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Agricultural Research



Financing Facility of Rs. 1 Lakh Crore Under Agriculture Infrastructure Fund Launched

Prieme Minister Shri Narendra Modi launched a new Central Sector Scheme of financing facility under the Agriculture Infrastructure Fund of Rs. One Lakh Crore on August 09, 2020 in New Delhi. The scheme will support farmers, PACS, FPOs, Agri-entrepreneurs, etc. in building community farming assets and post-harvest agriculture infrastructure. These assets will enable farmers to get greater value for their produce as they will be able to store and sell at higher prices, reduce wastage, and increase processing and value addition.

The first sanction of over Rs.1000 Crore has already been made to over 2,280 farmer societies. The event conducted through video conference was attended by lakhs of farmers, FPOs, cooperatives, PACS, and citizens from across the country.

At the same event, Shri Modi also released the 6th installment under the PM-KISAN scheme of Rs.17,000 Crore to nearly 8.5 Crore farmers. The cash benefit was transferred directly to their Aadhaar verified bank accounts with the press of a button. With this transfer, the scheme has provided over 90,000 Crore in the hands of more than 10 Crore farmers since its launch on 01 December 2018.

Interaction with Primary Agriculture Credit Societies

Shri Modi interacted virtually with three Primary Agriculture Credit Societies from Karnataka, Gujarat, and Madhya Pradesh who are among the initial beneficiaries of the scheme. He had an engaging discussion with the representatives of these societies to understand their current operations and how they plan to utilize the loan. The societies informed the Prime Minister about their plans to build godowns, setup grading and sorting units which will help member farmers secure a higher price for their produce.

Address to the Nation

Following his Interaction with the Primary Agriculture Credit Societies, in his address to the nation, the Prime Minister expressed confidence in how farmers and the agriculture sector will benefit from the scheme. He said the scheme shall provide a financial boost to the farmers and agriculture sector and increase India's ability to compete on the global stage.

He reiterated that India has a huge opportunity to invest in post-harvest management solutions like warehousing, cold chain, and food processing, and build a global presence in areas such as organic and fortified foods. Shri Modi mentioned that this scheme provides a good opportunity for start-ups in agriculture to avail the benefits and scale their operations, thereby creating an ecosystem that reaches farmers in every corner of the country.

Agriculture Infrastructure Fund

The Agriculture Infrastructure Fund is a medium - long term debt financing facility for investment in viable projects for post-harvest management infrastructure and community farming assets through interest subvention and credit guarantee. The duration of the scheme shall be from FY2020 to FY2029

(10 years). Under the scheme, Rs. 1 Lakh Crore will be provided by banks and financial institutions as loans with interest subvention of 3 percent per annum and credit guarantee coverage under CGTASE scheme for loans up to Rs. two Crore. The beneficiaries will include farmers, PACS, Marketing Cooperative Societies, FPOs, SHGs, Joint Liability Groups (JLG), Multipurpose Cooperative Societies, Agri-entrepreneurs, Startups, and Central/State agency or Local body sponsored Public-Private Partnership Projects.

(Source: Press Information Bureau release dated August 09, 2020)



Editorial

India has an agrarian economy and the role of agriculture research is pivotal for the sustainable development of agriculture sector. Sustainable development of agriculture depends on how well our farmers are versed about the recent advances in the Research and Development of agri-technology and their best applications towards efficient and effective management of agriculture inputs.

Indian agriculture has positioned itself more relevant for meeting the food, feed, fodder, fuel, fibre and timber demand of increasing human and animal population. The process of the development of agricultural research system in our country has its own significance. India has made remarkable progress in agriculture and crop sciences and has become one of the world's largest producers of foodgrains, spices, milk, etc.

Our lead article written by Union Minister of Rural Development, Panchayati Raj and Agriculture and Farmers' Welfare, Shri Narendra Singh Tomar talks about the different agriculture research institutes which have given a new direction to agricultural research in the country during the past several years.

Established in 1929, the Indian Council of Agricultural Research (ICAR) has an impressive record of promoting agricultural research in the country. It has, on its account, a glorious history of 91 years and has given a new dimension to the country's agricultural science, agricultural research, and agricultural technology. The ICAR has its role in guiding, managing, and coordinating activities and functions related to the agriculture sector, including horticulture, fisheries development, animal science, agriculture education, and research. It was the outcome of providing latest technology of agriculture to the farmers that as compared to the year 1950-51, today our country has registered growth of 5.6 times more in foodgrain production, 10.5 times more in the horticulture sector, 18.26 times more in the fisheries sector, 11 times more in milk production and 52.9 times more in egg production.

Chairman, National Bank for Agriculture and Rural Development, G.R. Chintala writes that agricultural research has been the key to technological development and increased productivity in agriculture. There is a need to increase spending on agricultural research and extension to address challenges such as achieving inclusive growth, improving resistance of crops to climate change, improving nutritional quality of food and improving resource use efficiency.

Indian agriculture Research and Development (R&D) policy has largely relied on public funding and provision, dissemination of R&D services through Central Government and State Government extension instrumentation. Major focus has been laid on achieving self-sufficiency in foodgrains production right from the 3rd Five-Year Plan (1961-1966) by enabling the emergence of an improved R&D atmosphere in the country.

The present Government desires that economic condition of all the farmers improves, agricultural production and productivity increase. For this, adequate agriculture research can play an extremely crucial role so that the farmers get adequate opportunity to do farming with scientific methods and research in all vital areas of agriculture.

We have tried to cover several areas related to agriculture research in this issue of Kurukshetra to enhance the level of knowledge of our readers on this particular subject. We would like to know the feedback from our readers as well about this issue. Stay Home Stay Safe.

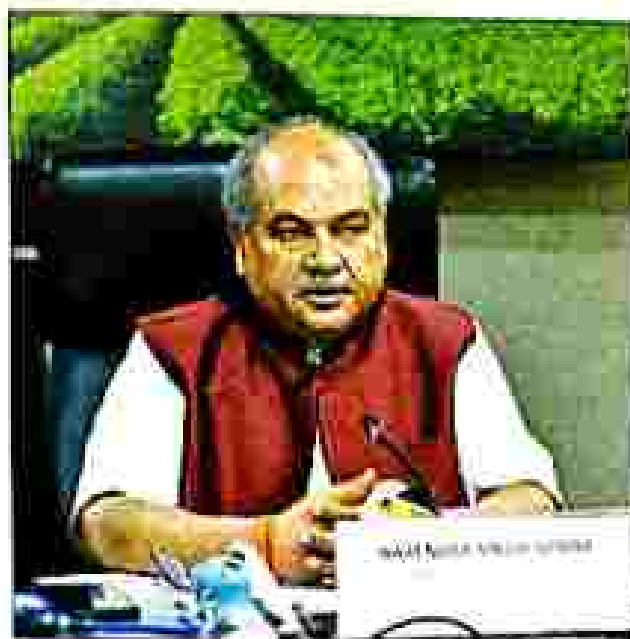
Rejuvenation of Agriculture through Research

Narendra Singh Tomar

Agriculture production has become the axis of the country's economy today. The Government desires that economic condition of all farmers improves, agricultural production and productivity increase, our farmers get adequate opportunity to do farming with scientific methods and research in all vital areas of agriculture accelerates. There should not only be the development of agricultural equipment and machines, but the ordinary farmer should have easy access to them also. Agricultural technology should be cost-effective rather than expensive so that every farmer can use it. Since the last tenure of the Modi Government, full attention has been given to boosting agricultural production and maintaining nutritional quality through agricultural research.

The NDA Government under the leadership of the Prime Minister Shri Narendra Modi, is making unprecedented efforts to boost the growth rate of the agriculture sector and for the welfare of the farmers. The focus is not only on production but also on raising farmers' income and reducing agriculture-related risks. The Government has initiated several policy reforms to increase the income of farmers. In July 2019, the Prime Minister constituted a high-powered committee of Chief Ministers to "rejuvenate Indian agriculture." The committee members included Chief Ministers of seven states, Union Minister for Agriculture and Farmers Welfare, and a member of NITI Aayog. The Government has allocated 2.83 lakh crore rupees in the budget for the year 2020-21 for agriculture and allied activities, irrigation and rural development, which is the highest budget allocation to date. The Government desires that economic condition of all farmers improves, agricultural production and productivity increase more and more, our farmers get adequate opportunity to do farming with scientific methods and research in all vital areas of agriculture accelerates. There should not only be the development of agricultural equipment and machinery, but the ordinary farmer should have easy access to them also. Agricultural technology should be cost-effective rather than expensive so that every farmer can use it.

While laying the foundation stone of Agricultural Research Institute at Hazari Bagh, Jharkhand in 2015, the Hon'ble Prime Minister had commented on the future of the agriculture sector and said that our country had witnessed the first Green Revolution and it was high time that the second Green Revolution takes place. In fact, the Prime Minister, sensing future food grain



[The Union Minister for Agriculture & Farmers Welfare, Rural Development and Panchayati Raj, Shri Narendra Singh Tomar addressing at the 92nd ICAR Foundation Day & Award Ceremony through virtual platform, in New Delhi on July 16, 2020.]

challenges, had urged the farmers, agricultural experts, and state governments for a second Green Revolution. Today, the nation is progressing at a fast pace to realise the vision of the Prime Minister with multi-faceted development of the agriculture sector, application of the scientific methodology, innovations and optimum use of modern technology in agriculture. Since the last tenure of the Modi Government, full attention has been given on boosting agricultural production and maintaining nutritional quality through agricultural research.

The Ministry of Agriculture and Farmers' Welfare, Government of India, and its associated agricultural research institutes have given a new direction to agricultural research during the past

years. It was the outcome of providing latest technology of agriculture to the farmers that as compared to the year 1950-51, today our country has registered growth of 5.6 times more in food grain production, 10.5 times more in the horticulture sector, 18.26 times more in the fisheries sector, 11 times more in milk production and 52.9 times more in egg production. It is a pleasant scenario that India's total food grain production, which was only 50 million tonnes in 1950-51, has increased to 285 million tonnes in 2018-19. India has achieved these milestones despite the decrease in availability of land and water resources. The Green Revolution of the 1960s completely transformed the scenario of food security in India. The Government has ensured availability of food to every citizen of the country by implementing policies and initiatives like National Food Security Act, National Nutrition Mission etc. and made every effort to make nutritious food items available to the needy at the minimum price.

The Indian Council of Agricultural Research (ICAR) was established on 16th July 1929 to promote agricultural research in the country. It has, on its account, a glorious history of 91 years. It has given a new dimension to the country's agricultural science, agricultural research, and agricultural technology. The ICAR is playing a pivotal role in guiding, managing, and coordinating activities and functions related to the agriculture sector, including horticulture, Fisheries development, animal science, agriculture education, and research. There are, at present, 102 research institutes and 71 agricultural universities affiliated to ICAR, across the country. It is one of the largest national agricultural systems in the world. ICAR has, through its various research works and technology development initiatives, played a significant role in the development of the agricultural sector and taking forward the benefits of the Green Revolution in the country. It is the result of the ICAR's agricultural research and hard work of the country's farmers that today our granaries are full of food grains. The term 'food crisis' has disappeared from the dictionary of our country, having the world's second-largest population. ICAR has also earned recognition internationally in teaching subjects like agronomy and agricultural engineering. This organisation has established a vast network of 718 Krishi Vigyan Kendras (KVKs) for extension and spread of its valuable agricultural

research benefits. Scientific research in agriculture has resulted in unprecedented success in the development of high yielding varieties of crops, high milk yielding cattle species, and development of the horticulture sector. Our agricultural scientists have brought out several research works and innovations and tried their best to make them available to our peasants. Some of these achievements can be described as follows:

Research Related to Crop Varieties

If we discuss about the recent past, total of 220 crop varieties have been notified and released for commercial cultivation in the year 2019-20. It includes 101 varieties that are climate-friendly, while 15 are multi-stress tolerant varieties. Of the total developed varieties, there are 96 grains, 51 oilseeds, 18 commercial crops, and 18 fodder crop varieties. Twenty bio-fortified varieties of various crops, including rice, maize, wheat, sorghum, millet, linseed, and ragi, have also been developed. It is encouraging to note that in the last two-three years, we have reached near self-reliance in production. To achieve this, ICAR and the Department of Agricultural Cooperation have set up 150 seed hubs in different parts of the country and provided seeds of improved varieties to the farmers.

The Prime Minister had expressed concern that despite being an agrarian country and agro-based economy, we still have to import edible oil. This problem must be resolved in mission mode through 'zero edible oil import.' Taking action in this direction, ICAR has conducted more than 50 thousand national level cluster frontline demonstrations on oilseed crops in the last one year. Through these demonstrations, the target achieved in linseed crops has fired the hope that we will soon be able to reduce the expenditure on imports of oilseeds.

A total of 545 varieties of crops were released during the period 2009 to 2014. In the period 2014 to 2019, ICAR developed 1020 varieties, which are about two times as compared to the period 2009 to 2014 and thus made a significant contribution to agricultural production. While only 269 varieties of horticultural crops were developed in the period 2009-2014, the period 2014 – 2019 saw the development of 339 varieties of horticultural crops. Pusa Basmati, developed by ICAR, is the world's longest kernel of paddy. It is the most sought after

rice variety in the world. Income from its production has increased by about Rs. 33,000 crore during 2014-2019 as compared to 2009-2014. About 16,700 crore rupees worth of foreign exchange is being earned every year by exporting this variety.

The productivity of sugarcane variety CO-0338, developed by ICAR's Sugarcane Breeding Institute, Coimbatore, is 75.5 tonnes per hectare, which is 14 tonnes per hectare more than the popular varieties. Farmers in North India earn good profits by growing this variety in more than half the area of sugarcane cultivation. This variety of sugarcane has significantly raised the income of farmers. Similarly, the disease-resistant varieties of tomato 'Arka Rakshak' and 'Arka Samrat' have been developed to ensure bumper production. These varieties are being cultivated by farmers in an area of about 30 thousand hectares in 27 states and they are earning more than Rs. 500 crore annually.

The ICAR has developed 53 bio-reinforced varieties of foodgrains between 2014 and 2019. These varieties of 10 crops like rice, wheat, maize, and mustard have proved to be useful in alleviating malnutrition. The health and nutrition level can be improved by providing food grains of these varieties to the people through mid-day meals and public distribution system.

Livestock Development Research

Agricultural scientists have also done remarkable work in livestock development and in triggering the White Revolution in the country. During the period 2014 - 2019, 40 new animal species have been registered and notified. During these five years, ten vaccines have been developed to combat animal diseases, which is 40 percent more than the number of vaccines developed during the period 2009-2014. An active surveillance system has also been developed to make India free from Foot and Mouth (FMD) disease by 2024. For this, a temperature tolerant vaccine is being developed. A total of 43 diagnostic kits were developed to diagnose animal diseases between 2014 and 2019, which is 51 percent more than the previous five year period.

Horticulture Sector

Today our country ranks first in horticultural production. The horticulture sector has emerged as

a significant agro-enterprise in driving momentum to the Indian economy. This sector has also created many new opportunities for employment generation. The report of the committee constituted in 2018 to take measures for doubling the income of farmers, estimated that the volume of horticultural production is expected to reach 451 million tonnes by the year 2022-23. For this, agriculture acreage will have to increase by 2.8 percent and productivity by 3.1 percent.



The ICAR has notified a total of 133 new varieties of horticultural crops during 2019-20 and released them for commercial cultivation. It includes 71 varieties of vegetables, 14 of spices, 15 of spice seeds, 5 of potatoes, 18 of tuber fruits, 6 of fruits, and 4 varieties of planting crops.

Fisheries Sector

The fisheries sector of India is playing a vital role in the country's economy with a production of 13.4 million tonnes. Apart from meeting domestic demand, the country has also earned \$7 billion in foreign exchange through fish exports. An online information system has been developed to provide information on various aspects of fish species of India origin.

