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Role of Innovation for Sustainable Development in Agriculture: A Review

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ABSTRACT

Modern agriculture is mainly concerned with enhancing output as well as quality improvement. This paper examines current thinking of agricultural improvements through innovations, what forms it takes, involvement of stakeholders and the social economic benefits derived. Rather than adopting newly developed technologies, agricultural advances frequently include the adaptation of existing updated technologies. Sustainable development is the process of meeting human needs and improving living conditions without endangering natural resources. It is a philosophy that tries to address human needs while simultaneously protecting the natural system. Economic growth, human development and ecological sustainability are all part of the sustainable development philosophy. Various research articles have been studied for current study which highlights the importance of innovation in agriculture and its benefits. The policy ecosystem of agriculture in India under the National Mission for Sustainable Agriculture as well as future prospects and solutions for India are also highlighted. We have found that there is a need to look at the potential barriers while implementing sustainable agriculture practice and the options for overcoming or minimising these barriers.

Key words: Economic development, Living conditions, Sustainable development.

Present growth on a sustainable basis fulfils the needs of the present generation without affecting the future generation's ability to satisfy their demands for enhancement of quality products.

In agriculture, sustainability means that the land and resources utilised for agriculture should be passed down to future generations in a sustainable state, allowing them to continue farming while sustaining food security must manage lands, water and other resources in such a way that future generations can profit from sustainable development as well. Three key goals are integrated into sustainable agriculture development are environmental health, economic prosperity and the ability to maintain one's livelihood (Dutt, 2019).

Importance of agriculture in the Indian economy is demonstrated by its contribution to GDP and employment. Agriculture industry also has a substantial impact on the country's long-term economic growth. Agriculture determines the fate of a country like India, where, after decades of urbanisation, about two-thirds of the population still lives in rural areas and relies on agriculture for a living. As a result, if agriculture fails, it will be devastating for the economy, as reduced agricultural growth impacts employment and GDP (Dutt, 2019).

The study was conducted in 2021-22 at CSIR-IHBT (Institute of Himalayan Bioresource Technology), Palampur, Kangra, Himachal Pradesh.

Agriculture innovation

Adopting an innovative idea for agriculture can be extremely difficult. It is extremely problematic when the proponents of the new idea seem to have quite obvious advantages. It can be difficult to apply new ideas in rural areas, especially in less developed societies where people are set in their ways that have been established through time via trial and error. Rural sociologists and extension service specialists who study the spread of agricultural innovations have traditionally concentrated on speeding up the process (Rogers and Williams, 1983). Because of their pro-innovation orientation, different sociologists overlook the reality that "changing people's beliefs is an even more delicate job than surgery"(Sharp and Spicer, 1952).

Although invention is a prerequisite for innovation and great creativity typically follows the discovery of how to put in use. The terms advancement and invention are not interchangeable. However, going from one well-established approach to another does not constitute innovation. Agriculture, like other inventions, necessitates a great deal of inventiveness, a break from traditional practises and the development of new production capacity (Fig 1).

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The agricultural innovation system (AIS) concept emphasises the outcomes of knowledge generation and adoption by focusing on the totality of actors required to stimulate innovation and growth. The framework considers economic forces and the effects of organisational learning and behavioural change, nonmarket organisations and public policy processes (Anandajayasekeram, 2011). It emphasises the significance of regulatory frameworks and links to other sectors and the larger science and technology (S and T) society both within and outside the country. This framework also incorporates the value-chain concept implicitly (Anandajayasekeram, 2011).

Importance of innovation in the agriculture sector

There is broad agreement that innovation is critical for overcoming the human race's requirements, which include the need to enhance competitive agricultural strength, sustainable development and equality. The agriculture system has changed dramatically throughout most of history due to technological advances and the latest developments. These changes have prompted the creation of new products and manufacturing processes, resulting in an evolution of the industry itself. When this occurs, we are talking about agricultural innovation. The innovation in the agricultural sector is summarised in three categories (Sunding and Zilberman, 2001) (Fig 2).

