TECHNOLOGIES FOR SUSTAINABLE AGRICULTURE (SA) DEVELOPMENT

Background

Agriculture and related sectors provide a living for more than 55% of India's population. 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 services and manufacturing. In 2000, the percentage of population employed in agriculture was 60.5%, indicating a clear shift away from agriculture.

- 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.
- Although agriculture sector's workforce as well as 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.

Sustainable Agriculture (SA) is The Key: Few Technologies That Can Help

Adopting SA practices in India is crucial for long-term sustainability of the agriculture sector.

Indian Govt have launched several initiatives to promote SA practices such as National Mission on Sustainable Agriculture (NMSA), National Food Security Mission, PM Fasal Bima Yojana (PMFBY), Soil Health Card, Rashtriya Krishi Vikas Yojana (to promote **INM** – Integrated Nutrient Management – through soil testing and use of organic fertilizers.) etc. 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:

> Sustainable Agriculture is a farming method that considers **soil, environment,** and **community's long-term health**. It is critical to meet *rising food demand while protecting natural resources* for future generations. It is a much-needed alternative to input-intensive agriculture, which in long-term degrades the topsoil, results in declining ground water levels and reduces biodiversity.

- **Precision Farming**: It involves sensors, GPS mapping, and data analytics to monitor and optimize crop performance. This can reduce the use of fertilizers and pesticides, improve water management, and increase yield. PM Krishi Sinchayee Yojana encourages precision farming techniques.
- **Agroforestry**: It 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. This method can reduce the need for pesticides and herbicides while increasing crop yields and lowering transportation costs.
- **Hydroponics**: It is gaining traction in various Indian states as a sustainable farming method that allows for efficient water and nutrient use, year-round cultivation, increase in yield, and reduced dependence on traditional agricultural practices. Hydroponics involves growing plants in nutrient-rich water ***without soil***. It can potentially revolutionize 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**: These technologies can help reduce labour costs, improve crop yields, and reduce the use of fertilizers and pesticides.

Gaps Identified in Adopting Sustainable Agriculture (SA) Development

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 SA practices is farmers lack of awareness and knowledge. Many farmers must know the benefits of sustainable agriculture practices or how to implement them effectively. According to a survey conducted by NSSO, *only 6% of farmers in India* have access to information on modern agricultural practices. To address this issue, the Government of India has 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.

2. **Lack of Infrastructure and Technical Support**: Adopting SA practices often requires significant infrastructure and technical support. However, many farmers need access to these resources, particularly in remote areas.
3. **Limited Access to Finance:** A practices often require significant infrastructure and technology investments. However, many tiny and marginal farmers need more access to finance to make these investments.
4. **Inadequate Policy and Regulatory Framework**: Adopting SA practices is not always supported by India's policy and the regulatory framework. One such evidence is that the NMSA (National Mission for SA) receives only 0.8% of the Ministry of Agriculture budget, indicating a neglect of SA in policy corridor.
5. **Limited Research and Development:** There is a need for more research and development in SA 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.
6. **Low Productivity**: Agriculture in India is characterised by low productivity, a significant barrier 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.
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.

Conclusion

SA practices have the potential to boost agricultural productivity, reduce production cost, enhance quality of crops, increase farm's income, promote gender equality etc. The Global Food Security Index (GFSI) indicates that a lack of access to fresh, clean water and land resources and a lack of political commitment to adaptation and SA practices are all factors associated with gender inequality.

The Indian Govt has launched several programmes to support SA practices, including Paramparagat Krishi Vikas Yojana, Soil Health Card Scheme, Rashtriya Krishi Vikas Yojana, Pradhan Mantri Fasal Bima Yojana, Pradhan Mantri Krishi Sinchayee Yojana, and National Agriculture Market (e-NAM) platform. But more needs to be done. A multifaceted approach will be necessary to close all the gaps identified above in adopting SA, which includes necessitating investments in R&D, regulatory and policy reforms, and creating infrastructure and extension services to encourage adopting SA practices.

- Farmers can develop sustainable farming systems that promote environmental, social, and economic sustainability by **adopting advanced technologies**.
- **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.
- Furthermore, **improved crop varieties, rainwater harvesting, and drip irrigation systems** are examples of SA practices in India. These practices not only increase crop yields but also ensure the efficient use of natural resources.

Some Agri Tech Startup Case Studies

- **AgriApp Technologies Pvt. Ltd**. is an IT, ICT, and loT-enabled technology company intending to bring technology to the agriculture and food sector. 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 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.
- **Aumsat** provides precision-driven, satellite-based, Al-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.
- **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.