Agricultural Education

The inclination of students towards agricultural courses is increasing day by day in the country. The Indian Council of Agricultural Research and our agricultural colleges have made exceptional prog-

ness in agricultural science and agricultural engineering education. New programmes and modules have been developed from time to time to make agricultural education innovative and employment-oriented.

Due to the Coronavirus crisis, many educated youths who have returned to the villages from the metros are now trying their hand in farming. Their focus is not only on production but also on giving scientific form to marketing, processing, and agricultural operations. These young farmers are engaged in farming professionally using modern farming techniques and information technology. Thus, it seems that the day is not far when a new agricultural revolution will soon emerge. During the lockdown, the Central Government removed restrictions from agricultural activities. As a result, the agriculture sector demonstrated an extraordinary resilience to withstand economic shocks even during the Corona crisis. When other sectors of the economy are facing a recession, the agriculture sector continues to maintain a satisfactory growth rate, which in itself is a great achievement. This is a clear proof that the Government is committed to providing full support to agriculture and farmers. If there was not enough stock of food grain in the country during this crisis, mere imagination of the critical situation that the country would have suffered is enough to shock anyone. To tap the inherent potential and possibilities in the agriculture sector, the present government, under the dynamic leadership of the Prime Minister, focuses on innovations in the agricultural sector so that farming can become a profitable deal, not just a means of survival and satisfying the fire of stomach. For this purpose, the government is also emphasising on promoting the export of agricultural products. A report by the World Trade Center says that India could register among the top five exporters in the world in terms of exports of agricultural commodities by focusing on farming and practical measures for the betterment of farmers. India is ranked eighth in 2019, with annual agricultural exports of \$39 billion. Europe ranks first with agricultural exports valued at \$181 billion.

To limit the use of chemical fertilisers in the agricultural sector, the Government is promoting organic farming. At present, the demand for organic products has also increased. Because of this, the government has implemented a scheme

to encourage organic farming in more than a hundred districts of the country. The Ministry of Agriculture provides financial assistance to the tune of 50 thousand rupees per hectare to the farmers associated with organic farming under Paramparagat Krishi Vikas Yojana (PKVY). The government is also promoting the food processing industry in areas under organic farming so that agro-based industrialisation can also be encouraged in those areas. The government is also promoting the cultivation of herbs to increase the supply of herbal products in the country which can also be exported.

Agricultural production has become the axis of the country's economy today. It has long been felt that new reforms should take place in the agriculture sector. The well-known agricultural scientist and the President of the then National Farmers Commission, Prof. M. S. Swaminathan had, in his report, recommended a steady increase in public investment for the agriculture sector, especially for improvement in irrigation, drainage, land development, water conservation, research development, road connectivity and development of agricultural infrastructure. The Swaminathan report emphasised on improving the implementation of the minimum support price. The report recommended inclusion of crops other than paddy and wheat in the MSP system. The report also recommended that the minimum support price for the crop be at least 30 percent more than the average cost of production. It is a matter of

great pleasure for crores of countrymen engaged in farming that the government has approved the Agriculture Infrastructure Fund of Rs. one lakh crore. Encouraging private investment through this fund will lead to the all-round development of rural areas for agricultural activities across the country. It will prove to be a boon for the rejuvenation of the farm sector and upliftment of farmers. Fisheries, animal husbandry, horticultural farming, beekeeping, and agricultural entrepreneurship are being promoted through the Innovation and Agri-Entrepreneurship Development Program under the National Agriculture Development Scheme. Rupees 1185.90 lakh have been made available to 112 start-ups. Funds worth more than Rs. 2485 lakh will be provided to the start-ups in the agriculture and allied sector. It will open up doors of new employment opportunities for the youths in the agriculture sector. Recently a state-of-the-art honey testing laboratory of international standard has been set up in Anand, Gujarat. It will increase the production of quality honey and its export to foreign countries. The government has made efforts to bring prosperity to the farmers by connecting more and more with schemes like Pradhan Mantri Fasal Bima Yojana, PM Kisan, and Kisan Credit Card.

The Government has taken four landmark decisions in the interest of farmers, which will write new chapters for their future. 'One Country One Market' has been introduced and Mandi Act has been amended so that farmers can get a fair price for their produce. With the implementation of the Farming Produce Trade and Commerce (Promotion and Facilitation) Ordinance, now farmers can sell their crops anywhere in the country. It is not to exaggerate that the country got independence from the British rule in 1947, but the farmer has got independence with the promulgation of this ordinance. The Farmers (Empowerment and Protection) Agreement on Price Assurance and Farm Services Ordinance, 2020, is also a landmark decision of the Government for the agriculture sector. Its main objective is to establish a legal order for agricultural agreements between farmers and sponsors so that farmers get fair and remunerative prices for their products. The system of electronic trade and e-platform for agricultural produce will make the farmers free from the difficulties arising out of physical

distances. The farmer will now be able to sell his farm produce sitting at his home to the trader in any state where he gets the better price. Farmers have also benefitted with the exemption of the Mandi fee.

The Government has increased the minimum support prices (MSP) of Kharif crops for the 2020-21 marketing season as per expectations. These prices are fixed by adding + 50 percent to 83 percent profit on the cost of production. Millions of farmers will get direct benefits from this. Since the beginning, it has been the endeavor of the present government that farmers must get at least one and a half times the cost of their produce. Prime Minister has announced setting up of 10 thousand Farmer Producer Organisations (FPO) so that agriculture becomes a profitable business all over the country and small farmers get more empowered. It would also facilitate increase in production and productivity, provide a proper marketing platform to farmers and encourage them to venture into the fields of processing and packaging. It is hilarious that we have taken rapid steps in this direction.

Our Prime Minister Shri Narendra Modi has said that it is a time to convert the challenge of COVID-19 into an opportunity. The path to self-reliance begins from here. The food provider farmer of our country is at its core, and his concern is on top priority. In fact, the resolve to fulfil the objective of upliftment of the village, the poor, and the farmer will certainly bring prosperity to our farmers in the future. In this, the scientific methodology of traditional agriculture and farming based on modern technology will play an important role. It is delightful to know that various branches of agronomy, agro-engineering, and agriculture are working today in a mission mode to bring forth new methodologies, research, and innovations. The day is not far when the farmer of our country will play pivotal role in establishing the agriculture sector of the country as an agricultural industry by using modern technology with a scientific mindset. No doubt, even the highly educated youth of our country will, then, take pride in adopting it as a most sought after enterprise.

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Prioritising Agriculture and its Research Needs

G.R. Chintala

Agricultural research has been the key to technological development and increased productivity in agriculture. There is a need to increase spending on agricultural research and extension to address challenges such as achieving inclusive growth, improving resilience of crops to climate change, improving nutritional quality of food and improving resource use efficiency.



Indian agriculture, supporting majority livelihoods, constantly needs knowledge inputs for addressing myriad problems. We have a robust agricultural research system catering to diverse research needs of the country. The research system plays an important role in generating knowledge, which is one of the factors of production in the modern farming. The success of the agricultural sector, however, depends on how effectively the research system generates, acquires, utilises, and disseminates knowledge and solves the problems. Indian agricultural research system comprises Indian Council of Agricultural Research (ICAR) Institutes, Central and State Agricultural Universities (SAUs), and Krishi Vigyan Kendras (KVKs), CGIAR Institutes, corporate/private research facilities. NABARD also conducts and supports research, besides building an empowered and financially inclusive rural India through its financial, developmental, and supervisory roles.

This article, in this context, covers the role of agricultural research system and NABARD in the growth of the sector and the way forward.

Importance of Agricultural Sector

The agricultural and allied sector carries immense importance for the Indian economy. It contributes about one-sixth to the national income (Chapter 7, Economic Survey Vol II, 2019-2020) and provides direct employment to nearly 50 percent of the workforce. It is fundamental for ensuring the food security of the nation and one of the major sources for foreign exchange earnings. In addition, it influences the growth of secondary and tertiary sectors of the economy through its forward and backward linkages. The performance of agricultural sector greatly influences socio-economic outcomes as well. For instance, World Development Report 2008 released by World Bank emphasises that growth in agriculture is, on average, at least twice as effective in reducing poverty, compared to growth

emerging outside agriculture. Agricultural growth reduces poverty directly, by raising farm incomes, and indirectly, through generating employment and reducing food prices.

However, the performance of the agriculture and allied sectors has been below its potential in recent years and has often been characterised by fluctuating of growth. After achieving a growth of 5.6 percent in 2013-14, GVA (gross value added) growth at constant (2011-12) prices from 'Agriculture, Forestry and Fishing' declined to -0.2 percent and 0.6 percent in 2014-15 and 2015-16, respectively (Chapter 7, Economic Survey Vol II, Government of India, 2019-2020). In 2019-20, its growth is expected to be nearly 4 percent (Press Note on Provisional Estimates of Annual National Income 2019-20 and Quarterly Estimates of GDP for Q4 of 2019-20). The low and fluctuating growth rate is an indication of many existing challenges in the agricultural sector: small & fragmented landholdings, high dependence on rainfed farming, degradation of natural resources due to practices such as imbalanced use of inputs, low scale of mechanisation and low input productivity of crops.

Agricultural Sector for Economic Recovery

The economic implications of the novel Coronavirus (COVID-19) pandemic have brought the agricultural sector into sharp focus and heightened its responsibility to feed and employ thousands who might have lost livelihoods. At this time when most sectors of the economy are reported to be under significant stress, the agricultural sector continues to be promising and cushioning the economy. The area sown under all major kharif crops is expected to be higher than corresponding period during the last year. Since the agricultural sector continues to be one of the bright spots amidst this pandemic, we need to prioritise agricultural sector during this time is essential to ensure speedy economic recovery of the country. It requires initiating measures to find solutions to many of the contemporary challenges through a differentiated focus on agricultural research.

Role of Agricultural Research

One of the most notable achievements of Indian agriculture over last few decades has been the expansion of food grain output from nearly 51 Million Tonnes (MT) in 1950-51 to over 285 MT in

2019-20 (Third Advance Estimate of Production of Food grains for 2019-20 released by MOA/FW, Govt. thereby obviating any fears of food security for the country. Similarly, production of horticultural crops has surpassed 300 MT. The Green Revolution proved instrumental in providing the much needed stimulus to agricultural production in the country to overcome food shortages by augmenting the yields of produce through the provision of HYV seeds, improved irrigation facilities and fertilisers. Development of infrastructure for agriculture, extension, irrigation and input supply and a supportive price policy played a crucial role in making of the Green Revolution.

Our country has reaped tremendous returns for its investment in agricultural research. Expansion of agricultural technology has been instrumental in achieving higher growth, food security and poverty reduction in India. It has also enabled us to achieve lower food prices for its vast population, improved nutritional outcomes, expansion of rural employment, agricultural exports, and enhanced level of foreign exchange earnings through improved competitiveness of our agricultural commodities in the world markets. This improvement in rural sector of the economy has helped the growth of other sectors of the economy through the backward and forward linkages. Research studies indicated that high levels of R&D can lead to higher productivity, and therefore, improved economic performance. Also, the return on investment in agriculture research is comparable, if not better than other expenditure incurred to support the agricultural sector. A recently released book entitled 'Supporting Indian Farms the Smart Way' shows that every rupee spent on agricultural research and development, yields better returns (1.3), compared to fertiliser subsidy (0.88), power subsidy (0.79), education (0.97) or on roads (1.10) (Gulati et al, 2018). The focus of research policy should remain on improving efficiency of public research system and encouraging participation of private sector wherever possible. Further, the barriers to technology transfer from labs to land should be removed to stimulate technology transfer and growth. Three things that make technology transfer more effective are extension, irrigation, and rural infrastructure.

Agricultural Research Structure

Agricultural research has been the key to technological development and increased

productivity in agriculture. A brief background related to the agricultural research system in India is given below:

i) Development of Agricultural Research System

The Famine Commission Report (released in 1880) was an important step for laying the foundation of agricultural research structure in India. It resulted in creation of the Departments of Agriculture at the Centre as well as in the Provinces which were assigned the primary role of undertaking agricultural research apart from famine relief. The next major step was the establishment of the Imperial (now Indian) Agricultural Research Institute at Pusa, Bihar along with other agricultural colleges. On the recommendation of the Royal Commission on Agriculture (1928), the Imperial Council of Agricultural Research (ICAR) was established in 1929 which was renamed as Indian Council of Agricultural Research (ICAR) after independence.

India presently has one of the largest agricultural research systems in the world with a large number of scientific personnel engaged in research and education relating to agriculture and allied areas. The present system comprises essentially two main streams, viz. the ICAR at the national level and the Agricultural Universities at the state level. Besides, several other agencies such as the General Universities, Scientific Organisations, and various government departments participate

directly or indirectly in research activities related to agriculture.

The agricultural research and education System in India comprises of multiple institutions, including over 70 Agricultural Universities. Over the years, the extension system has evolved with the main responsibility lying with the state line departments in association with other institutions. After the establishment of first KVK in 1974 at Pondicherry under Tamil Nadu Agricultural University, their network has expanded to over 700 KVKs as of January 2020. These KVKs are envisaged to play multiple roles of on-farm testing, front-line demonstration, and capacity building of farmers. In the recent years, another crucial institution that has gained attention is the Agricultural Technology Management Agency (ATMA) which holds responsibility for technology dissemination activities at the district level by involving key stakeholders such as line departments, research organisations, non-governmental organisations (NGOs), etc.

ii) Future of Agri Research

The system of agricultural research and extension in India has so far responded well to the challenges of agriculture sector. To address the contemporary and future challenges, it is important to incorporate the following in agricultural research:

- a) Higher Agri Research Spending: Considering the importance of the agricultural sector for



achieving various desirable outcomes for the country, there is need to increase the spending on agricultural research. The expenditure on agricultural research as percentage of agriculture-GDP has been low at around 0.48 percent during 2012-14. Compared to India, the expenditure in other countries is much higher: 1.8 percent in Brazil and 0.5 per cent in China. In 2008, the same ratio was nearly 0.54 percent for developing countries together while developed countries, on average, spent around 1.07 percent of their agri-GDP on research (Pal, 2017).

- b) **Focus on Crop and Non-crop Sector:** Research on crop sector is still relevant for a country like India with a vast and increasing population, a large section of which is below the poverty line, considering that national food security faces many challenges in the coming decades such as those of climate change. However, non-crop sector too needs emphasis since it is expected to be the pillar of future growth of agricultural sector.
- c) **For Small Holders and Women:** Two noteworthy trends in Indian agriculture have been the prevalence of small holders (86 percent of total farmers having 47.3 percent of land holding, as per Agriculture Census 2015-16) and increasing feminisation of agricultural sector with 73.6 percent of rural women workers being farmers with 32.6 percent of land holdings. With formation of 10,000 FPOs being targeted for next 5 years, future research in agricultural sector may look to develop low-cost effective solutions to address the challenges being faced by the small holders and women. For example, aggregating smallholders through Farmer Producer Organisations (FPOs) is being considered an important step to allow them to reap the benefits of economies of scale. Continuous research to analyse the impact of farmers' welfare as a result of being associated with an FPO as well as the addressing the challenges being faced in its effective functioning may prove instrumental in achieving inclusive growth.
- d) **Private Sector for Research-Extension:** Collaborating with private sector is essential to undertake agricultural research and taking the

same from lab to the field. There is a need to provide appropriate ecosystem to agri-preneurs to enable them to innovate in the form of products, services or applications across the value chain for improving competitiveness of the agriculture sector.

