and Farmers Welfare.

The liberalisation of the economy has led to a transformation of the farm sector, shifting from traditional food crops to commercial and horticultural crops, utilising modern scientific production techniques. The foreign trade of agricultural goods has witnessed a remarkable expansion, accompanied by a significant structural shift in the composition and direction of trade.

Trends in Agricultural Trade

Presently, India has not only achieved self-sufficiency in food grains but also emerged as a prominent net exporter of agricultural products, occupying seventh position in the world. Though the exports of agricultural commodities started to pick up after 1970-71, a substantial boost was witnessed from 1994-95 onwards, following the implementation of global trade reforms and progressive reductions in agricultural tariffs under the WTO regime.

The export basket of India includes a diverse range of agricultural and allied products, such as rice, pulses, fruits, vegetables, tea, coffee, tobacco, spices, sugar & molasses, cashew, raw cotton, fish, meat, and processed food. In 1960-61, these exports amounted to Rs. 284 crore. Over the course of past three decades, there has been a remarkable growth, with agricultural exports reaching Rs. 6,013 crore in 1990-91 and further escalating to Rs. 3,75,742 crore in 2021-22, at the rate of 14.27 per cent per annum (Table 3).

Table 3: Trends in Agricultural Exports and Imports of India (Amount in Crore)

Years	Agriculture Exports	Percentage of Agriculture Exports to Total Exports	Agriculture Imports	Percentage of Agriculture Imports to Total Imports	Agriculture Trade Balance
1990-91	6013	18.49	1206	2.79	4807
1995-96	20398	19.18	5890	4.8	14508
2000-01	28657	14.23	12086	5.29	16571
2005-06	45711	10.78	15978	3.26	29733
2010-11	113047	10.28	51074	3.41	61973
2015-16	215396	12.55	140289	5.63	75107
2020-21	308830	14.30	154511	5.30	154319
2021-22	375742	11.94	231850	5.07	143892
ACGR(%)	14.27		18.49		

Sources: (1) Agricultural Statistics at a Glance, (Various Issues) (ii) Economic Survey (Various Issues).

It is noteworthy that whereas the overall balance of trade in India has consistently been negative, the trade balance of agricultural goods has not only been positive but also increased nearly 30 times during the last three decades, which reflects the pivotal role of agriculture in generating foreign exchange for the nation. In the wake of liberalisation, the composition of Indian agricultural exports has undergone a substantial transformation. Traditional agricultural commodities such as tea, sugar, molasses, tobacco, cashew kernels, and oil cakes have given way to a more diversified range of value-added products. The shift encompasses processed and canned fruits, juices, vegetables, meat, fish, and fish preparations, as well as various packaged goods. This shift towards higher value-added items demonstrates India's adaptability and ability to cater to the emerging global market's demands. The major export destinations of India's agriculture and allied products are Bangladesh, China, Iran, Indonesia, Japan, Malaysia, Nepal, the Netherland, Pakistan, Saudi Arabia, Thailand,

the UK, the USA, and the United Arab Emirates, etc. Despite a multifold expansion in agricultural exports, India's agri-export basket accounts for a little over 2.5 per cent of world agri-trade. Its overall share in total world exports has always been less than 1.7 per cent. Considering the diverse agro ecological zones in the country, there is huge scope to enhance its agricultural exports through focused interventions. In this direction, the Mission for Integrated Development of Horticulture (MIDH), a centrally sponsored scheme, was launched on 1 April 2014 for the holistic growth of the horticulture sector. The MIDH provides financial, technical, and administrative support to State Governments for the development of the horticulture sector, covering fruits, vegetables, root and tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa, bamboo, and saffron. Apart from this, to promote horticultural exports, several centres for perishable cargoes and for post-harvest handling facilities have been set up with the assistance of APEDA in the country.

Conclusion

Agriculture continues to remain the largest employment- generating sector and a major source of foreign exchange earnings. Over the past seven decades of planned economic development, Indian agriculture has made remarkable progress, ensuring food security for its growing population and emerging as the seventh largest exporter of agricultural products worldwide. The country has experienced substantial growth in food grain production, outpacing population growth and resulting in a significant increase in per capita food availability. The liberalisation of the economy has led to a transformation of the farm sector, shifting from traditional food crops to commercial and horticultural crops, utilising modern scientific production techniques. The foreign trade of agricultural goods has witnessed a remarkable expansion, accompanied by a significant structural shift in the composition and direction of trade. India's agricultural export basket has become more diversified, encompassing value-added and non-traditional items such as processed and canned fruits, juices, vegetables, meat, fish, and other marine products. The yield per hectare of all crops in the country has exhibited a consistent rising trend. However, it is important to acknowledge that India still lags far behind the developed countries in terms of yield per hectare for both field and plantation crops.

In order to enhance agricultural productivity, it is crucial to embrace modern farming practices and employ quality inputs effectively and efficiently. This entails the adoption of HYV seeds, judicious utilisation of water, fertilisers, and pesticides. Furthermore, promoting easy access to institutional credit at affordable interest rates is essential, as it facilitates the acquisition of modern agricultural machinery, tools, equipment, and other costly inputs. In addition to these measures, timely government intervention in agriculture marketing is essential to support farmers in maximising their profits and ensuring fair market conditions. ❑

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