CLIMATE SUSTAINABLE AGRICULTURE

Agriculture in coming years is sure to face formidable challenges from adverse climatic changes which affects food production and productivity. Rising temperatures due to global warming have already started eating up the yield of food grains and other agricultural crops. The food security challenge will only become more difficult, as the world will need to produce about 70 % more food by 2050 to feed an estimated 9 billion people, Thus, the world needs to find ways to sustainable agriculture and the answer lies in **Climate Smart Agriculture (CSA).**

Global Warming Challenge

- The situation for agri-production is a two-way challenge: first, to shield the production from the 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, 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 ^{O}C could lead to 20-40 % reductions in cereal grain output.
- The **5th Assessment Report** by **IPCC** (Intergovernmental Panel on Climate Change) predicts that the temperature will increase by 2.5-5.8 ^{O}C before 2100. With such an increase, the damage to crops can only be imagined.
- 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 oilseeds oils.
- Producing crops with 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 condition 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 induces GHG emissions. Agriculture is one of the main sources of methane and nitrous oxide emissions. So, any solution for sustainable agriculture must take care of saving environment from agriculture along with saving agriculture from the environment.

What is Climate-Smart Agriculture (CSA)

World Bank defined CSA as an **integrated approach to managing landscapes - cropland, livestock, forests, and fisheries**, that address the *interlinked challenges of food security and climate change*. Basically, the CSA targets three outcomes simultaneously:

- **Increased Productivity** - A 2020 World Bank report found that nearly 690 million people (8.9 % of the global population) are hungry. Saving this population from hunger and providing them with necessary nutrition are the two major dimensions of increasing the productivity of agricultural produce.
- **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 season and variable weather patterns are the major objectives under enhancing resilience.
- **Reduced Emissions**- 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

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.

- **Use of Quality Seeds and Planting Materials of well-adapted crops and varieties**

- The varieties being bred to resist the detrimental effects of climate change should be resistant to the climate-related phenomenon. Droughts, flood, extreme heat waves, extreme cold, and salinity are the most common manifestations of global warming for which crop varieties are being bred.
- There are other impacts too, like pest attacks, higher frequencies of frosts at the seedling and/or pollination stages, high temperature at grain-filling stage, heavy rains that compress soil etc. Climate-smart crops have to take care of all these situations in order to secure food for the world population.
- To effectively implement a climate-smart agriculture strategy, there are some components that are recommended by FAO:

  (i) 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.

  (ii) 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.

- **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.
  - 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**
  - 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, minimise the risk to human health and environment, and disrupt agricultural ecosystem as little as possible.
- **Improved Water Use and Management**
  - 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.
  - So, to achieve sustainability in agriculture, water resource management comes on the 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.

- 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, when combined with conservation agriculture, reduce CO_2 emission, and minimise soil disturbances that are common in tillage-based crop system. The timely availability of agricultural equipments such as drills, harvesters etc permits producers to plant, harvest, and process crops in an efficient manner.

Government Initiatives Towards Achieving CSA

In India, the decline in major crop yields due to climate change effects between 2010 and 2039 could be as high as 9 %. The productivity of crops is likely to decrease 10-40 % by 2100 due to adverse climate. The GoI estimated the annual loss of US $ 10 billion due to adverse effect of climate change. To mitigate the impending impact, the Government has taken many initiatives, some of which are as follows -

- **National Innovation on Climate Resilient Agriculture (NICRA):** Launched in 2011 by ICRA, 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 NMSA works through adoption of sustainable development pathway by progressively shifting to environment friendly technologies, adoption of energy efficient equipment, conservation of natural resources, enhanced water use efficiency, soil health management, location-specific practices, integrated farming, etc.
- **National Adaptation Fund for Climate Change (NAFCC):** 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.
- **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

technology to be applied at farm level. Under this scheme, so far 146 Biotech-KISAN Hubs have been established covering 15 agroclimatic zones and 110 aspirational districts in the country.

- **Sub-Mission on Agro-forestry:** It was launched in 2016-17 with the objective of planting trees on farm bunds.
- **National Livestock Mission:** This Mission was initiated by the Ministry of Agriculture and Farmers' Welfare in 2014-15 focusing mainly on livestock development through sustainable approach ultimately protecting the natural environment, of 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 % 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. ICAR along with NARS has developed **District Agriculture Contingency Plans** for 650 districts in India and is being updated regularly. The fertiliser policies in India have grown positively by enhancing crop production and productivity. The additional foodgrain production of 13.66 Mt using fertilisers avoided the conversion of 11.48 million hectares of forest land to be 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.