Role of NABARD

Realising the importance of research and development for organisational as well as societal development, NABARD has established the Research and Development (R&D) Fund in accordance with the provisions of the NABARD Act 1981, with a corpus of Rs 50 crore replenished annually. It aims at acquiring new insights into the problems of agricultural and rural development through in-depth studies and applied research and trying out innovative approaches backed up by technical and economic studies. The R&D Fund is leveraged for formulating policies on matters of importance to agricultural operations and rural development, including facilities for training, dissemination of information and promotion of research by undertaking techno-economic studies and other surveys in the fields of agriculture, rural banking and rural development. Through R&D Fund, grant is provided for conducting research projects & studies, organising seminars/conferences/symposia, publishing Occasional Papers and other publications, supporting professors to conduct thematic research relevant to the domain of NABARD through NABARD Chair Units, etc. Over the last four decades, NABARD has supported over 350 studies and 2000 seminars and conferences on various topics. NABARD has also supported NABARD Chairs and Dr. S.K.Roy, Dr. Ashok Gulati, Dr. Ayyappan, have been some of NABARD Chair Professors. Below mentioned are couple of important research studies sponsored by NABARD in recent years.

i) NABARD Survey

NABARD launched the 'NABARD All India Rural Financial Inclusion Survey' (NAFIS) in 2016-17 to gain deeper insights into the livelihood and financial inclusion aspects of households and bridge critical gaps in the understanding the present rural financial inclusion scenario. With a sample of over 1.87 lakh members from 40,327 rural & semi-urban households from 29 states,



245 districts and 2016 villages/centres. NAFIS is expected to aid evidence-based policy making.

NAFIS 2016-17 reflects the state of development in rural India. Although the findings show a considerable inter-state variation in terms of the progress achieved, as measured by different indicators, the figures at national level may be used to gain a broad understanding of the status of the rural economy.

The survey has estimated that the average monthly income of agricultural households (AH) is higher at Rs 8,931, as compared to Rs 7,259 for non-agricultural households (NAH). The major contribution to total income for the AH is from cultivation (35%) and wage labour (34%), while it is from wage labour (54%) and Govt./pvt. service (32%) for the NAH. On the consumption front, the AH spent almost 51 percent of the expenditure on food items. The analysis of the investment data shows that, on average, AH invested Rs 62,734 in the last one year preceding the survey, but the penetration of agricultural implements is still low, with only 5 percent and 1.6 percent of the AH reported ownership of tractors and drip irrigation, respectively. This shows huge opportunities for investment in agri-infrastructure with the expansion of bank credit. The survey also points out that nearly 47 percent of households in the country were found to be having some outstanding debt and the incidence was higher among AH as compared to NAH. Other findings indicate that nearly 88 percent of the households (HH) reported having a bank account; 55 percent of AH and 46 percent of NAH reported any savings

during the last year and average savings were reported to be Rs 18,007.

The survey also points towards some areas of concern. Only about one-fourth of HH reported to have been covered under one or the other type of insurance. Particularly, with respect to crop insurance the penetration is low at 7 percent. Apart from these major findings, the survey also reveals many other aspects that are important for policy makers. The Survey underlined the areas need attention and improvement.

II] Water Productivity Mapping of Major Indian Crops

This study has been carried out by NABARD in association with Indian Council for Research on International Economic Relations (ICRIER). It attempts to answer two primary questions (using 10 major crops under study, covering more than 60 percent of gross cropped area):

- Are the existing cropping patterns in India in line with the natural water resource endowments of various regions?
- Are these cropping patterns sustainable from a water-use perspective?

To answer these questions, the report makes use of certain useful concepts. The water productivity has been analysed from three broad perspectives namely – Physical water productivity (crop output per unit of total consumptive water used (TCWU)), Irrigation water productivity (crop output per unit of irrigation water applied by farmers) and Economic water productivity (value of crop output produced per unit of TCWU as well as irrigation water applied) and mapped indicating the suitability of the crop with respect to water use across the region.

The broad findings of the study indicate that there are regions in India which are heading towards unsustainable agriculture with highly skewed distribution of water for certain crops. This means that there is evidence of significant misalignment in the cropping patterns and available water resource. This is clearly visible in the case of sugarcane and

rice showing almost a perverse relation between land productivity and irrigation water productivity in certain regions.

At the present level of water stress existing in the country, there is a need to re-calibrate the cropping patterns in line with their irrigation Water Productivity (particularly for water guzzler crops like rice and sugarcane). Else, country will be moving towards unsustainable agriculture from water availability point of view, raising risks for the farmers, and promoting extreme inequity in the use of scarce water resources.

III) Other R&D Efforts

Socio-economic research in upcoming areas related to agriculture and rural prosperity viz. Farmer Producer Organizations (FPOs), debt waiver schemes for farmers, climate smart agriculture, micro-finance, financial inclusion, etc. are also being carried out by NABARD on an ongoing basis. It also regularly brings out many useful publications/study report the soft copy of which may be accessed at www.nabard.org (Recent Publications under Information Centre).

Way Forward

The Indian agricultural research system has so far responded well to the challenges facing the Indian economy, including enhancing agricultural growth, reducing poverty and making India self-sufficient in foodgrains. While continuing to address these key issues, the Indian agricultural research system needs to incorporate certain issues in future. There is a need to increase spending on agricultural research & extension to address challenges such as achieving inclusive growth, improving resistance of crops to climate change, improving nutritional quality of food and improving resource use efficiency. Bio-fortification methods must be used to develop high quality crop varieties having high protein, zinc, iron, etc. nutritional content. The plant breeders need to use latest bio-technological methods in addition to traditional methods of farming. While emphasising on the need for 'Smart Agriculture', we need to go for a 'technology revolution' encompassing Big Data, Artificial Intelligence, Internet of Things, Computing and Block Chain, Nanotechnology, etc. to accelerate growth in agriculture sector.

It may also require developing low-cost technologies that may be taken to the farms by

agri-entrepreneurs, thereby allowing greater participation of private sector in research-extension. There is a need for the multi-stakeholder approach in generating and sharing knowledge, including traditional knowledge, for addressing production constraints and harness growth opportunities in agriculture. NABARD will look forward to partner with different institutions to deliver maximum services to rural India to achieve its mission of promoting sustainable agriculture and rural development.

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Agricultural Research for Food Security and Income

J. P. Mishra

With the increasing population and diversifying dietary demand under the developing economies like ours, the demand for food and other related commodities has been increasing steadily. The agriculture research has been the answer for addressing the food security, income to farmers and those who work on the farms and farm related activities and on a larger note to sustainability of the natural resources for the very sustenance of the mankind. By addressing the pre-harvest and post-harvest management, it ensured the three facets of food security-availability, access and affordability.

In an agrarian economy like ours, speedy and sustainable development of agriculture and allied activities is the potent tool for the progress of the country. Agriculture has positioned itself more relevant for meeting the food, feed, fodder, fuel, fibre and timber demand of increasing human and animal population. Since primitive time, agriculture and hunting have been the major source of livelihood, food and income which gradually diversified towards allied activities basically dependent on agriculture for raw materials like textiles, dairying, logging, fishing, etc. The agriculture, however, enjoys the vitality in entirety for ensuring food security to all on a given geography and income for those who adopt or opt it as a primary occupation. With the increasing population and diversifying dietary demand under the developing economies like ours, the demand for food and other related commodities has been increasing steadily. On

the other side, the base resources for agriculture like land and water, being finite, are not available beyond a point. This competition in production and resource use caused larger sustainability issues over time. The agriculture research has been the saviour for addressing the food security, income to farmers and those who work on the farms and farm related activities and on a larger note to sustainability of the natural resources for the very sustenance of the mankind. By addressing the pre-harvest and post-harvest management, it ensured the three facets of food security-availability, access and affordability.

Pre-Independence Agricultural Research

The process of the development of agricultural research system in India started as early as in 1869, when Lord Mayo, Governor General in India prepared to create Department of Agriculture in the Government of India with counterparts in the provinces. The foundation for scientific research in



agriculture was laid in 1889 with the establishment of the Imperial Bacteriological Laboratory in Poona (Pune), subsequently shifted to Mukteshwar in 1895. During the time of Lord Curzon, in 1905, the Imperial Agricultural Research Institute was established at Pusa, Bihar followed by a series of departments of agriculture and colleges in the different provinces, besides central institutions. Later, it was decided to have a coordinating unit. Royal Commission on Agriculture in 1926 proposed an Imperial Council of Agricultural Research (ICAR) to promote, guide and coordinate agricultural research throughout India. ICAR was registered as a society under the registration of societies Act 1860 in July 1929. The institute was shifted to New Delhi in 1935. At the time of establishment of the Imperial Council of Agricultural Research, there were also a few commodity committees. They primarily worked as advisory services to the government, but to a limited scale they have also taken up research work on specific crops like Cotton, Lac, Jute, Sugarcane, Coconut, Tobacco, Oilseed, Arecanut, Spices and Cashew nut, etc.

Post-Independence Agricultural Research

Rainfed agriculture dominated the independent India. To intensify the research on rainfed crops like cotton, Oilseeds and Millets, the Project for Intensification of Regional Research on cotton, Oilseeds and Millets (PIRRCOM) was established in different agro-climatic zones in 1954 and in 1957, All India Coordinated Research Project (AICRP) on Maize was started. The AICRP model proved successful. Subsequently, AICRPs on all major commodities, natural resources, farm machineries, livestock, home science etc. These projects are characterised by combining state-central efforts avoiding any duplication and waste of expenditure. Traditionally long duration tall rice varieties were being grown in India prior to 50s which were less responsive to synthetic fertilisers. As the use of synthetic fertilisers became popular after the World War II, India needed the varieties which respond to heavy fertilisation. The major breakthrough in rice varietal development happened in 60s with the help of International Rice Research Institute. It helped in evolving dwarf high yielding varieties by using the gene from semi-dwarf Chinese varieties. To give rice research a fillip, AICRP on Rice was launched in 1965. This worked as a coordinating platform for interdisciplinary and

inter-institutional research on rice for improving the production, productivity and profitability. The most intensive rice breeding was initiated in 1965 with the development of Taichung (Native)-1 from the semi-dwarf mutant, Paroma and Jaya were the first varieties that emerged from the programme. Subsequently, several semi-dwarf varieties of high yield potential were released. The semi-dwarf varieties have been found superior in efficiency of grain production as compared to the tall traditional varieties. To accelerate the rice productivity, hybrid rice research was initiated during 1970. However, the intensified efforts were started from 1983. As a consequence, within a short span of 5 years, half a dozen rice hybrids were developed by public and private sectors. The first 4 rice hybrids were released in 1994. The number grew to 19 by the end of 2001. The crops under the category coarse cereals (maize, sorghum, bajra, barley, ragi and small millets) were central for food security in arid and semi-arid regions of the country with low to lowest rainfall regions. In maize, over 230 varieties (composite and hybrids), were developed since 1957. These include 132 hybrids released after 1966 including 4 dozen public-bred single cross hybrids. The spread of modern varieties and hybrids of pearl millet and sorghum began in the mid-1960s. These developments led to substantial yield gains in these crops in arid and semi-arid regions and increased overall production of maize, sorghum and millets. The fruits and vegetables are integral to food and hence food security. The research on fruits and vegetables in India is steered by several institutes and AICRPs on fruits, vegetables, spices, tuber crops, potato, arid fruits, mushroom, floriculture, etc.

The success of the improved varieties emanated from the Government interventions for (i) higher investments during 70s in crop improvement programmes agricultural systems, both national and international; (ii) introduction and development of efficient seed systems during 80s and gradual inclusion of the private sector; and (iii) the liberalisation of the seed industry in the late 90s.

While new varieties and hybrids were vital revolutions in plant types much responsive to fertilisers and irrigations, they brought new challenges in soil and water management for production and protection. When the population was low, single cropping in a year was a rule rather

than exceptions. However, with growing population, multiple cropping became the order of the day. Consequently, the man and machine activities on land increased leading to soil and water issues. The huge land mass was rain dependent at the time of independence as about 83 percent cropped area was unirrigated. Hence, the Government gave topmost priority to the development of irrigation projects from first 5-year plan onwards. Simultaneously, to provide the scientific solutions for moisture conservation, crop production, selection of varieties, crops and cropping systems, crop substitution, alternate land use, etc the AICRP on Dryland Agriculture (AICRPDA) was initiated in 1987. The ex situ rainwater management, integrated nutrient management, crop diversification, alternate land use, integrated farming systems, strategies for climate variability, etc were the thrust areas. The research on long term fertiliser experimentation, soil test crop response, micronutrients, salt affected soils, agro-meteorology and agro-forestry, etc were introduced to steer the research on specific areas to develop practices and protocols for higher production of food crops. Livestock and Fisheries research were also carried out simultaneously to develop new breeds, quality standards, strains and fingerlings, health and hygiene etc.

The research on farm implements and machinery was initiated in 1975 for development, testing and popularisation of need-based farm implements and machinery for different regions of the country which proved promising in enhancing the use efficiency and reducing the cost of cultivations besides, reducing the drudgery in farm operations. The frontline extension system in India started with the first Krishi Vigyan Kendra (KVK) established in Puducherry in 1974. At present each district in India has one KVK, many big districts are having 2 KVKs. Today, 113 research institutions and 57 AICRPs and 25 Network Projects are functioning under ICAR. Besides, 718 KVKs are the gateway of frontline extension at district level.

The State Agriculture University (SAU) play complimentary responsibility for location-specific agricultural research. The University Education Commission headed by Dr S. Radhakrishnan, in 1949, recommended to establish the rural universities on the pattern of land grant college philosophy of USA. Subsequently, the first SAU was established at Pantnagar in 1960. Today, the

National Agricultural Research System is a two-tier system, comprising of ICAR at National level, and State Agricultural Universities (SAUs) at state level.

The developments of agriculture and self-sufficiency in food grain production is due to integration of both the national (ICAR) and state (SAUs) joint efforts. The concerted research efforts could develop the technologies and package of practices for soil productivity, water management for storage, expansion and efficiency. These were central in transforming a food deficit nation into food surplus and net exporter after independence. The declining size of farms, depleting resources and escalating costs of applied inputs and farm labourers opened new challenges for agricultural research for enhancing the production and monetary return from farming. The strong linkages with international research organisations and scientific institutions, located in different regions of the world also played critical role in vanishing the food insecurity from the country. The research system in India rose to all the occasions of need and solved the challenges emanating from climate change, insects-pests and virus infections in crops and livestock and helped eradicating them to sustain the food security. Today, we have a state-of-the-art facility for advance research in plant, livestock and fisheries. The recent advances in basmati rice, multiple disease resistance in wheat, tomato, rice, etc along with genomics in pigeon pea, chickpea, rice, tomato, etc are some examples to cite.

Research for Food Security: Post-independence

While pre-independence periods were marked with severe famines and stresses, the hurtful memories of the mid-'60s still haunts many when, after two successive severe droughts in 1964/65 and 1965/66, India needed American wheat under PL 480 on at relatively low prices and on rupee payment due to lack of foreign exchange to buy food in the world market. The transaction with US turned sour at early stage due to India's criticism of American bombings of Hanoi and Haiphong in the course of the Vietnam War. The country was labelled with much undignified remarks of 'ship to mouth' when imported wheat used to be directly distributed from port to households. The then Prime Minister late Lal Bahadur Shastri gave a call to skip one day meal in a week to help saving foodgrains. While India was struggling to provide two square meal

a day to its people, the Norman Ernest Borlaug's new semi-dwarf, disease-resistant varieties, revolutionised the spring wheat in Mexico making Mexico fully self-sufficient in wheat production and net exporter in 1963. At the same time, in India, the imports were being made as a contingent measure to feed the population and Dr. C. Subramaniam, the then Union Minister for Agriculture and Dr. M. S. Swaminathan, former DG, ICAR along with team of scientist after assessing the possibility of increasing the production of wheat through the use of Mexican wheat varieties, introduced 5 dwarf varieties, Lerma Rojo 64-A, Sonora 63, Sonora 64, Mayo 64 and S 227 along with about 200 other breeding lines in 1963. These varieties were stiffer and shorter and relatively photo-insensitive and capable of high yields at high doses of fertilisers, irrigation and other inputs. The success in rice varietal development and other commodities like maize, jowar, bajra, small millets, etc caused significant growth in the production of foodgrains production. However, oilseeds and pulses remained our pain points.