1. Agro-chemical innovations

The evolution of technology in the agrochemical business has resulted in the development of a wide range of field goods, all targeted at raising production levels. Today, it is well understood that there are two different and differentiated trends in agricultural types: conventional and biogenic crops, which use both non-chemical fertilisers and pest control methods that are natural, biological and ecological. Today, there is a significant movement toward organic agriculture, as well as a reduction in the use of chemical pesticides, which has contributed to developing new agricultural products that meet these requirements (Sunding and Zilberman, 2001).

2. Mechanical innovations in agriculture

It focuses on technical processes of mechanisation of the agricultural method through machines that enhance the production methods in all phases, from land preparation and seed sowing to harvest. The use of mechanical aids (farm mechanization *e.g.* tractors, tractor-mounted harvesters, sprayers, bed-making machines, threshing machines, *etc.*) reduces of time, which would otherwise be much longer in manual processes. Seeders, agricultural tractors, combine harvesters and motor cultivators are the most common machines. Any cultivation process that requires transitioning to an industrial or pre-industrial phase must, by definition, make use of machinery in order to remain competitive in the market (Sunding and Zilberman, 2001).

3. Biotechnological innovations in agriculture

The laws and principles of physics are being applied to biological functions in new inventions of biophysics. Biophysics has been used in various ways to stimulate

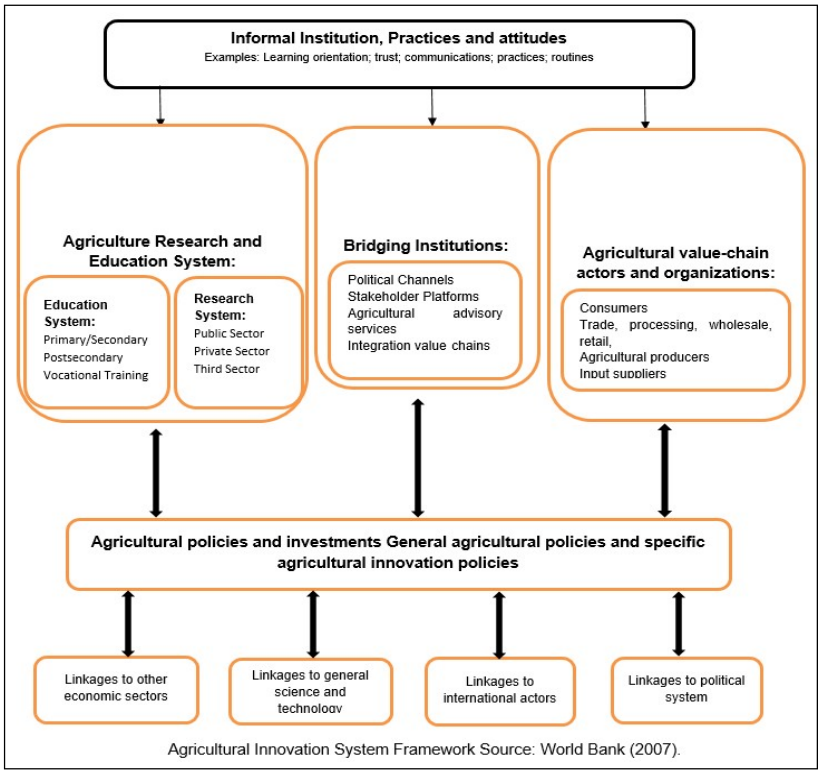
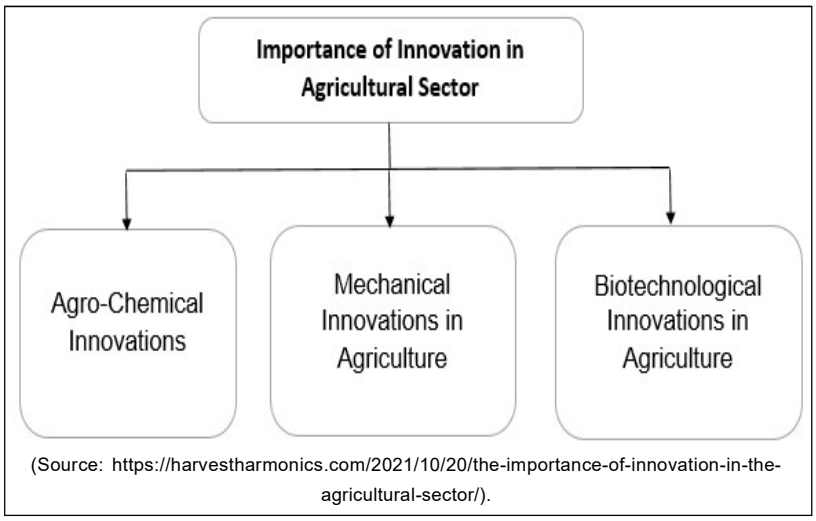


Fig 1: National agricultural innovation system framework.