DRYLAND FARMING

Dryland farming has assumed special importance in the view of looming crisis of global warming and climate change. It 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. These areas have generally poor or degraded soils with *low water holding capacities and multiple nutrient deficiencies.* 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. In dryland areas, landholdings are generally small (less than 2 hectares), and scattered which makes farming less renumerative. 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. Despite many constraints, with the understanding of local climate & soil conditions, the selection of suitable crops, and the use of appropriate technologies, dryland farmers can produce bountiful of crops even in driest condition.

Distribution of Dryland Farm

- 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

Associated Benefits of Dryland Farming

- It helps conserve water resources, minimises soil erosion and promotes sustainable agriculture.
- Technologies for dryland farming can help mitigate the adverse impacts of climate change by reducing greenhouse gas emissions and promoting soil carbon sequestration.
- Dryland farming helps increase the amount of organic matter in the soil, improving its fertility, and structure.
- The dryland areas have tremendous potential for increasing food production which, if realised, would address the problem of hunger and malnutrition prevailing in society.

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'**. 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. As per estimates, nearly 40 % 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 India, close to 80 million hectares (56 %) is under dryland farming which produces nearly 44 % of total food grains in the country.
- Globally, 41 % of land surface is covered by drylands, of which 72 % lies in developing counries.
- 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 Deccan Plateau of Andhra Pradesh, and the Tamil Nadu highlands.
- 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.

Contributions of Dryland Farm

- 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.
- 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.
- Almost 80% of the Sorghum and Maize, 90 % of pearl millet, 75 % of oilseeds, and 95 % of pulses are obtained from dryland agriculture. 33 % of wheat and 65 % of rice are also still rainfed.
- **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, pests and diseases, and need minimum care.
- **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 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. The improvement in production of oilseeds in rainfed areas will save valuable forex reserve.
- Pulses are called climate smart crops because they require less water, survive weather flcutuations, improve soil health, and provide more nutrition per drop.

Strategies and Schemes

- There is a vast scope to increase the productivity of dryland agriculture from current average of **1.2 tonnes per hectare to 2.0 tonnes per hectare**.
- This potential can be easily achieved by inclusion of new technologies, diversification of crops, adoption of drought-tolerant varieties, and implementation of moisture retention techniques in the field.
    - The introduction of crop diversification and integrated farming systems in dryland regions has brought many changes in terms of area and yield.
    - Selection of ***proper cropping system*** suitable to the area is one of the key strategies in drylands.
    - Similarly *proper tillage, fertiliser management, proper weed control, and adoption of plant protection measures* also contribute towards enhancing productivity.
    - The selection of ***drought-tolerant varieties*** is another key technique.
    - 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 etc. Cover crops are plants that are planted to cover the soil rather than for the purpose of being harvested.

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. **Check dams and farm ponds** are common water harvesting structures in rainfed regions that help provide life-saving irrigation during long dry spells.

- 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 adaptive research, ICAR established **CRIDA (Centre Research Institute for Dryland Agriculture)**. The CRIDA has played an important role in development and disseminating improved rainfed farming technologies in different agro ecological regions of country.
- 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.
- **Agricultural Contingency Plans** for 650 districts have been made available online for policy makers to take decisions in the vent of delayed monsoons and other extreme weather events.

- 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 climate variability. The scheme aims to cover an area of 6.74 lakh hectare with location-specific Integrated Farming System.
- Schemes such as per crop more drop, Soil Health Card, and Paramparagat Krishi Vikas Yojana are also contributing in improvement of dryland agriculture.

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 dryland agriculture system. Primary focus may be on rain water harvesting and soil health management.
- As per the vision, cutting edge technologies such as remote sensing and GIS will be used for land-use planning.
- Nanotechnology based products and processes will also be developed for application in dryland agriculture.
- 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.

SUSTAINABLE AGRICULTURE CHALLENGES AND WAY FORWAD

According to 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".

Five Principles of SA Practices

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

1. Continuous production of crops
2. Protection and conservation of natural resources like soil, water, etc.
3. Improve the social and economic well-being of the people.
4. Use state-of-the-art technology.
5. Require government support for the institutional changes in production, marketing, law enforcement, etc.