By the time the country was readying itself to reap the benefits of technological advancement due to research outputs in agriculture and allied activities, the population increased by 1.5 times adding 18.55 crore more people with an annual growth of about 1.9 percent per year. The most satisfying achievement on agricultural research front was that the growth in wheat in terms of per

capita availability outpaced the growth in population during 1951-1971 period (Figure 1). This was the beginning of resounding confidence amongst the people that agricultural research and technological development can outpace the increasing demand for food and related items required for growing population. The trend continued in subsequent decades also.

Post green revolution, the white revolution happened in the country which augmented the milk production. The research in cross-bred breeds and their feeding and shelter management helped sustaining the growth in milk production. The research in small ruminants, poultry and fisheries for breeding, feed and nutrition, diseases management helped these sectors grow in leaps and bounds. The production of milk and milk products, meat, egg and fish has increased multiple times since 1950-51 (Table 1, see on page no. 20). It all happened due to improved breeds, quality protocols for feed and feeding of milch animals, poultry and fisheries. The diagnostics and vaccines developed after the concerted research have helped not only controlling the diseases but also eradicated some of the dreaded diseases from the country such as Rinderpest, Contagious bovine pleuro-pneumonia, African horse sickness and Dourine – a parasitic disease. The country is poised to be FMD Mukta by 2030. Several silent revolutions, in field crops, happened in Indian agriculture after the green revolution due to introduction of new varieties and

Figure 1: Growth Rate (per cent/annum) in availability of foodgrain and population

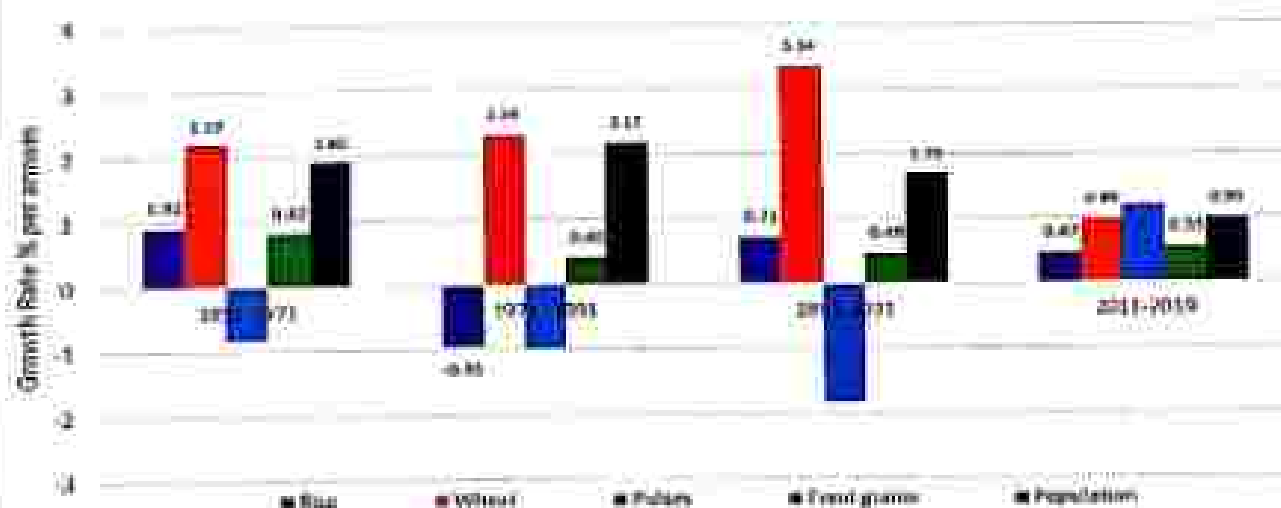


Table 1: Increase in production of food grain and other commodities due to technological advancement

Item	Production (m tonnes)		Times Increase (%)
	1950-51	2018-19	
Food grains*	50.83	251.67	5.23
Pulses*	8.41	23.05	2.74
Oilseeds*	6.16	72.59	6.43
Cotton*	0.52	6.13	11.75
Sugarcane*	57.05	358.14	6.28
Horticulture*	16.36 (1991-92)	113.35	1.25
Milk*	17.00	187.79	11.04
Egg (no. in billion) *	0.75	13.42	17.89
Fish*	16.1 (1985-86)	103.95	6.42
Meat*	1.9 (1958-59)	8.11	4.27

* In Adv. Economy, 2013-20, p1 Adv. Ec., 2018-20, p Figure, 2018-19

(Source: Ministry of Agriculture and Ministry of Fisheries and Animal Husbandry & Dairying)

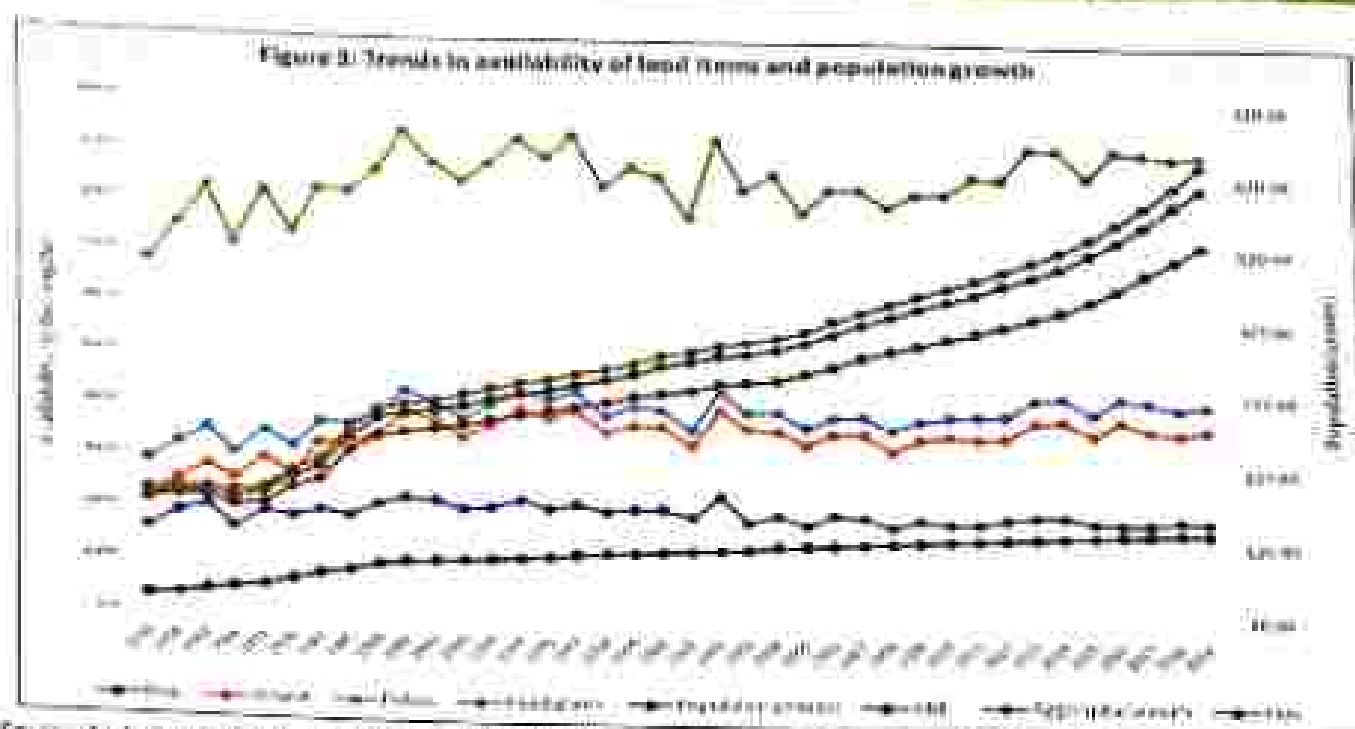
improved production technologies. In 1985, the Government introduced Technology Mission on Oilseeds (TMO) to enhance the oilseeds production through technological interventions and area expansion. Later, pulses were included under TMO to make it TMOP. A significant boost in the production of oilseeds was witnessed post Technology Mission on Oilseeds which created enabling environment for adequate funding support to research and development. Driven by area expansion, use of quality seeds of HYVs and management of other applied inputs, the production got doubled in 10 years during 1985-1996. The TMO in 1985 could deliver the desired result due to defined role and dedicated funding mechanisms for Research and

Development. The new HYVs in soybean, B&M, Groundnut and other oilseeds with concerted efforts on the seed development and promotion could transform the oilseeds production within 10 years. Afterwards, the stagnation in area of oilseeds was seen and growth in production dipped although the productivity has shown a remarkable increase of 37 percent during 1997-2017. At the luxury of bringing more area under oilseeds has almost dried up, the past approach of TMOP of area expansion will not work anymore. The data on area under cropping reflected that the area remained almost constant since 1975-76. It is the growth in productivity due to technological advancement for varieties and production techniques, which

Figure 2: Area, Production and Yield of foodgrains



Source: Agricultural Statistics at a Glance, 2019



Source: *Agricultural Statistics at a Glance, 2019* and basic statistics on animal husbandry and fisheries (M/o RWHQ)

has helped raising the production (Figure-2). The real benefits of enhanced production have been visible with the increase in per capita availability of foodgrains and other commodities inspite of higher growth in population (Figure 3). In the recent times, the significant increase in pulse productivity, due to introduction of new varieties in the seed system, has helped country attaining near self-sufficiency in pulses production. This is the most recent testimony of research contributing for the food security of the nation and also import substitution. The development of new varieties with multiple resistance for diseases and abiotic stresses in horticultural crops could boost the production surpassing the foodgrains production in the country.

The horticultural production has increased from 96.56 million tons in 1991-92 to 313.35 million tons in 2019-20 (Table 1).

The population of our country is expected to reach at 1.531 billion by 2030-31. To feed this population and another 40 percent additional for seed, feed, wastage and industrial uses put the projected foodgrains demand at 326 to 350 million tons depending upon the various approaches of estimates. The demand for edible oils, milk and milk products, meat, egg and fish, vegetables, fruits and sugar has been projected at 24.31, 256.43, 29.45, 316.33, 178.74 and 44.77 million tons, respectively

in the year 2030-31 (NITI Aayog, 2018). These have to be achieved with declining per capita availability of land, water and other finite natural resources. The climate change effects are looming large on the entire agri-food system. The strategy revolves around raising productivity for the farmers' welfare and reduce agrarian distress by enhancing the income of the farmers. The performance of Indian agriculture during the last 7 decades has been remarkable owing to dynamism in the research and extension system of the country which is capable of absorbing immediate shocks and emerging challenges with innovative technological advances and breakthrough as has happened in the past. The pursuit of making India *Aatmanirbhar* will continue with much concerted efforts in agricultural research for developing new varieties, production and protection technologies and quality and safety standards for the Indian products. There is necessity to invest in the R&D for infrastructure and human resources development to make India globally competitive and sustain the food and nutritional security for all and income to farmers and rural workers.

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Research and Development for Sustainable Agriculture

Dr. K. K. Tripathy and Dr. Sanku Kumar

Agriculture and allied sector have witnessed historical capability of India's economy in securing the sustenance of inclusive growth. The Indian economy and development (GDP) with the agriculture witnessed a rapid growth from 1970s due to liberalised policies governing agriculture at right kind of R&D. Sustainable development of agriculture depends on how well our farmers are utilised when the sector advances in the R&D of agri technologies and then put applications towards efficient and effective management of agriculture inputs.



India has made remarkable progress in agriculture and crop sciences and has become one of the world's largest producers of foodgrains, spices, milk, etc. As per the 3rd Advance Estimates of Production of Foodgrains, Oilseeds and other Commercial Crops for 2019-20 released by the Ministry of Agriculture and Farmers Welfare, the country has produced a record 395.67 Million Tonnes (MT) of food grains (272.66 MT cereals and 23.01 MT Pulses), 33.50 MT Oilseeds, 358.14 MT Sugarcane, 36.05 million bales of cotton and 9.92 million bales of jute and mesta during 2019-20. Besides this, Government of India's 2nd Advance Estimates of 2019-20 of Horticulture Crops released by Ministry of Agriculture and Farmers Welfare estimated that the country is expected to register a bumper horticulture production of 320.48 MT during 2019-20.

The agriculture and rural sectors' contribution to employment, income and wealth largely depends on how sustainable and climate-smart agriculture practices are, and how the country prepares itself for adopting improved agriculture practices, climate resilient varieties and technologies through enhanced research and development interventions. In this backdrop, this article reviews the trend of the Research and Development (R&D) interventions in the Indian agriculture sector and tries to find out the issues and opportunities of R&D and technology use for sustainable agriculture besides reviewing output and outcome matrix of a few select government schemes aiming at turning agriculture smart and sustainable.

Research and Development Policy

Indian agriculture Research and Development

Innovative agriculture practices have helped in minimising the profit, reducing wastes and the social impact focusing on livelihood and rural employment. Agriculture has generated new opportunities for employment through research in different sectors. The agriculture value chain, farmer producer organisations, collectives, cooperatives and collaboration from the research centres have driven the social feasibility. The social impact has contributed to agriculture for development of youth and conservation of energy. Modern agriculture practices have the potential to reduce emissions of greenhouse gases and pollution. It is adept in assuring food and nutritional security without harming the environment. A few select schematic interventions, output, outcome and constraints in the implementation of such schemes aiming at sustainable agriculture in India are at Table 1.

Agriculture Inputs

The transition of the country from the stage of food scarcity to food surplus has been possible only because of continuous emphasis on R&D in the agriculture input sector. The R&D environment in the agri-input sector is explained as follows:

- (a) **Seed:** Production of breeder, foundation and certified seeds resulted in sustaining the agriculture. Indian Council of Agricultural Research (ICAR) developed various drought resistant and hybrid seeds to sustain and improve agriculture. Hybrid seeds penetration has been found highest in cotton (90%), corn (80%) and oilseeds like sunflower (80%). Various rules/regulations and statutes viz. Seed Act (1966), Seed Control Order (1983), Seed Rules (1968), and National Seeds Policy (2002) have helped in strengthening the seed industry. Genetic manipulation of crops has resulted in increasing the yield of crops too.
- (b) **Fertiliser:** R&D has improved the fertiliser sector in India. Nutrient Based Subsidy Scheme (2010) focused on efficient targeting of subsidised fertilisers. The recent research and application of Neem Coated Urea in the field have not only reduced the consumption of chemical fertiliser and improved the quality of the soil, but also became largely responsible for restricting diversion of Urea for purposes other than agriculture. More and more emphasis on production of bio-fertilisers and promotion of chemical free cultivation has increased the area

under organic farming. As in March 2020, about 1.8 percent of the total cultivable area (27.2 lakh hectare) has been covered under organic cultivation in the country. Government has been promoting Integrated Nutrient Management and farmers are advised to use biofertilisers, organic manure in conjunction with chemical fertilisers to maintain fertility of soil. Further, Nano-fertilisers, a recently launched product has immense potential for ensuring soil health through efficient management of fertility for improved crop production.