(Source: https://harvestharmonics.com/2021/10/20/the-importance-of-innovation-in-the-agricultural-sector/).

Fig 2: Importance of innovation in agriculture sector.

biological mechanisms or assess the effects of other innovations, such as the aforementioned chemical innovations (Sunding and Zilberman, 2001). The Kyminasi Plant Booster is the first breakthrough in this field, stimulating the entire process of photosynthesis of plants at the same time (Harvest harmonics, 2022). The Kyminasi Plant Booster is an irrigation system-mounted set of sophisticated tailored micro transmitters that employ 3,000 or more low-frequency radio waves. When water first passes by the Kyminasi Plant Booster, it becomes active. Kyminasi Plant Booster is made specifically for each farm and is made to work among all crops that are grown in soil. There is no need for a power system or maintenance. A sophisticated communication system is used by irrigation equipment to increase photosynthesis and agricultural production in plants. This yields far more impressive results than other approaches that only address one aspect of this process. As you may have noticed, agriculture has always been innovative and it is a critical component of competitive nature, not only for the farmer in his small or large business, but also for an industry. Because technology motivates and enables this invention, it is critical to stay up to date on changes and new trends (Harvest Harmonics, 2022).

Advantageous circumstances for innovation

Similar to other industries, innovation in agriculture and rural development occurs within a specific socioeconomic context and is influenced by the presence (or absence) of favourable factors. These factors include, in particular and, adequate sustainable growth, organizational and regulatory frameworks, a pool of knowledge and human skills, favourable economic and financial terms, a society that values innovative thinking and a welcoming regional and international environment. Certain interactions and connections also influence innovation. In general, innovation processes emerge in response to various kinds of triggers, whether from the market, technology, society, or the landscape; regardless of nationality, they always require the addition of favourable conditions. As a result, it is critical to create a conducive environment for innovation, as well as the government (including the various sectors, ministries and organisations) should play a key role. The existence of economic practices that eliminate market distortions is a fundamental component of favourable conditions for innovations. Policies for science, technology and innovation, trademark and copyright policies, regulatory simplification whenever feasible and the development of financial and technical services to support innovation processes along the value chain links are all important. The presence of secure, dependable legal and regulatory frameworks with stable political aims that encourage innovation is a basic requirement; systems for innovation must also be created.

Agricultural Innovation Systems (AISs) are defined by two major factors: the number of participants involved and their dynamic interactions (French *et al*., 2014). Farmers and farmer organisations, providers of inputs or financial and technical services that enhance the creation or adaptation of new expertise, those who encourage knowledge exchange and learning, those engaged in value creation to production and those who enable market access are among the key participants. The AIS includes technology and research development organisations and governmental and non-governmental extension services that play an important role in enabling access to information and capacity building (French *et al*., 2014). If the AIS's work can be improved through better collaboration among participants, it will result in a greater ability for invention to respond to emerging needs and opportunities. It can also promote the private sector to invest in developing and implementing new technologies.

Fig 3 depicts the systemic interconnections in the AIS between all public and private, civil society and intellectual participants for creating, disseminating, adapting, learning