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

Some Major Sustainable Agriculture Practices

SA is a much-needed alternative to input-intensive agriculture, which in long-term degrades the topsoil, results in declining ground water levels and reduces biodiversity. Some of the practices of SA are -

- **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. 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.
- **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.
- **Adopting Agroforestry:** Discussed earlier in Article 1.
- **Grow the Cover Crops**: Discussed earlier in Article 3.
- **Integrated Pest Management system**: Discussed earlier in Article 2.
- Other methods include polyculture, biofuels, urban agriculture, etc.

Sustainable Agriculture and Use of Technology

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),
- 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.

National Mission for Sustainable Agriculture

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 4 %)** of all Indian farmers. Many are practiced by less than 1 %.
- **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**. 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 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 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.
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.

Sustainable Agriculture In India: Challenges and Recommendations

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 % 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.
- 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.

Based on the above context, some key recommendations for successful adoption of SA 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 for research** should be provided 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.

ORGANIC FARMING STATUS AND POTENTIAL

From the 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 long term. Punjab and Haryana have borne the brunt of this excessive use of fertilisers and pesticides. Even with recommended doses of NPK, micronutrients deficiency has become a yield-limiting factor over the years. There is a possibility of **nitrate contamination** in groundwater above permissible limit due to excessive use of nitrogenous fertilisers.

Looking at these impacts, the Government has launched a **National Mission on Soil Health Card** to promote soil test-based and balanced fertiliser application. The Govt 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 end-to-end support for farmers engaged in organic farming, i.e., from production to processing, certification, marketing, and post-harvest management support.

It is time to talk about nutritional security, not just food security (which consists of carbohydrates only). Organically grown food generally contains higher levels of antioxidants, micronutrients, no harmful chemicals, pesticides etc.

Organic Farming: India and World

Organic farming is considered a climate-friendly farming practice that promotes low external input usage, recycling, reuse, and reduced use of synthetics in farming. It is practised in 187 countries, and 72.3 million hectares of agricultural land were managed organically by at least 3.1 million farmers worldwide, 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).

India is home to 30% of total organic producers in the world: 27, 59,660 total farmers. 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 2 % of the 140.1 million ha net sown area in the country.

PKVY	MOVCDNER
• Under PKVY, farmers of various states 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) for creation of FPO, support to farmers for organic inputs, quality seeds/ planting material, training, hand holding, and certification. • Under the scheme, assistance is provided of Rs. 7500/ha for 3 years for training and capacity building whereas, Rs. 2700/ha 3 years is provided for certification. • Financial assistance of Rs. 20 lakh/cluster of 1000 ha for 3 years is provided for value addition and infrastructure creation. • 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.	• Under MOVCDNER, an assistance of **Rs. 46,575/ha** for 3 years is provided for the same. • Under MOVCDNER, there is also a provision of financial assistance of **Rs. 10000/ha for 3 years** for training, handholding, and ICS documentation. • 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 Rs37.50 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.

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 last three years (2019-20, 2020-21, 2021-22) which constitute 2.10 %, 2.72 % and 4.22 % of cultivable land of 140 million ha.

A few states have taken lead in improving organic farming coverage. **Madhya Pradesh** tops the list with 0.76 million ha of area under organic cultivation. The top three states – MP, Rajasthan, & Maharashtra – account for half the area under organic cultivation. The top 10 states acoount for about 80% of the total area under organic cultivation. During 2016, Sikkim achieved the remarkable distinction of converting its entire cultivable land under organic cultivation, was declared the forst organic state.

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.
- 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, etc.
- The organic food export realisation was around Rs 5249 crore. Organic products are exported to USA, EU, 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 the products, followed by oilseed (12.85 %), cereals & millets (12.71 %), sugar (4.77 %), Tea & coffee (2.16 %) etc.

- The primary reason for India's relatively low share in world organic export is our huge domestic consumption base for agriculture products, due to our large population base. According to IMARC report, Indian organic food market is expected to exhibit a CAGR of 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 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.
    - To promote direct marketing of organic products from farmers to end consumers. A dedicated web portal www.jaivikkheti.in/ has been created to jhelp farmers get a better price for their products.
    - Two types of organic certification have been developed for quality assurance of organic products – **Third Party Certification** by Accredited Certification Agency under NPOP under Ministry of Commerce & Industry and Participatory Guarantee System **(PGS-India)** under MoAFW.

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

MILLETS: FUTURE OF SUSTAINABLE AGRICULTURE

India has been the **largest producer of millets** globally. 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**. The production target fixed 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.