- (c) **Agro Chemicals:** R&D has resulted in manufacturing of various insecticides, pesticides and herbicides to protect the agriculture yield. Integrated Pest Management System is an initiative in agriculture to control pests and insects by combining biological, cultural and chemical practices.
- (d) **Farm Machinery and Equipment:** Recent R&D in technology have resulted in the production and use of different and innovative agri-equipment like tractors, balers, combines, plows, power tillers, mowers, harvesters, planters and sprayers, etc. These farm machinery and equipment have helped in improving application of improved agriculture practices. The Union Government has launched two mobile applications viz. CHC Farm Machinery and Krishi Kisan App. While the former aims at facilitating and maximising farm mechanisation through networking



Table 1 Output, Outcome and Constraint Revolution of a Select Major Schemes for Sustainable Agriculture

Scheme	Output	Outcome	Revolution of Constraints
Ministry of Agriculture National Horticulture Mission (NHM)	• Enable preparation of agriculture plans for districts and states based on agro-climatic conditions • Take up agriculture entrepreneurship provide facility & assistance to states in planning & executing agriculture & allied schemes	• Making farming remunerative through strengthening farmers' effort, risk mitigation and providing opportunities, extension, security	• Identifying and mapping gaps in the planning and implementation
Farmer's Organic Input Scheme (FOIS)	• Provide organic training and disseminate latest technologies on organic farming practices • Enhanced awareness about organic farming practices and assistance for PGS Certification	• Increased coverage of area under organic certification	• Enhancing awareness level of farmers on the benefits of organic farming • Facilitating certification process involving community • Addressing implementation issues of various activities at the field level • Ensuring enhanced productivity in comparison to chemical fertilizer based farming to improve adoption
Pradhan Mantri Kisan Sankalp Yojana (PMKS)	• Making available efficient water conservation and precision water application devices—sprinklers, drip, jets, rain-guns etc. • Provisioning of protective irrigation facilities in rain-fed agriculture	• Increased crop productivity, enhanced farmer income • Improved water use efficiency • Drought-proofing of agriculture	• Identifying factors leading to time and cost over-run in completion of irrigation works • Provision of adequate scientific knowledge, training & awareness amongst the farmers
National Program on Soil Health & Fertility	• Promoting location as well as crop specific sustainable soil health management including residue management and organic farming practices • Provision of Soil Health Card which provides information to farmers on soil nutrient status of their soil and recommendation on appropriate dosage of nutrients to be applied for improving soil health and fertility	• Increased soil health through creation and linking of soil fertility maps with macro-micro nutrient management practices, appropriate land use based on land type	• Setting up of additional soil testing laboratories testing labs and fertilizer control laboratories • Generating awareness on soil health to reduce dependency on chemical fertilizers
National Mission for Sustainable Agriculture (NMSA)	• Manage the water harvesting through drip irrigation and sprinkler irrigation • Enhance agriculture productivity • Promotion of improved agriculture practices	• Sustained the agriculture growth through soil health and rain-fed management	• Identifying and mapping agriculture risk with adaptation and mitigation needs

with custom hiring centres in a short span of time, the later envisages *inter alia*, demonstration of high-yielding variety (HYV) of crops and seeds, geo-fencing and geo-tagging of crops.

- (e) **Irrigation:** Frequent dry-spell, reduced availability of ground water for irrigation and the resultant droughts and drought-like situations impacts Indian agricultural production and productivity. This calls for promotion of climate-

smart agriculture by focusing on new and innovative irrigation and fertigation techniques

Smart Agriculture

Smart agriculture is a global initiative to maintain sustainable agriculture through judicious use of improved and updated technology. Precision farming is one such initiative in agriculture using Internet of Things (IoT) and Information Communication Technology, Big data analytics,

predictive analytics, cloud computing, machine learning and artificial intelligence can bring a revolution in the efficient use of agri-inputs so as to make agriculture sustainable and profitable (Chart 2). Some of the future-oriented smart agri-technology which needs investment and implementation are deliberated as follows:

- Farm Management Information System (FMIS) provides various information at a given period instantly which later on, includes data on soil sample, weather conditions, sensor data, maps, etc. Advance analysis of such information is necessary to arrive at right farming decisions at an appropriate time. However, to maximise benefits to the farmers, the system should have a robust synchronisation with the stakeholders and end-users of such information. The farmers, being one of the important stakeholders, should be guided through an interactive voice response mechanism inbuilt into the system so as to firm up their agri-based decisions scientifically.
- Geographical Information System is powered by the latest image and map information and transforms remaining tables into graphic maps. It examines and analyses the wider range of agricultural-related resources such as soil, weather, hydrology i.e. irrigation pattern and various socio-economic variables which are important parameters of crop productivity.
- Nanotechnology has prospects for integrated pest and nutrient management involving processes for pest disease control, efficient fertiliser applications with minimised nutrient loss. A lack of expertise, low level of field demonstration and a lack of awareness have reduced the acceptability of such advanced technology.
- Artificial Intelligence helps in capturing images and identifying pests and plant diseases for better agricultural administration at

field level. Machine Learning algorithms provide for digital mapping of crop health and ground level moisture. IoT for Agriculture has built in mechanism for monitoring crop fields with the help of sensors (light, humidity, temperature, soil moisture, etc.) and automating the agriculture practices. However, data constraint and lack of robustness in the data so available gives inaccurate results.

- While LED Lighting ensures a precise control of photoperiod, soil, and environmental sensors, drones can perform several significant tasks like application of fertiliser, pesticides, crop monitoring, crop estimation and damage assessments, etc. Low levels of technology penetration, small farm size and shortages of qualified workers at the rural areas have remained the major limiting factor for use of drones. Cooperatives and other collectives like Farmer Producer Organisations can pool lands and can take the benefits of use of drone technology for the production of their crops.

Clean and Green Agriculture

Significant losses from fruits and vegetable processing industries have become a serious concern for the pillars of Sustainable Agriculture. Such huge wastes have an adverse effect on the environment. The solid wastes can be used as animal feed or even as a fertiliser. The wastes generated from agro-based industries can be utilised either for disposal to avoid contamination of ground and surface water or they can be valorised in a bio-methane plant that needs additional input and generates compost which

Chart 2: Smart Agriculture Promotes Sustainable Agriculture



can be directly supplied to local farmers. Biogas qualifies on the merits that this technology utilizes organic agricultural waste and converts it to fuel and fertiliser. Researchers have paved a road map for reuse, reduce and recycle of agriculture by-products and wastes for sustaining the environment and social aspects. There is a huge potential to convert crop residues and food/plant wastes into bio-fuel.

Conclusion

Agriculture and allied sector have remained important segments of the Indian economy in ensuring the objective of inclusive growth. The comprehensive and continuous initiatives and efforts by the Union Government, State Governments and agricultural universities have, undoubtedly, led to notable accomplishments in natural resource management, input use efficiency, climate resilience in agriculture, economic transition and transformation of farmers through technological interventions.

Farming in India is a complex and high risk business in the wake of climate change, water scarcity and land degradation. The agricultural R&D system of the country has helped India achieve a smart development infrastructure to support advancements in agri-science, scientific discovery and technology transfer to the farmers and other end-users. However, there are many issues which restrain the country to realise the full crop production potential through its existing R&D system. To address the risks and challenges of the inherent complexities in the agriculture sector, the country needs to address multiple developmental challenges ranging from sustainable natural resource management to community led inclusive growth, food security and environmental safety. There is a need for rolling out of an R&D framework which would reflect on demand-driven innovations engaging development stakeholders both in the public and private sectors. The applications of smart technology and digital innovation in agriculture will not only help in infrastructure development in rural areas, but also would enable integrated supply chain management by assuring quality, traceability, logistics and distribution areas of agriculture value chain.

The emerging issues for sustainable agricultural development include growing

population pressure on land, resource degradation and water scarcity, impacts of rapid urbanisation, increasing pressure on diminishing natural resources, low level of investment in agriculture R&D, etc. This demands conservation of natural resources and tapping of the current potential of farming system through technology revolution especially in the areas of input management, molecular biology, biotechnology, space technology and ecology.

Sustainable development of agriculture depends on how well our farmers are sensitised about the recent advances in the R&D of agri-technology and their just applications towards efficient and effective management of agriculture inputs. Social and economic progress will be ensured only when steps are taken towards eradication of hunger, mal-nutrition and food insecurity through sustainable management, mapping and utilisation of natural resources including land, water, air, climate and genetic resources for the benefits of current and future generations. This calls for constant consultations with the farmers, cooperatives, farmer producer organisations and other end-users of modern technology and agri-approaches to design and implement an efficient farmer and consumer preferred easy-to-implement solutions.

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74th Independence Day

Prime Minister address to the Nation: Key Highlights



The Prime Minister, Mr. Narendra Modi addressing the Nation on the occasion of 74th Independence Day from the ramparts of Red Fort, in Delhi on August 15, 2020.

Highlights

- In this extraordinary time of Corona, Corona warriors have lived the mantra of 'Seva Paramo Dharma'. Our doctors, nurses, paramedical staff, ambulance personnel, safai kirmacharis, policemen, service personnel and many people are working round the clock continuously.
- Self-reliant India has an important priority-self-sufficient agriculture and self-reliant farmers.
- Time demands that our agriculture sector becomes modern and there should be value addition, there should be food processing, food packaging. And it needs better infrastructure. Government has sanctioned 1,00,000 crore rupees for agriculture infrastructure even during the Corona pandemic. This infrastructure will be for the welfare of the farmers and they will be able to get better prices of their produce, and will be able to sell their produce in foreign markets. They will have greater reach to foreign markets.
- There is a need to strengthen rural industries. Special economic zones will be created in the rural areas. A web of agriculture and non-agriculture industries will be created. We have tried to create FPO (Farmer Product Association) which will go a long way in their economic empowerment.
- Apart from 'Make in India', we must also embrace the mantra of 'Make for World'.
- My dear countrymen, our experience says that whenever there is an opportunity for women power in India, they have brought laurels to the country, strengthened the country. Today, women are not only working in underground coal mines, but also flying fighter planes, touching new heights in sky. Of the 40 crore Jan Dhan accounts opened in the country, about 22 crore accounts are of women only. At the time of Corona, in April-May-June, about thirty thousand crores of rupees have been directly transferred to the accounts of women in these three months.
- How long will the raw material from our country become a finished product and return to India. There was a time when our agricultural system was very backward. The biggest concern then was how to feed the countrymen. Today, we can feed not only



India but many countries of the world. Self-reliant India not only means reduction of imports, but also to increase our skills and our creativity.

- National Infrastructure pipeline project worth Rs 110 lakh crore will boost our overall infrastructure projects. We will now focus on multi-modal connectivity infrastructure. We can't work in silos anymore; we need to focus on comprehensive and integrated infrastructure. About 7,000 projects of different sectors have also been identified. It will bring a new revolution in the infrastructure sector.
- Today, the whole world is inter-connected and inter-dependent. It's time for India to play an important role in the global economy. For this, India has to become self-reliant. From agriculture, space to healthcare, India is taking several steps to build Atmanirbhar Bharat. I am confident that measures, like, opening up the space sector will generate many new employment opportunities for our youth and provide further avenues to enhance their skills and potential.
- Education of the country has great importance in building self-reliant India. In building modern India, in building new India, in building prosperous India. With this thinking, the country has got a new National Education Policy.
- Every Indian will be given a health ID. National Digital Health Mission will bring a new revolution in India's health sector. All your tests, every disease, which doctor gave you which medicine, when, what were your reports, all these information will be contained in this one health ID.
- Before 2014, only 5 dozen panchayats in the country were connected with optical fibre. In the last five years, 1.5 lakh gram panchayats in the country have been connected with optical fibre. All 6 lakh villages in the country will be connected with optical fibre within coming 1000 days. There are more than 1300 islands in our country. In view of their geographical location, considering their importance in the development of the country, work is underway to start new development schemes in some of these selected islands. After Andaman and Nicobar Islands, in the next 1000 days, Lakshadweep will also be connected to submarine optical fibre cable.

(Source: Press Information Bureau release dated August 15, 2020)

Strategies to Boost India's Global Agriculture Trade

Dr. Ishita G. Tripathy

For an effective implementation of a strategy for boosting agricultural exports, the linkages both within and outside the country, need to be tapped and strengthened, along with addressing trade barriers. Agricultural exports include both food and non-food products. There are specific bodies including Agricultural and Processed Food Products Export Development Authority and Marine Products Export Development Authority. Besides statutory commodity boards like Coffee Board, Rubber Board, Spices Board, Tea Board and Tobacco Board which inter alia specifically promote exports of agricultural commodities.



The tentacles of the world-wide pandemic have engulfed almost every activity in the global economy, including trade between nations. Fallout of the pandemic in the form of lockdowns, reverse migration from urban to rural areas, etc. have affected both the global supply chain and the demand for agricultural products. The World Trade Organisation (WTO) has forecasted that in 2020 global trade will plunge between 13 percent and 32 percent due to the ongoing pandemic.

In 2018, agriculture accounted for 10 percent of global merchandise trade which stood at US\$ 19.67 trillion. Agriculture accounts for a vital part of the Indian economy, accounting for 17 percent of Gross Value Added, 40 percent of employment and 11 percent of India's trade with the rest of the world.

India is the eighth largest exporter of agricultural produce. These figures underscore the need for having a pragmatic strategy for India's trade in agriculture, especially in the wake of the pandemic. Amidst reports of some green shoots being visible in the agriculture sector, this article reviews some extant strategies and the possibility of tweaking a few of those, to tap the potential of Indian agriculture and putting the economy back on track.

Agricultural Exports

In 2019-20, while agricultural exports from India were US\$ 33.9 billion, i.e. 10.8 percent of India's total merchandise exports, agricultural imports stood at US\$ 19.9 billion, accounting for 4.2 percent of India's total merchandise imports. Compared to the previous financial year, while agricultural

exports dipped by 7.4 percent, agricultural imports hiked up by 1.8 percent in 2019-20.

Agricultural exports include both food and non-food products. There are specific bodies including Agricultural and Processed Food Products Export Development Authority and Marine Products Export Development Authority, besides statutory commodity boards like Coffee Board, Rubber Board, Spices Board, Tea Board and Tobacco Board which inter alia specifically promote exports of agricultural commodities.

There are more than 130 agricultural products and food items which have been accorded Geographical Indications in India. These include Basmati rice, Nagpur orange, etc. At least 10 of these Geographical Indications are for products of other countries, which include Irish Whiskey, Scotch Whiskey from United Kingdom, French Cognac, various types of cheese from Italy, etc.

Reverse migration, due to the pandemic, has resulted in a shortage of agricultural workers at affordable rates in some States, thereby adversely affecting the supply side of agricultural exports. The demand side has also been constrained globally. To capture the seasonal variations in agricultural demand and supply, the chart below compares the monthly exports from India during the six-month period from November, 2019 to April, 2020, with their corresponding months in 2018-19. As depicted in the chart, in November, 2019 and February, 2019, India's agricultural exports were marginally higher

than the corresponding months in the previous year. In the other four months, exports dipped in comparison to their corresponding period in the previous year, with the decline being more pronounced in March, 2020 (26%) and April, 2020 (30%). In fact, the decline in agricultural exports was noticed from February, 2020 onwards, with the decline increasing rapidly every month. While the decline from February, 2020 to March, 2020 was 8.4 percent, the decline from March, 2020 to April, 2020 was 29.7 percent. In January-March, 2020 quarter, foreign direct investment in agricultural machinery and services dipped to US\$ 22.36 million as compared to the preceding quarter viz. October-December, 2019.

Trade Constituents and Constraints

The top five agricultural commodities which were exported from India in 2019-20 accounted for almost 64 percent of India's agricultural exports. Cereals constituted about 30 percent of India's agricultural exports (Table-1). The top five destinations of the top five exports constituted a major share, indicating the need for diversification of products for exports and also to tap potential newer markets.

As far as imports are concerned, close to 50 percent of India's agricultural imports are accounted for by animal or vegetable fats and oils (Table-2). The top five sources of the top five imports constitute a major share.