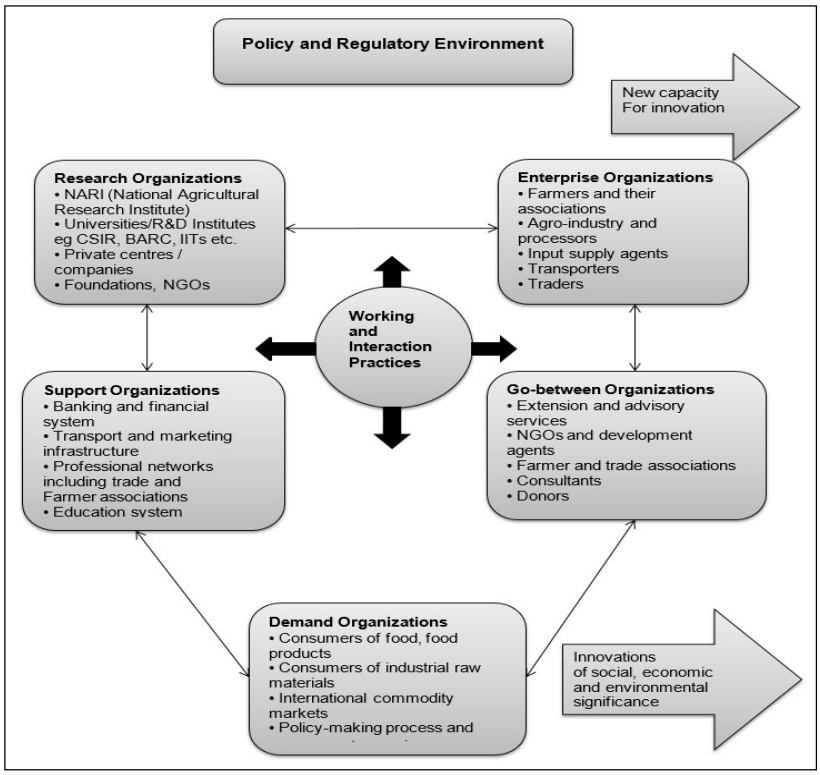


Fig 3: Dynamics of Innovation system.

and using knowledge to improve agriculture's ability to implement innovative ideas at all links of the value chain.

Policy ecosystem for sustainable agriculture in India

The National Mission for Sustainable Agriculture (NMSA) has promoted sustainable agriculture in India since 2014-15. Agroforestry, rainfed areas, water and soil health management, climate impacts and adaptation are among the many initiatives that make up this system. Aside from the NMSA, the Pradhan Mantri Krishi Sinchai Yojana encourages the use of precision farming methods such as micro-irrigation, as well as the Integrated Watershed Management Program that encourages water recycling (PRS India, 2022). However, NMSA's budget allocation is negligible (0.8%) in comparison to the Ministry of Agriculture and Farmers Welfare's entire budget. In addition to the ministry of agriculture and farmers welfare-budget of INR 142,000 crore, the central government additionally spends roughly INR 71,309 crore each year on fertilizer subsidies (PRS India, 2022).

Agriculture, Cooperation and Farmers' Welfare, which implements policies and programs relating to crop husbandry and manages agricultural inputs and Agricultural Research and Education, which coordinates and advances agricultural research and education, are the two departments that make up the Ministry of Agriculture and Farmers Welfare.

With a 14% yearly increase from 2019-20, the Department of Agriculture, Cooperation and Farmers' Welfare would receive Rs 1, 23,018 crores in 2021-22 (PRS India, 2022. Three programmes under this department are proposed to receive 76% of the Ministry's budget: the income support programme *i.e*. PM-KISAN (49%); the interest subsidy on short-term loans to farmers (15%) and the crop insurance programme *i.e*. Pradhan Mantri Fasal Bima Yojana (12%) (PRS India, 2022).

In 2021-22, the Agricultural Research and Education department would get Rs 8,514 crore, up 6% from 2019-20. In 2021-22, the Indian Council of Agricultural Research (ICAR) received 63 per cent of the department's allocation (PRS India, 2022). So, while the Government of India acknowledges the importance of promoting sustainable agriculture, the emphasis continues to remain heavily skewed toward green revolution-led agriculture.

In India, there are 30 sustainable agricultural practices (SAPs) (CEEW, 2021). Some people are solely interested in one facet of agriculture (we call them practices). Others, though, are more holistic when it comes to agriculture as a whole or most of it (we call them systems). Eight of the thirty SAPSs (Sustainable Agriculture Practices) practices receive-some financial support through various central and state government programs. Organic agriculture, integrated farming systems, rainwater harvesting, shape agriculture (terraces), composting, mulching, precision farming and IPM (Integrated Pest Management) are examples of these SAPs. Organic agriculture has received the most policy attention, with Indian states enacting separate organic farming policies (CEEW, 2021) (Fig 4).