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 % of the world's production. 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 % and 20 %, respectively. Further, average productivity in India is higher at **1,239 Kg per hectare**, compared to world average of 1,229 kg/ha. 10 States and 6 states (Gujarat, Rajasthan, Haryana, Karnataka, Maharashtra, and UP) account for **98 % and 83 %** of total millets production in country respectively.

Data for 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)

Nutritional Value of Millets

Millets have gained acceptance as nutri-cereals all over the world. The year 2018 was declared as the **National Year of Millets** and 2023 is being declared the **International Year of Millets**. 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. Some nutritional benefits of millets include low absorption of fats and low glycemic indices.

Environmentally Sustainable

- Millets have the capacity to reduce overdependence on more commonly raised water-guzzling crops like rice.
- 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.
- While rice requires temperature above 25 ^{O}C with an annual rainfall of above 100 cm, bajra requires 40-60 cm of annual rainfall, and jowar can be grown in areas with less than 20 cm of annual rainfall. Moreover, millets as compared to rice and wheat (100-200 days) require a shorter duration (60-90 days) between sowing and harvesting.

Awareness To Boost Millet Consumption

- 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 TPDS, PM Poshan Shakti Norman, 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, facilitating buyer-seller meets, organising promotional campaigns, *inclusion of millets in 'One District One Product'* 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 Govt of India, and awareness programmes through the FCI and the Central Warehousing Corporation.

Concluding Remarks & Way Ahead

- Indian millets have registered respectable demand in international markets. The need of the hour is to ensure the emergence of an appropriate supply-chain and value-chain from pre-production to processing to 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 (828) 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 global demand-pull for millets produced in India.
- 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.

CONTRIBUTION OF WOMEN TO SUSTAINABLE AGRICULTURE DEVELOPMENT

Rural women contribute significantly to agriculture as paid labourers, unpaid labourers and managers. They 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 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.

Women's role has been growing with **"feminisation of agriculture"** as men are migrating to urban areas in search for productive employment, leaving women to manage the farmlands. While women are now de-facto playing multiple roles in managing the farm and non-farm activities, their typical work continues to be limited to less skilled jobs such as sowing, transplanting, weeding, harvesting , rearing livestock etc. The participation of women as unpaid subsistence labourers in agriculture work is also quite common. Some of the issues and challenges typically faced by rural women engaged in agriculture are listed below:-

1. **Lack of Recognition of Women's Role**: Women farmers in India work about 3,300 hrs per crop season, more than double their male counterparts. 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.
2. **Skill Development**: Due to lack of skill, women are relegated to long working hours in low skill farm activities that are time-consuming and labour-intensive. 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 % of Indian women engaged in agriculture are illiterate, creating an education barrier that prevents them from participating in more skilled labour sectors.
3. **Land Ownership and Records**: Only 13.9 % of operational holdings are owned by women. 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.
4. **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.
5. **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 such as -

- ***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.
- ***Mahila Kisan Sashaktikaran Pariyojana*** has helped over 8.6 million SHG women access resources and services for enhanced agricultural productivity.

- The financial inclusion and financial literacy achieved by women farmers through PMDJY has helped with uninterrupted access to financial aid for agricultural operations.
- 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 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 (SAU) 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.

Collectivism 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. Likewise, in absence of modifications to tenancy laws by State Governments alternative solutions can be employed, like the issue of 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), 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.

AGRICULTURE PAVING THE WAY FOR SUSTAINABLE GROWTH

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 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. The contribution of agriculture and allied sectors to foreign exchange earnings has also declined from 44.24 % in 1960- 61 to 11.94 % 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.

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

Trends in Agricultural Production

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 %. It is noteworthy that India's foodgrain production has outpaced its

population growth, with a compound growth rate of 2.61 % per annum as compared to the population growth rate of 1.95 % 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.

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.

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

- 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.

Trends in Livestock Production

- 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.
- Poultry production in India has also experienced remarkable progress, through the adoption of scientific farming practices and technological interventions.
- 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.

Trends in Agricultural Trade

- The export basket of India includes a diverse range of agricultural and allied products, such as rice, pulses, fruits, vegetables, tea, coffee, tobacco,

Year	Agriculture Exports	% of Agriculture Exports to Total Exports	Agriculture Imports	% 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		

spices, sugar & molasses, cashew, raw cotton, fish, meat, and processed food.

- 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 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.
- 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.

Conclusion

Agriculture continues to remain the largest employment-generating sector and a major source of foreign exchange earnings. The country has experienced substantial growth in food grain production, outpacing population growth and resulting in a significant increase in per capita food availability. 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. 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.