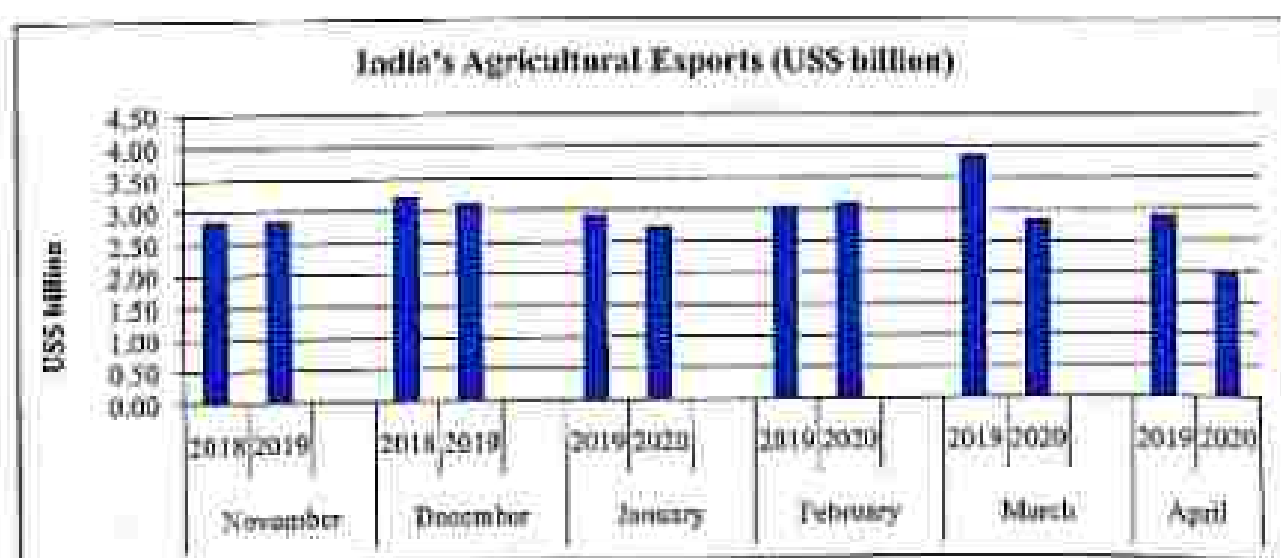


Table -1 Country-wise India's Top-5 Agricultural Exports, 2019-20

Table - 1. Country-wise India's Top 3 Agricultural Exports, 2018-19			
ITC Chapter No.	Description	Destination	Value of Exports (US\$ billion)
10	Cereals (19.7%)	All Countries	6.7
		Iran	1.3
		Saudi Arabia	1.0
		Iraq	0.5
		Nepal	0.4
		UAE	0.3
3	Fish & crustaceans, etc. (18.2%)	All Countries	6.1
		USA	2.2
		China	1.1
		Japan	0.4
		Vietnam	0.3
		Thailand	0.2
2	Meat and edible meat offal (9.75%)	All Countries	3.3
		Vietnam	1.1
		Malaysia	0.4
		Egypt	0.3
		Indonesia	0.2
		Iran	0.1
9	Coffee, tea, mint and spices (4.74%)	All Countries	3.2
		China	0.5
		USA	0.3
		Iran	0.21
		Bangladesh	0.2
		UAE	0.1
17	Sugars and sugar confectionery (4.5%)	All Countries	2.2
		Iran	0.3
		Sudan	0.29
		Somalia	0.2
		Sri Lanka	0.16
		Bangladesh	0.15
Total Agricultural Exports (US\$ billion)			33.9
Total Exports (US\$ billion)			313.2

Notes: 1. ITC stands for Indian Trade Classification

2. Figures in parentheses indicate export figures as a % of total agricultural exports.

Source: Export-Import Data Bank, Department of Commerce, Government of India

Trade Barriers

For an effective implementation of a strategy for boosting agricultural exports, the linkages both within and outside the country, need to be tapped and strengthened, along with addressing trade barriers. Trade barriers may take the form of

tariffs or non-tariffs. While the former includes the imposition of customs duties which raise the price of the import and erode their competitive edge; the latter entails quotas, subsidies, prohibitions, standards, etc. which make it difficult to penetrate the destination market.

Table-2 Country-wise India's Top 5 Agricultural Imports, 2019-20

ITC Chapter No.	Description	Source	Value of Imports (US\$ billion)
15	Animal or vegetable fats & oils, etc. (49.7%)	All Countries	9.9
		Indonesia	2.8
		Argentina	2.0
		Malaysia	1.9
		Ukraine	1.5
		Russia	0.3
8	Edible fruit and nuts, etc. (36.6%)	All Countries	1.3
		USA	0.9
		Afghanistan	0.3
		Benin	0.217
		UAE	0.216
		Tanzania	0.210
7	Edible vegetables, etc. (7.3%)	All Countries	1.6
		Canada	0.4
		Myanmar	0.3
		Mozambique	0.4
		Tanzania	0.1
		Turkey	0.07
22	Beverages, spirits and vinegar (4.0%)	All Countries	0.8
		USA	0.3
		UK	0.2
		Singapore	0.1
		Belgium	0.05
		Nepal	0.04
9	Coffee, tea, mate and spices (3.3%)	All Countries	0.78
		Vietnam	0.3
		Indonesia	0.1
		Sri Lanka	0.075
		Madagascar	0.072
		Nepal	0.066
Total Agricultural Imports (US\$ billion)			19.9
Total Imports (US\$ billion)			474.0

Notes: 1. ITC stands for Indian Trade Classification.
2. Figures in parentheses indicate share figures as a % of total agricultural imports.

Source: Export-Import Data Bank, Department of Commerce, Government of India

Tariff Barriers

Tariffs are an important trade barrier used by most countries. Table-3 indicates that a large number of developed countries, including Korea and Norway, protect their agricultural sector by imposing high rates of tariffs. Evidently, Indian exporters find a steep tariff wall, both in developing and developed countries. High rates of tariffs render imports uncompetitive vis-à-vis the domestic produce. The average tariff on agricultural products in Switzerland is 36.5, which is comparable with India's 38.8.

Non-Tariff Barriers

Even when tariffs have been reduced or dismantled, there can be non-tariff barriers to trade in the form of requirements of certification, registration, testing, packaging, labelling, licensing, prohibition, restrictions, etc. In this context, it is important to note that despite the pandemic, India has not imposed any export restrictions on agriculture.

Over the years, developed countries have moved from tariffs to non-tariff barriers. Therefore, despite having low tariffs, developed countries offer low market access to exporters, which signifies that the full potential of India's agricultural exports to developed countries has not yet been tapped.

As recently as in 2016, the EU reduced the permissible level of a fungicide in imports of rice, citing health reasons. Consequently, India's rice



Table-5 Select Country-wise Average Tariff on Agricultural Products

S.No.	Country	Average Tariff on Agricultural Products
1	Australia	1.2
2	Bangladesh	17.3
3	Brazil	16.1
4	Cambodia	15.1
5	Canada	15.9
6	China	15.8
7	European Union (EU)	12.9
8	Iceland	20.3
9	India	33.8
10	Indonesia	8.5
11	Japan	15.7
12	Korea	57.9
13	Malaysia	7.9
14	Norway	44.3
15	Pakistan	13.5
16	Russian Federation	13.2
17	South Africa	8.7
18	Sri Lanka	27.2
19	Switzerland	35.2
20	Thailand	24.0
21	Turkey	41.8
22	USA	5.3
23	Vietnam	15.5
24	Zimbabwe	26.4

Source: World Tariff Profile, 2019, WTO.

exports, especially basmati, had taken a hit. Levels of aflatoxin in peanuts have been specified by many countries. However, some countries which have set the level at 0 percent, are as good as closed as an export destination for Indian exports. Steps to ensure symmetry of information with all stakeholders will ensure that Indian agricultural exports do not face border rejections due to physical, chemical or microbiological regulations of the destination countries.

Specifications on slaughter houses put in place by certain countries make exports of meat from India difficult to these countries. Some destination markets have banned the import of Indian meat because of reports of foot and mouth disease from some parts of the country. The requirement of a health certificate from the government of the destination country acts as a deterrent both in terms of being expensive and also being time-consuming for Indian exporters. For example, some countries mandate that the exporter of some

agricultural products, especially fruits, should get a health certificate from their governments. Certain countries require some additional certifications for poultry products which are not even relevant to poultry. Further, some countries have very stringent plant quarantine procedures. Different sets of regulations for countries in the same region may pose problems for Indian exporters. Eg- the specifications of rice required are different in various ASEAN countries.

Some Recent Developments

Due to the COVID-19 pandemic and the associated lockdown, the Government had to take a number of measures. Agriculture and allied sectors were exempted from the lockdowns and the thrust was on ensuring uninterrupted harvesting and availability of foodgrains. Early on, in March, 2020, the Indian Council of Agricultural Research issued advisories related to harvesting and threshing of kharif crops and post-harvest, storage and marketing of farm produce. Benefits were extended to farmers on crop loan repayments. The CRIP software of Central Insecticide Board & Registration Committee was used to facilitate issuance of certificates. The launching of the *Atsam Rath* app facilitated farmers and traders in identifying suitable modes of freight transport for movement of agricultural produce. Besides, All India Agri Transport 24x7 Call Centres too have been launched. Two new modules, viz. warehouse based trading module and FPO module were added to the National Agriculture Market (e-NAM) portal to facilitate farmers to sell their produce from Warehousing Development and Regulatory Authority registered warehouses notified as deemed markets; and to enable FPOs to upload their produce from collection centres for on-line bidding, respectively. To provide employment opportunities and to enhance incomes, the Government has encouraged start-ups in agriculture. Cabinet approval has been accorded to the setting up of an Animal Husbandry Infrastructure Development Fund which would be useful for investments, including private sector investments, in dairy, meat processing and animal feed plants. In the early phase of the lockdown itself the Government had initiated a dialogue with the exporters of agricultural commodities to redress their issues. In its report submitted on 31st July, 2020, the 15th Finance Commission's High

Level Group on Agricultural Exports recommended a State-led export business plan for a crop value chain cluster as an integral link in the value chain.

Some theories suggest that in early stages of economic growth, agriculture leads growth. In later stages, the share of agriculture in GDP and the share of agricultural exports in total merchandise exports decline with economic development. Moreover, some economic growth theories advocate a two-way relationship between trade and growth. While economic growth leads to trade, trade has been ascribed as an engine of growth. Proponents of free trade observe the benefits of trading by practising division of labour and adopting specialisation in areas which reflect a comparative advantage. Under free trade there is no scope of protectionism and the role of the government is that of a facilitator. However, trade need not bestow equal gains for all, but it definitely needs to ensure that the gains are equitable and some preferential treatment may be required for some developing countries within the WTO framework.

India's agriculture is an important constituent of the global agricultural value chain. Therefore, it is imperative that the remuneration that the farmers receive is more than the subsistence level. In this context, it is essential to note that WTO has set the subsidy limit at 10 percent of total value of food production for developing countries and in case of a breach, action by other member countries may be avoided under the 'Peace Clause'. India is the first country to invoke the 'Peace Clause' for breaching the subsidy limit for rice in 2018-19. India's food security programmes have the triple objectives of providing minimum support prices for farmers, stabilising food grain prices and ensuring their equitable distribution at affordable rates to the needy. Another case related to subsidies is those given to small fishermen. India's stand in the WTO has been to seek a 'carve-out' for them from the negotiations which are going on for ending subsidies for illegal, unreported and unregulated fishing. The recently approved scheme of the Government of India called Remission of Duties and Taxes on Exported Products is WTO-compliant. By reimbursing taxes/duties/levies at the central, state and local level, the scheme will provide a level playing field to Indian exporters.

The Way Forward

India's Agriculture Export Policy, released in December, 2018, had rightly stressed on "agriculture export oriented production, export promotion, better farmer realization and synchronisation within policies and programmes of Government of India". In the current dispensation, apart from a strong logistic support entailing pre- and post-harvest facilities and storage, a conducive environment for investment and an effective extension of agricultural research, the following may contribute to augmenting the performance of agricultural trade:

(i) Accessibility of Farmers

The Government has recently amended the Essential Commodities Act and passed the Farming Produce Trade and Commerce (Promotion and Facilitation) Ordinance, 2020 and the Farmers (Empowerment and Protection) Agreement on Price Assurance and Farm Services Ordinance, 2020. Effective implementation of these would ensure affirmative steps towards mitigating farmers' accessibility issues to markets, processors, wholesalers, aggregators, large retailers and exporters.

(ii) Farmers' Producer Organisations

The foundation of Farmers' Producer Organisations is based on the tenets of both cooperatives and the corporate. Collectivizing the strengths of small farmers may go a long way in specialisation and export-orientation of products by efficiently utilising economies of scale.

(iii) New Products, New Markets and R&D

As a long-term strategy, new products for exports and new destinations may be explored. The role of research and development (R&D) in doing so cannot be undermined. However, the choice of new products/crops needs to be prudent, lest scarce resources like water get indiscriminately depleted. For example, one of the reasons for a receding water table in some States is the shift from the cultivation of traditional crops to cultivation for export purposes. A move towards exporting higher value products and hitherto untapped ones, like horticulture, would, undoubtedly ensure more foreign exchange.

R&D in agriculture is a goal right in not only ensuring the sustainability of agriculture, but also in keeping abreast with the latest developments in the field and catering to the demands of the destination countries. The role of R&D is pivotal in agricultural inputs like fertilizers, irrigation and seeds. Less than 1 percent of India's agricultural Gross Domestic Product is spent on agricultural research. A pragmatic usage of technology can help in overcoming hurdles.

(iv) Trade Agreements

One way to clear out trade tariff and non-tariff issues is to negotiate them in bilateral, plurilateral or regional trade agreements. For example, equal treatment for Indian agricultural GIs may be negotiated within the framework of free trade negotiations with other countries.

(v) Alerts

Putting in place an earlier system of alerts on imports which do not match Indian specifications/standards may be a potent tool for negotiators of trade agreements with other countries. A database of incidents of rejections and detentions of consignments may be useful in maintaining a minimum quality of imports.

(vi) Facilitation

It is imperative to make the farmers aware of the non-tariff barriers in the destination countries. This gains added importance given that agriculture is a State subject, while negotiations on trade pacts are done at the central level, led by Department of Commerce and active participation from the Department of Agriculture, Cooperation and Farmers Welfare; Department of Animal Husbandry and Dairying; Department of Fisheries and Ministry of Food Processing Industries. A helpdesk, in the form of a toll free phone number and an e-mail, may be useful to provide information on non-tariff barriers in destination markets. Apart from reaching out to the farmers, it is also important to have their inputs/views prior to any trade negotiations. Inputs from the farmers regarding four aspects is vital, viz. sensitive products which cannot be allowed to be imported; competitive products which can withstand competition from imports; products which face tariff or non-tariff barriers in destination markets and potential exportable

products which require market access in other countries. Such consultations will effectively equip teams which negotiate trade agreements.

Conclusion

The World Bank's 'Ease of Doing Business, 2020' shows an improvement in India's performance under the head 'Trading Across Borders', with India's rank having jumped up from 80 in 2019 to 68 in 2020. A focused approach to fill the void created by disruptions in the supply chain in the current pandemic situation may be gainful for India's agricultural trade. India's current share in global trade may be less than 2 percent, yet the encouraging fact is that positive steps have been made towards doubling farmers' income and boosting India's agricultural trade.

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Strengthening Human Resources in Agri-supply Chain

Rajiv Theodori

Agri-supply chains are economic systems which distribute benefits and apportion risks among participants. Supply chains also ensure that farmers have real time access to market information and technology, which are critical components for improving the sector. Other benefits of an efficient supply chain include environmental development, more employment opportunities and significant decline in product losses which in turn resolves the inherent issues in the agricultural sector.