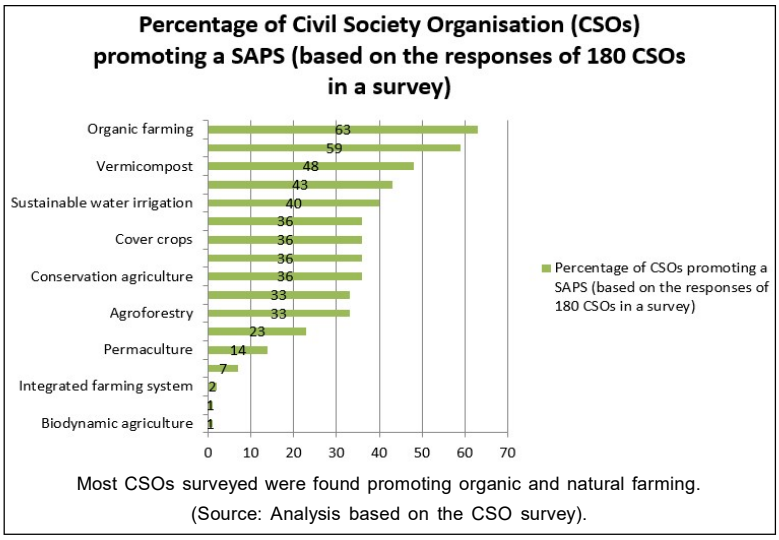


Fig 4: Percentage of Civil Society Organization.

Benefits of innovation in agriculture

According to data collected by government agencies, India is primarily an agrarian economy that employed 58 per cent of the population in 2019 (IBEF, 2022). The agriculture sector in India is predicted to increase because of consistent demand, advantage of the culture to live in rural areas and adopting farming practices and policy backing opportunities to promote commercial crops through agripreneurship.The innovation in the agriculture sector has great benefits *e.g.* tissue culture, hydroponics, aeroponics *etc*.

1. The major source of livelihood

Agriculture is a major source of income. More than 58 per cent of India's population earns a living through agriculture in some form or another. Agriculture, forestry and fishing were estimated to generate Rs. 19.48 lakh crore (US$ 276.37 billion) in FY20 (IBEF, 2022). Agriculture and allied sectors contributed 17.8 per cent of India's gross value added (GVA) at current prices in FY20. Following the pandemic-induced contraction, buyer costs in India will return to expansion in 2021, increasing by up to 6.6 per cent. Due to its huge possibilities for value addition, especially in the food processing business, the Indian food industry is primed for massive expansion, with its contribution to the global food trade expanding yearly. India has the world's sixth largest food and grocery market, with retail accounting for 70 per cent of total sales. The food processing sector in India is one of the country's largest, accounting for 32 per cent of the entire food market. It is ranked fifth in terms of production, consumption, export and predicted growth (IBEF, 2022). People who rely on agricultural activities in one way or another for a living. People in affluent countries such as the United States, Japan and Germany are less reliant on agriculture than in India.

2. Improves productivity

More output is produced when new technology is used than when primitive methods are used. The use of cutting-edge technology increases the productivity of both land and labour. Innovation will aid in improving efficiency and productivity in proportion to labour time. Total food grain production in the country reached a record 310.74 million tonnes in FY 2020-21, up 13.24 million tonnes from the preceding calendar year's production of 297.50 million tonnes (Directorate of Economics and Statistics, Department of Agriculture and Farmers Welfare, 2021-22).

- Rice production reached a new high of 124.37 million tonnes in 2020-21. It is 5.5 million tonnes higher than the five-year average of 118.87 million tonnes.
- Wheat production reached a new high of 109.59 million tonnes in 2020-21. It exceeds the average wheat yield of 107.86 million tonnes by 1.73 million tonnes.
- Nutri/ Coarse Cereals production reached 51.32 million tonnes, up 3.57 million tonnes from the 47.75 million tonnes produced in 2019-20.
- Total pulses production in 2020-21 reached 25.46 million tonnes, up 2.43 million tonnes from the previous five-year average of 23.03 million tonnes.
- In 2020-21, total oilseed output is predicted to hit a new high of 35.95 million tonnes, up 2.73 million tonnes from the previous year's yield of 33.22 million tonnes.
- Sugarcane production in the country reached 405.40 million tonnes in 2020-21. Sugarcane production in 2020-21 was 34.9 million tonnes higher than the previous year sugarcane cultivation of 370.5 million tonnes.
- Cotton production reached 35.25 million tonnes which was 0.81 million tonnes less than the average cotton production. Jute and Mesta production is estimated to be 9.35 million tonnes.

3. Creates employment opportunity

Indian agriculture employs and provides work for the vast number of the rural Indians. Agriculture and allied agro-industries provide a living for over 70% of the inhabitants in rural and backward areas. When a country's policy supports

innovation, multiple jobs are created in research and development and agriculture. According to the World Bank's collection of economic growth compiled from officially recognised sources, agriculture employment (per cent of total employment based on modelled ILO estimate) in India has been reported at 41.49 per cent in 2020 (Trading Economics India, 2022) (Fig 5).

4. Source of industrial growth

Agriculture contributes significantly to industrial development by providing industrial raw materials. Sustainable agriculture is essential for the farming industry's implementing more energy-efficient and resource-efficient infrastructure. Sustainable agriculture professionals can advance by focusing on systems with a lower environmental impact. The following are some recent agricultural developments (IBEF, 2022).

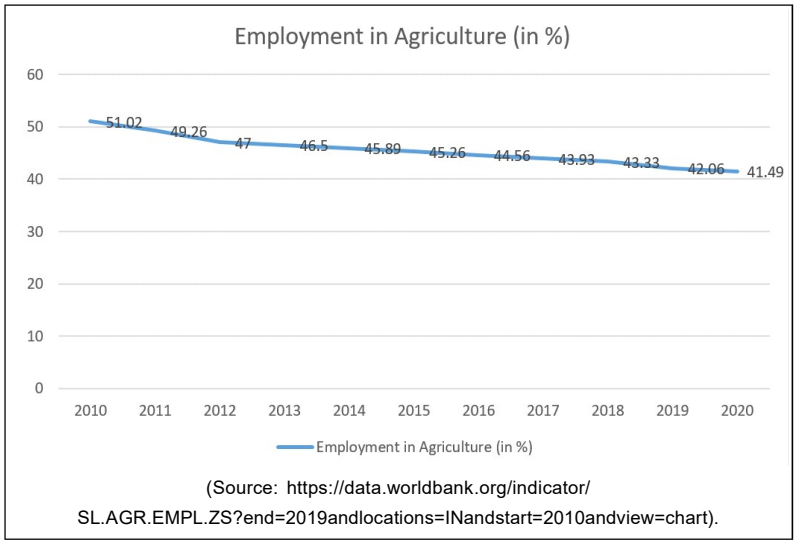
- Between 2017 and 2020, India received $1 billion in agritech financing. With strong investor interest, India ranks third in terms of agritech funding and the number of agritech start-ups. By 2025, Indian agritech start-ups will likely get $30-35 billion in investment (IBEF, 2022).
- The country's oldest large-scale fertiliser company reached 1 million output and sales in March 2020 (IBEF, 2022).
- The development of Nestle India's ninth factory in Gujarat will cost Rs 700 crore (US$ 100.16 million) (IBEF, 2022).
- In November 2019, Haldiram signed a deal with Amazon's worldwide sales program to sell its specialties online in the United States (The Economics Times, 2019).
- Coca-Cola introduced 'Rani Float' fruit juices in November 2019 as a way to branch out from its signature fizzy drinks (Business Today, 2019).

5. Source of food supply

Agriculture is the primary source of food supply for all countries worldwide, whether they are underdeveloped, developing, or developed. The demand for food is increasing rapidly due to the large population pressures in underdeveloped and developing countries, as well as their rapid growth. If agriculture fails to meet the rising demand for food products, it negatively impacts the economy's growth rate. Raising food supply through the agricultural sector is thus critical for an economic growth of the country. For the fiscal year 2021-22, the Department of Food and Public Distribution has been granted Rs 2,42, 836 crore (99 per cent of the Ministry's budget). There is a 48 per cent increase in annual spending from 2019 to 2020 (PRS India, 2022) (Table 1).