Ascendancy legacy of a refined agricultural past gives India a solid continuity into the modern times when today involves the complexities of supply chain management coupled with agri-education and efficient human resources.

Being the single largest employer in the country, agriculture involves approximately 80 percent of the Indian population and contributes about 18 percent to India's GDP and export earnings too. Also, approximately half of the total population in the country relies on this industry as a main source of income and it contributes around 14 percent to India's GDP. Today, there is an even more vital need to take the quality of human resources in agriculture, especially in areas like agri supply chain, to the next level. Being the backbone of India's economy, this resource is generally a key to attain the country's goal towards a host of activities leading to sustainable growth and development.

To drive home a point, India has some very

fascinating facts on its agricultural produce. With 101 million hectares India has the 2nd largest arable land and 55 million hectares of irrigated land in the world. It has been reported as the largest producer of wheat (172 million tonnes) in the world and contributing around 15 percent of global wheat production. It has also the distinction of being the second largest producer of pulses with the production of 15 million tons. This amounts for 31 percent of global pulse production. India also earned the pride of becoming the largest producer of milk in the world by producing 96 million tonnes, which contributes to the 17 percent of global milk production. Mango, around 10 million tonnes per annum from an area of 14 lakh hectares and now India is among the largest growing and exporter of spices in the world. India has become the 2nd largest producer of tea which further accounts for nearly 28 percent of the global tea production. It has also registered its name among the largest producer of rice by contributing up to 22 percent of global rice production.



But, agriculture in India has remained largely fragmented and unorganised with a not so enviable track record in fairly recent areas like supply chain management. The network of the supply chain is many a time too long due to the presence of many intermediaries creating long gaps between the consumers and the producers as a result the farmers or the producers are unaware about demand side scenario. It is not uncommon for the farmers to receive distorted information thus depriving them of real time scenario. Since real time information is the key to success of any supply chain model, the existence of a substantial number of other players pocket a major proportion of the remuneration. This results in the farmer getting hold of the wrong end of the stick and concomitant price escalation. And the recent COVID-19 outbreak has not helped the situation either.

For example, producers of agro products are getting merely 30–35 percent of the market price in most of the cases due to supply chain issues. Annual wastages of agricultural output are also very high which in monetary term sums up to around Rs 900 billion, mainly attributable to inadequate supply chain infrastructure. In India supply chain for food grains plays a major role. Large retail chain operators, caterers, hotels, restaurants and domestic customers in urban areas require a regular supply of fresh fruits, vegetables, meat and other perishable food products. The emergence of supermarkets has led to changes in the retailing model of fresh produce and the management of the supply chain. Supply chains of horticultural produce such as fresh fruits and vegetables (FFV) are particularly of interest as they involve a large number of players and have significant impact on many employment and social issues.

The term Supply Chain can be defined as a process where all members of the value chain (i.e., the customers, vendors and all third party logistics service providers) are interrelated and integrated in such a way that the goods and the information are made available at the most suitable time. This information travels smoothly from the inception point to the consumption point and finally ensures a superior value to all.

And a closely related concept is the Agri-supply chain which is basically economic systems that distribute benefits and apportion risks

among participants. It also has an inbuilt internal mechanism that offers chain wide incentives for the timely performance of production and delivery commitments. They are linked and interconnected by virtue of shared information and reciprocal scheduling, product quality assurances and transaction volume commitments. Extensive pre-planning and co-ordination are required up and down the entire chain to affect key control processes such as forecasting, purchase scheduling, production and processing programming, sales promotion, and new market and product launches etc. Supply chains also ensure that farmers have real time access to market information and even technology, another critical component for improving the services. Other benefits of an efficient supply chain includes environmental development, more employment opportunities and significant decline in product losses which in turn resolves the inherent issues in the agricultural sector.

As the Supply Chain involves a number of players, the extent of integration of services depends on the degree of trust and information sharing amongst the players. It is often observed that the big players in their efforts to make vertical/horizontal integration of different activities end up gobbling up the weak ones. What in fact is called for is strengthening of the system and process, so that requisite synergies evolve to give benefits to all the partners. In order to shore up the emergence of professionally managed agri-supply management of different agricultural produce, the Government should play its facilitating role to its hilt.

Today, agri-food supply chain covers the entire gamut of activities from production on the farm to processing, distribution, and retailing. It's a complex process that affect the ways in which food is produced, processed and delivered to the market. On the other hand, there is also a growing pressure on governments and corporates to monitor the environmental and resource aspects of the production, distribution and consumption of agro-based products.

Since each member of the supply chain largely depends upon timely and accurate information, organisations like Indian Council of Agriculture Research (ICAR), National Informatics Centre (NIC) in India and world organisation like FAO (Food and Agriculture Organisation) have been involved in

providing quality information services. They try to ensure that the agriculture sector remains efficient, relying on speed and seamless communication networks. These bodies also make sure that the sector is not hindered by geographical barriers and has adequate social networking and cheaper accessibility.

The government has already taken several initiatives at national level in the recent past. An initiative in this direction, the National Agriculture Market (e-NAM) a pan India unified electronic portal has been set up where farmers can directly sell their produce. It connects all the markets formed under Agriculture Produce Committee (APMC). Presently 385 markets are being connected to this portal. Traditionally, farmers sold their products through the physical Mandis or Bazar Committees which were highly incompetent and levied a number of duties on their products. Under e-NAM, there is only one license for each State and duty is levied only on one point. Prices are decided through electronic auction. It is now facilitating the conversion of the whole state to one market. The farmers are directly exposed to the markets and available prices. They can finalise the price and then sell their produce. This system is more transparent and has facilitated farmers to get better price for their agro product.

Recently, a whole new eco-system with a host of novel features has been introduced to the agricultural sector of the country:

1. **Digital and analytics**—This is poised to play a critical role in building India's farms of the future:

- Precision farming including integrating field data, weather patterns to drive agronomic advice to farmers, and yield forecasting.
- Efficient farm lending with electronic applications, disbursement of loans, insurance payouts linked to weather, field data, Direct Benefits Transfer in agriculture.
- Centralised platform integrating farmers and wholesale markets, to provide timely information for price realisation.

- IoT-based advanced analytics in manufacturing plants to improve availability, throughput and save costs.
2. **Financing and crop insurance** — can help in strengthening the ecosystem.
 - Provide innovative financing models to farmers through partnerships with manufacturers, weather forecast agencies, and digital partners.
 - Offer easy financing for Farmer-producer organisations (FPOs) for community infrastructure for storage and transportation.
 - Create digital ecosystems for financing and crop insurance.
 3. **Establishing market linkages between farmers and buyers** — This will establish transparency in pricing and better value, especially for perishable products. It could also help to increase farmer incomes by at least 8 to 10 percent.
 4. **Investing in cold-storage** — Despite current challenges, this segment is expected to enjoy significant growth on the back of rising food demand, supply deficits, and improved market economics. The cold chain market is expected to double in size to reach \$7 billion to \$9 billion by end of 2020. Cold chain players could invest in alternate energy technologies like solar-powered systems, they can explore chemical treatments to extend the shelf-life of produce, set up pack houses, and cooler transport. They could also optimize the use of existing facilities



by opening them up for multiple crops instead of a single crop or product.

5. **Invest in fruits and vegetables (F&V) and pulses to meet demand:** These investments could unlock around \$15 billion to \$20 billion by 2025 and boost farmer income by 35 percent. With demand concentrated in six crops — mango, tomato, potato, pomegranate, onion, and grapes by 2025, these crops will account for around 65 percent of the incremental produce value, through a combination of exports and food processing. In pulses, the demand will be driven by a need for packaged and branded pulses, fortified pulses, and the market for ready-to-eat snacks, which is growing at 20 percent Compound Annual Growth Rate (CAGR).

Agri business has today emerged as a lucrative sub sector. Recent estimates place the size of the global agribusiness at US\$ 5 trillion. For India, it is also the most significant sector of the economy, both from the perspective of inclusive growth and from national and global development perspectives of addressing the challenges of food, livelihoods, energy and environmental security. The value chain of agribusiness links input companies, farmers, traders, food companies, retailers, and various other service providers and regulatory institutions. There is a huge diversity and variety in each component of the value chain. Input companies range from strong R&D-based companies to generic manufacturers, farmers from small subsistence holdings to high tech holdings, and food companies and retailers from small and medium sized enterprises (SMEs) to large multinational corporations. The large scale, wide diversity and range of stakeholders in the value chain make agribusiness the largest business sector globally.

With increasing private investment in the food retail sector and impending changes in contract and marketing laws, shorter and more direct supply chains with traceability are expected to become more common. The incidence and spread of coordinated supply chains will be closely connected with the pace and direction of food retail sector modernisation within India. Changes in food retail have been gradual, and considerably slower than observed in many other developing countries.

Supermarket procurement for sourcing of fruits, vegetables, dairy and meat strongly influence the organisation of the supply chains. The rising scale of organised retail in the Asian countries (like Metro Cash & Carry, Tata Chemicals and Field Fresh Foods, Shakti Enterprises, Reliance Fresh in India) is now playing a vital role in organising farmer production bases and integrating these into the retailers' fresh produce supply chain, thus procurement systems in this segment is changing fast responding to the consumer demand and competition.

Need for a Specialised Agri Education

Archeo-botanical evidences unearthed during excavations have revealed the evidence of a full blown agricultural practice way back in 10,000 BCE. There was a sizeable economic and technological development during the Neolithic phase which coincided with a revolution in agriculture. This age brought major changes in economic and technological developments that included cultivation of rice, banana, yam sequencing in eastern India and the cultivation of millets and pulses in South India. Excavations in Kalibangan in Western Rajasthan reveals ploughed fields where mostly rainy season crops were grown. Wheeled carts were commonly used in the Indus valley and river boats were used to carry grains. Benefits of crop rotation were appreciated. Around 400 BC an almanac on agriculture *Krishi Parashara* was written to help farmers in planning and managing their. Even *Arthashastra* mentions seed treatments, for example how cotton seeds were treated with cow dung and how fish were used as manure. Similarly, *Amarakosha*, written by Amar Sinha contains information on soil, irrigation and agricultural implements. The legacy of agricultural education in India can also be traced back to the ancient curricula of Nalanda and Takshashila Universities where it was treated as an important subject.

The earliest formal steps to institutionalise education emerged in 1929 in the form of a canal and ox-breeding farm at Karnal about 130 Km from Delhi. In 1868 in southern India, an agricultural college and research station was established at Coimbatore followed by a Bacteriological Research Laboratory for Veterinary Sciences in Pune in 1909. Most important, the Imperial Agriculture Research Institute (IARI) was started at Pusa in Bihar in 1905. It later became the famous Pusa Institute

—The Indian Council of Agriculture Research (ICAR) after it shifted to New Delhi, an organisation instrumental for building a rock solid foundation for a trained human resource centre. From a mere five sections in 1936, in the centre today as a network of 35 divisions of multi-disciplinary laboratories and centres of excellence that had been instrumental in enhancing human resources quality and education in agriculture. It must be recalled here that agricultural research, education and extension (AGREE) received limited attention during the pre-independence period. AGREE received a much greater attention during the post-independence period, which helped in ushering the famous 'Green Revolution', turning the country from a state of acute food shortage to that of a food surplus state. The major contributing factor in achieving the phenomenal increase in agricultural production was the research input in providing improved technologies.

Estimates suggest that by the year 2020, more than 16,000 scientific manpower would be required to cater to the needs of R&D in the country. At present, there is substantial gap of 50 percent or more between demand and supply of manpower in agriculture and allied sciences sector. The projections indicate that by 2020, the annual out turn required for Undergraduate and above would be about 54,000 as against the present annual out turn of around 40,000. This means that sincere efforts are required to attract more number of students towards Higher Agricultural Education.

The days when agricultural education focused on academic disciplines related to improving on-farm productivity are nearly over as it today stretches beyond the farm to encompass many entities that operate at different links in the production, processing and distribution chain of food and agri-products. The non-farm components play a critical role in promoting agricultural growth and sustainable livelihoods security of farmers. They enable farmers to transform productivity gains into higher incomes through value addition and improved access to markets. Together with public institutions that regulate and support farm and non-farm activities, the agricultural farm-nonfarm enterprise constitutes what is called agribusiness.

The agricultural education in India, comprising of State Agricultural Universities (SAUs), Deemed

to be Universities and other related institutions has the most direct responsibility to foster the next generation of agribusiness leaders and need to address the national and global development challenges. Agricultural human resource development is a continuous process undertaken by these agricultural universities. These higher centers of learning impart education in the various disciplines of agriculture like Agricultural Engineering, Forestry, Horticulture, Veterinary and Animal Husbandry, Dairy Science, Food Technology, Fisheries Science, Agriculture Information Technology, Agri Business Management etc. It imparts education at the level of diploma, degree, masters and doctoral level. The history of agricultural education in India can be traced back to medieval period when study of agriculture was included in the curricula of Nalanda and Takashasila Universities as an important subject.

Today, the Agricultural Education Division of ICAR is involved in strengthening and streamlining of higher agricultural education system to enhance the quality of human resources in agri-supply chain to meet future challenges in agriculture sector in the country. This calls for regular planning, development, coordination and quality assurance in higher agricultural education in India. The division strives for maintaining and upgrading quality and relevance of higher agricultural education through partnership and efforts of the ICAR-Agricultural Universities (AUs) system comprising of State Agricultural Universities (75), Deemed to be universities (3), Central Agricultural University (2) and Central Universities (4) with Agriculture Faculty. The intake capacity of students, which was less than 5,000 in 1960, has now gone up to 40,000.

The division is headed by the Deputy Director General and three sections under the division, viz. Education Planning and Home Science (EP&HS), Human Resources Development (HRD) and Education Quality Assurance and Reforms (EQA&R) each headed by an Assistant Director General (ADG). Three ICAR Institutes viz. National Academy of Agricultural Research Management (NAARM), Hyderabad; Central Institute for Women in Agriculture (CIWA), Bhubaneswar and National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi are also under this division. Agricultural Education Division through its three sections carries out a

number of schemes to support and strengthen the Higher Agricultural Education in the country, which is enumerated here under:

The Human Resource developed by ICAR has played a pivotal role in transforming agricultural scenario in the country and achieving self-sufficiency in food grain production. In this endeavor, ICAR has contributed significantly through strengthening and development of higher agricultural education. There is an urgent need to develop quality human resource to face the multifaceted and complex challenges of the Indian agriculture arising due to changing climate, threat to sustainability, inefficient use of agro-inputs and depleting quality of the natural resources and rising competitiveness under the globalisation pressure. Renewed thrust to higher agricultural education has necessitated enhanced support of the ICAR to the AU system by providing funds for development and strengthening in critical areas. It is essential to put in motion new initiatives especially attracting talent for matching agricultural education consistent with global technology development and stakeholder expectations.

This to a large extent is expected to remove the constraints, attract talent, and enable the agricultural education system to churn out graduates capable of meeting new challenges facing Indian agriculture. The approach is multi-pronged, addressing the issues of competence enhancement, attracting talented youth to agriculture education, curriculum and delivery mechanism, improving quality of post graduate research, addressing the needs of different stakeholders by making agricultural education relevant, responsive and promoting entrepreneurship skills to enable graduates to take up their own enterprises as job providers rather than job-seekers and improving the overall infrastructure in terms of student and faculty amenities pertaining to teaching and learning.