6. Increase in foreign trade

A large portion of our agricultural output is exported to other countries. The export of agricultural and allied commodities was Rs. 2.74 lakh crore between April 2020 and February 2021, up from Rs. 2.31 crore during this period last year, resulting in a rise of 18.49 per cent (Press Information Bureau, 2022). The country's trade of (non-Basmati) rice has increased by 132 per cent. Non-Basmati rice exports increased to Rs 13,030 crores through 2019-20 to Rs 30,277 crores through 2020-21. This increase in exports is due to a



(Source: https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?end=2019andlocations=INandstart=2010andview=chart).

Fig 5: Employment in agriculture.

Table 1: Allocation to the ministry (in Rs crore).

Department	2019-20 Actuals	2020-21 Revised	2021-22 Budgeted	% change (annualised) in 2021-22 over 2019-20
Food and public distribution	1,15,173	4,38,649	2,53,974	48%

(source: Expenditure Budget, Union Budget 2021-22; PRS).

number of factors, the most important of which is India's entry into new markets, namely Timor-Leste, Papua New Guinea, Brazil, Chile and Puerto Rico. Togo, Senegal, Malaysia, Madagascar, Iraq, Bangladesh, Mozambique, Vietnam, Tanzania Republic and Madagascar were also recipients of exports. Despite COVID-19, the agricultural balance of trade increased to Rs. 132,579.69 crores from April 2020 to February 2021, up from Rs. 93,907.76 crore over the same period in 2019-20 (Press Information Bureau, 2022). Increases in the production of high-quality output can multiply exports by a factor of ten. With increased exports, India's relationship with other countries will improve (Fig 6 and 7).

7. Optimal utilisation of produced output

With advancements in warehousing and storage facilities, produced output will not go to waste and will reach the population that requires it.

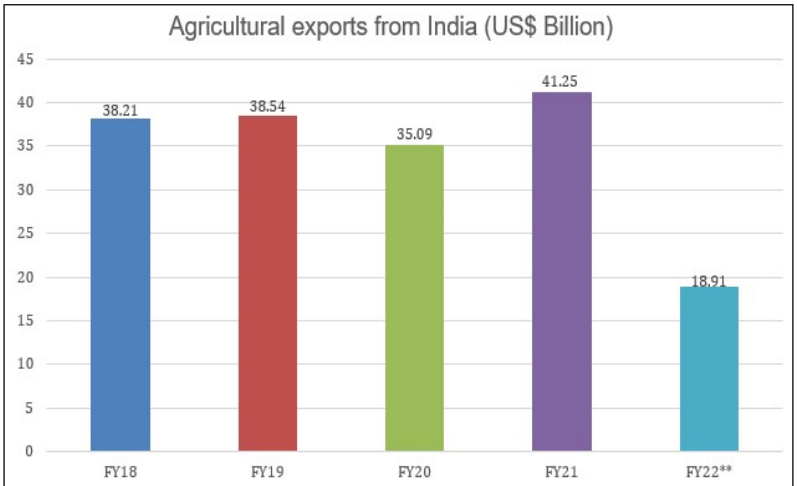
Future prospects and solution for India

The agriculture sector, which accounts for 20.2 per cent of India's GDP (Press Information Bureau, 2021. and revolves around socioeconomic gains and setbacks, is a big contributor to the country's economy, as well as any change in its structure is likely to affect the current pattern of social fairness (Table 2).

Table 2: Contribution of agriculture sector towards GDP (In %).

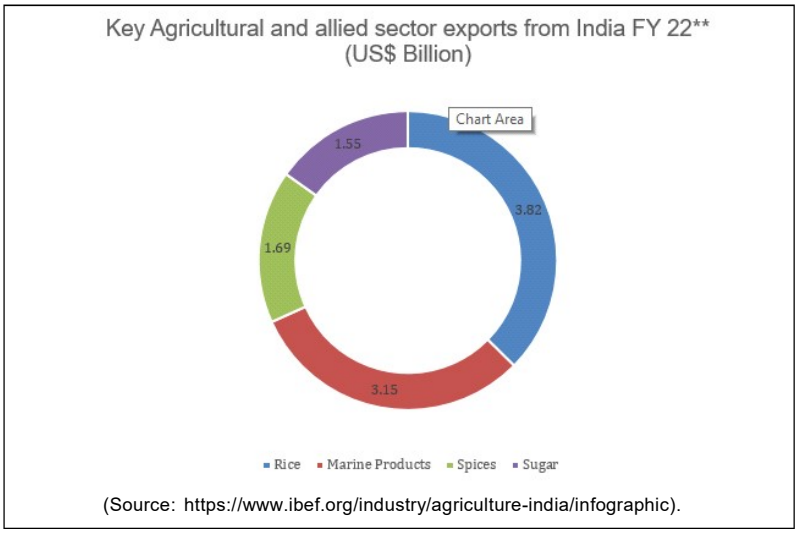
Year	Percentage share of gross value added (GVA) of agriculture and allied sector of total economy
2018-19	17.6
2019-20	18.4
2020-21	20.2

(Source: National Statistical Office (NSO), M/o Statistics and PI).



(Source: https://www.ibef.org/industry/agriculture-india/infographic).

Fig 6: Agricultural exports from India.



(Source: https://www.ibef.org/industry/agriculture-india/infographic).

Fig 7: Key agricultural and allied sector exports from India FY 22**.

The proper utilisation of soil, water, livestock, plant genetics, forest, environment, rainfall and topology is essential for sustainable agricultural output. Resource restrictions, infrastructural limitations, institutional factors, technology limitations and policy-induced limitations all affect Indian agriculture. Sustainable development can be defined as the development and preservation of the biophysical environment, as well as the direction of technical and institutional change, in order to assure the fulfilment and continuation of people's desires for following generations. This type of sustainable development (in agriculture, forestry and fisheries) conserves space, irrigation, plant and animal biological resources, is ecologically friendly, technically feasible and socially acceptable. As a result, the most efficient use of environmental assets, human resources, financial resources and technical resources is required to accomplish sustainable agriculture development. Crop yields in India are strongly rely on rain, which is one of the key reasons for the agriculture sector's slowing development rate. Poor farmers and labourers, living on a shoestring budget, are the hardest hurt by these difficulties. As a result, something has to be made to strengthen farmers and appropriate quantities of water and energy must be provided to them, as they continue to suffer from drought, floods and fire. India is the world's second most populous country and it should recognise that its people are a precious resource for the nation. There are a lot of idle people in India. Hence the need to discover ways to tap into their expertise and make the results contribute to growth. Passive unemployment is noticeable, particularly in agriculture. Full utilisation of human resources can also lead to long-term development in India. Agriculture employs a large portion of the country's poor population; without raising their living standards, overall growth in the country is impossible. If we continue to ignore the poor, the gap between classes will widen. Farmers are committing suicide as a result of the country's debt traps. People have been moving to cities in search of a better way of life, but the poor urban population in cities is also rising. As a result, the rural population should be given opportunities to work and prosper in their communities. For a long time, India has been labelled as a "developing" country; in order to make it "developed" we must reduce our reliance on agriculture (Chahal, 2015).

CONCLUSION

Agriculture development is essential for a country's economic growth. Even developed countries prioritise agricultural development. There is a great scope for agriculture development through innovation in agriculture and developing entrepreneurship amongst farmers. Educating the farmers through agri-extension services, print and digital media, organizing workshops, *etc*., promoting commercial crops *e.g*. medicinal crops, floriculture crops and other plantation crops under different farming systems. The current article also emphasized innovations for sustainable development in agriculture to reap the benefits of improving livelihood, enhancing productivity, creating employment opportunities, industrial growth, food supply and increasing foreign trade.

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Authorship contribution statement

The authors confirm contribution to the paper as follows: Compiled information and writing: Saurav Vyas, overall provided suggestions and information: Sukhjinder Singh. All authors reviewed the results and approved the final version of the manuscript.The author confirms sole responsibility for the following Study conception, design, analysis, interpretation of results and manuscript preparation.

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