The government has also approved the continuation of the Three Year Action Plan (2017-2020) of the scheme for Agricultural Education Division and ICAR institutes, with an outlay of Rs. 2,225.46 crore for strengthening and developing higher agricultural education in India. The scheme has allotted Rs. 2,050.00 crore for strengthening and development of higher agricultural education in India, Rs. 34.25 crore for ICAR- National Academy of Agricultural Research Management (NAARM),

Rs. 151.21 crore for ICAR-Central Institute of Women in Agriculture (CIWA) including All India Coordinated Research Project on Home Science.

The scheme aims to generate quality human resources from the institutions. It is taking measures for quality faculty, international ranking, and alumni involvement, promote innovations and more. ICAR-NAARM will cater to farmers, young scientists, students and agri-industry in National Agricultural Research and Education System (NARES), to enhance their capability. NAARM has played a key role in enhancing the capacities of individuals, and institutions of NARES in agricultural research, education and technology management. ICAR undertakes planning, development, coordination and quality assurance in higher agricultural education through a partnership with 75 Agricultural Universities (AUs) established across the country. The human resource developed by Agricultural Universities has played a pivotal role in transforming agricultural scenario.

Conclusion

It must be kept in mind that Indian agriculture is dominated by innumerable small farms which are highly dispersed and unorganised. Since the nature of agricultural produce is highly perishable and erratic in supply because of its seasonality and other stresses, it calls for innovative supply chain management (SCM) to address these issues. Through the application of SCM in different sectors of agriculture will help throw innovative ideas to define the shape of future agriculture in the country. Additionally, there is surely a need to step up higher education in agriculture and increase the quantum of research on agri-supply chain simply because of its critical relevance to food security, availability and safety. An efficient agri-supply chain has the potential of not only increasing the equity of enablers in the chain but also incentivise farmers to produce more with quality and cater to the changing wants and preferences of consumers.

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Innovative Practices for Smart Agriculture

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There is a need to transform agriculture in order to feed a burgeoning global population and provide the basis for economic growth and poverty reduction. However, this transformation must be accomplished without depletion of the natural resource base. Transformation of Indian agriculture needs to be more productive through efficient use of inputs, sustainability is productive, and needs more resilience to risks, shocks and long-term climate variability.

World's population is expecting a one-third increase from now to 2050 and most of these additional two billion people will live in developing countries. At the same time, more people will be living in cities. If current income and consumption growth trends continue, Food and Agriculture Organisation (FAO) estimates that agricultural production will have to increase by 60 percent by 2050 to satisfy the expected demands for food and feed (Conforti 2011). Agriculture must therefore transform itself if it is to feed a burgeoning global population and provide the basis for economic growth and poverty reduction. Climate change will continue to make this task more difficult due to adverse impacts on agriculture, requiring new technologies, which seems very promising to move to the next level of farm productivity and profitability. To achieve food security and agricultural development goals, adaptation to climate change and lower emission

of greenhouse gases (GHG) are the necessity of changing scenarios. However, this transformation must be accomplished without depletion of the natural resource base. Transformation of Indian agriculture needs to be more productive through efficient use of inputs, sustainability in production, and needs more resilience towards risks, shocks and long-term climate variability. (FAO) defined climate-smart agriculture (CSA) as the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. These three main pillars are as follow;

- 1) Sustainably increasing agricultural productivity and income;
- 2) Adapting and building resilience to climate change;
- 3) Reducing and/or removing greenhouse gases emissions, where possible.



To address these three intertwined challenges, production systems need to become more efficient and resilient at the farm level. Resource conserving and innovative practices should be more efficient in resource use; use less land, water and inputs to produce more food sustainably, and be more resilient to changes and shocks. These resource conserving technologies (RCTs) and innovative practices are targeted at precise level with highest accuracy to achieve more precision in inputs application like seed, fertilisers, pesticides, irrigation etc. at farm level with information communication technologies (ICTs) and decision support systems (DSS) which is considered as Smart Agriculture.

Smart Agriculture or/and precision agriculture involve the integration of advanced technologies into existing farming practices in order to increase production efficiency and the quality of agricultural products. As an added benefit, they also improve the quality of life for farm workers by reducing heavy labour and tedious tasks. Smart or precision agriculture, which consist of applying inputs (what is needed) when and where it is needed, has become the third wave of the modern agriculture revolution (the first was mechanisation and the second the green revolution with its genetic modification). Nowadays, it is being enhanced with an increase of farm knowledge systems due to the availability of larger amounts of data. Recently, there have been enormous innovations in agricultural production, not only improving productivity, but just as importantly, safeguarding the environment. Several systems-research tools relating to information technology have become available for fertiliser management. With the introduction of geographic information systems (GIS), global positioning systems (GPS) and remote sensing (RS), farmers can now refine nutrient recommendation and water management models to the site-specific conditions of each field.

Innovative Practices for Higher Resource Use Efficiency

1. Precision in Seed Sowing and Planting

Seed sowing at right place and right amount is very tedious in fields. Effective seeding requires control over two variables: planting seeds at the correct depth, and spacing plants at the appropriate distance apart to allow for

optimal growth. Precision seeding equipments are designed to maximise these variables every time. Combining geomapping and sensor data detailing soil quality, density, and moisture and nutrient levels takes a lot of the guesswork out of the seeding process. Seeds have the best chance to sprout and grow and the overall crop will have a greater harvest. In future, existing precision seeders will come together with autonomous tractors and ICT-enabled systems that feed information back to the farmers. Prototype drones are being built and tested for use in seeding and planting. These drones can use compressed air to fire capsules containing seed pods with fertiliser and nutrients directly into the ground.

2. Precision in Nutrient Management

The approach of site-specific nutrient management (SSNM), a systematic approach to provide sound knowledge on "feeding crops" with nutrients as and when needed to make synergy between nutrient demand and supply under different field crops production system, is the solution to manage spatial variability of nutrients and better nutrient use efficiency.

- i) **Smart Fertilisers:** Smart fertilisers are new type of fertilisers which are formulated based on micro-organisms and nano-materials. Nanotechnology based smart fertilisers development with an emphasis on controlled-release and/or carrier/delivery systems will synchronise nutrient availability with the plant demands thereby reducing nutrient losses. Increased nutrient use efficiency has reduced dose of phosphate by half to one fourth and increased yields by 10 percent. For smart micronutrients the reduction in dose was up to 90 percent. Due to less investment, farmers' income can be raised by 15-20 percent. Biostimulants have direct hormonal effect on plants that positively affect root growth, root efficiency, nutrient uptake and characters that are beneficial in shifting from chemical to organic fertilisation regime. Major groups of biostimulants are humic substances, protein hydrolysate and amino acid stimulants, seaweed extract and PSBR. Biofertiliser on the other hand have an indirect effect on nutrient availability without itself supplying nutrients.

They are live microbial formulations that aid in nutrient availability and uptake.

- ii) **Leaf Colour Chart:** Leaf colour is a fairly good indicator of the nitrogen status of plant. Nitrogen use can be optimised by matching its supply to the crop demand as observed through change in the leaf chlorophyll content and leaf colour. The leaf colour chart developed by International Rice Research Institute, Philippines can help the farmers because the leaf colour intensity relates to leaf nitrogen status in rice plant. The monitoring of leaf colour helps in the determination of right time of nitrogen application. Use of leaf colour chart is simple, easy and cheap under all situations. The studies indicate that nitrogen can be saved from 10-15 percent using the leaf colour chart.
- iii) **NDVI Sensors:** Studies in wheat as well as in rice crops have shown that seed based nitrogen application using remote sensing based Normalised Difference Vegetation Index (NDVI) sensors can save 15-20 percent nitrogen without any yield penalty (Bijay-Singh et al., 2015) leading to improved profit margins to the farmers.
- iv) **SPAD Value:** SPAD (Soil-Plant Analysis Development) is a simple, quick and portable diagnostic tool for monitoring leaf nitrogen (N) status and improving the timing of N topdressing in rice. SPAD is a low cost chlorophyll meter and affordable by farmers.

It is possible to monitor leaf N status using SPAD thresholds and guide fertiliser-N timing on irrigated rice. Measuring SPAD readings of the uppermost fully expanded leaf to reveal plant N status has been accepted as a common practice, although it was found that leaves in lower positions could be more suitable to serve as testing sample for N status diagnosis, as the lower leaves were much better than the upper leaves in separating N level, in case the total N was used as an indicator. SPAD meter-based N management appeared to be more efficient and smarter N management.

- v) **Nutrient Expert (NE):** NE is the recently developed precision nutrient management technology guided by decision support system software for improving crop yields, environmental quality and overall agricultural sustainability. International Plant Nutrition Institute (IPNI) in collaboration with CIMMYT has developed a Nutrient Expert (NE), a nutrient decision support system, based on site-specific nutrient management (SSNM) principles. NE provides fertilizer recommendations by considering yield responses and targeted agronomic efficiencies along with contribution of nutrients from indigenous sources. This system follows systematic approach of capturing site-specific information that is important for developing a location-specific recommendation. NE has been successfully used to provide fertilizer recommendations in major maize growing



agro-ecologies of country and also increased yield and farm-profitability over existing fertiliser recommendations.

- vi) **Urea Deep Placement (UDP):** UDP technique, developed by the International Fertiliser Development Center (IFDC), is a good example of a climate-smart solution for rice systems. The usual technique for applying urea, the main nitrogen fertiliser for rice, is through a broadcast application which is a very inefficient practice, with 60-70 percent nitrogen losses contributing to GHG emissions and water pollution. In the UDP technique, urea is made into "briquettes" of 1 to 3 grams that are placed at 7 to 10 cm soil depth after the paddy is transplanted. This technique decreases nitrogen losses by 40 percent and increases urea efficiency to 50 percent. It increases yields by 25 percent with an average 25 percent decrease in urea use (Singh et al., 2010).

3. Innovative Practices for Efficient Water Management

Water is the most critical natural resource for human survival and sustainable development as its availability is decreasing day by day. The total projected demand of water for irrigation sector will be more than the present level, so there will be three major challenges viz., (i) "more crop per drop of water" by efficient and productive use of available water resources in irrigated areas, (ii) increased productivity of sub-productive challenged ecosystems, i.e., rainfed and waterlogged areas, and (iii) making use of grey water (waste water) for agriculture production. It is possible only through efficient irrigation management where and how much required by the crop.

- i) **Automation Irrigation System:** Pressurised irrigation systems like sprinkler, drip and subsurface drip irrigation are already prevalent irrigation methods that allow farmers to control when and how much water their crops receive. By pairing these irrigation systems with increasingly sophisticated Internet of things (IoT)-enabled sensors to continuously monitor moisture levels and plant health, farmers will be able to intervene only when necessary, otherwise allowing the system to operate autonomously. While

pressurised systems aren't exactly robotic, they could operate completely autonomously in a smart farm context, relying on data from sensors deployed around the fields to perform irrigation as needed.

- ii) **On-farm Reservoir (OFR):** Rainwater harvesting and efficient water use are inevitable options to sustain rainfed agriculture in future. Different states have initiated special programmes for OFR to ensure the sustainability and to improve livelihoods of people.
- iii) **Deficit Irrigation Supplies:** Under limited water availability condition, irrigation strategies based on meeting the partial crop water requirements should be adopted for more effective and rational use of water. The adoption of deficit irrigation such as regulated deficit irrigation and controlled late-season deficit irrigation are becoming an accepted strategy for water conservation and to reduce the amount of water used for crop production.

4. Innovative Practices for Weed and Pest Management

- i) **New Generation Herbicides:** Recently some post emergence new generation herbicides are available in the market with the assurance of selective effective control of weeds in field crops. These herbicides are required in very low doses and these are very easy in handling and transportation. Few post-emergence herbicides like imazethapyr, fenoxaprop-p-ethyl, cyhalofop butyl, quizalofop ethyl and clodinalop-propargyl in pulses and oilseeds; tembotrione in maize, pyrazosulfuron ethyl, chlorimuronethyl + metsulfuron methyl in rice; clodinalop + metsulfuron methyl in wheat are found very effective to control both broad leaved and grassy weeds.

- ii) **Herbicide Resistant Crops (HRCs):** Herbicide resistant crops are genetically modified (GM) crops engineered to resist specific broad-spectrum herbicides, which kill the surrounding weeds, but leave the cultivated crop intact. These HRCs comprised 83 percent of the total GM crop area, equating to just fewer than eight percent of the arable land worldwide. Most herbicide resistant GM crops (maize, soybean, cotton) have been engineered for

glyphosate tolerance but now GM crops are evolved resistance against 2, 4 D, dicamba, glufosinate, glyphosate, sulfamylurea, oxyfl, mesotrione and isoxaflutole. If Government of India allows growing herbicide resistant GM crops then weed management will be more efficient.

- iii) **Artificial Intelligence and Automation in Weed Management:** Weeds and pests management are the most critical aspects of plant growth and development which can be perfectly managed through autonomous robots. A few prototypes are already being developed to monitor the crops and simultaneously control the weeds. Similarly, automated cultivator can be used to control weeds. With advanced machine learning, or even artificial intelligence (AI) being integrated in the future, machines such as this could entirely replace the need for humans to manually weed or monitor crops.

There are also drones currently available and in development for crop spraying applications, offering the chance to automate yet another labour-intensive task. Using a combination of GPS, laser measurement and ultrasonic positioning, crop-spraying drones can adapt to altitude and location easily, adjusting for variables such as wind speed, topography and geography. This enables the drones to perform crop spraying herbicides, fertilisers and pesticides more efficiently, and with greater accuracy and less waste.

These robots designed for weeding, with the same base machine can be equipped with sensors, cameras and sprayers to identify pests and application of insecticides. These robots, and others like them, will not be operating in isolation on farms of the future. They will be connected to autonomous tractors and the IoT, enabling the whole operation to practically run itself.

5. Innovative Resource Conserving Practices

- i) **Laser Land Levelling:** Precision land levelling is another resource conservation technology, which using laser guided system, helps in obtaining a perfectly levelled field. Yield advantage in both direct seeded rice (DSR) and transplanted rice (TPR) and saving of 20-25 percent of irrigation water apart from several other benefits like better crop establishment, nutrient use efficiency, uniform irrigation etc. have been reported with laser land levelling.

- ii) **Raised-bed Planting:** Raised-bed planting refers to growing of crops (wheat, maize, pigeon pea and horticultural crops) in row geometry and on raised beds with furrow irrigation arrangements using a multi-crop raised bed planter. Helps in saving irrigation water by 30-40 percent, furrows act as drainage channel in case of heavy rains and hence save crops from excess moisture. This provides excellent opportunity for inter-cultural operations and crop diversification.

- iii) **Conservation Tillage:** Conservation tillage practices range from zero tillage (No-till), reduced (minimum) tillage, mulch tillage, ridge tillage to contour tillage. Conservation tillage farming is a way of growing crops without disturbing the soil through tillage using zero-till planter/drill. It increases the amount of water that infiltrates into the soil and increases organic matter retention and cycling of nutrient in the soil. Conservation tillage improves soil properties, making it more resilient. It helps in timely planting, reduce cost, improve soil health, increase profits, help in adapting to terminal heat stress and reduce environmental foot prints.

5. Innovative Practices for Higher Productivity and Profitability

i) Crop Diversification

Crop diversification is the most important agricultural activity providing employment and food security to millions of people in the country. Crop diversification can be practiced in two ways i.e. temporal/horizontal/crop rotational diversification and spatial/vertical diversification. The component crops which are less productive or need more inputs is substituted with more remunerative, less inputs requiring and which sustain the soil fertility. Rice-wheat cropping system is most dominating cropping system and nearly contributes 42 percent to the total food grains production. The growth in crop productivity of component crops is either stagnating (wheat) or declining (rice) despite the use of high yielding cultivars. Thus, substitution of rice which require more water with maize or cash crops like sugarcane and cotton will not only reduce water requirement but also enhance the system productivity which leads to increase in farmers' income.

ii) Integrated Farming Systems (IFS)

IFS is adoption and integration of wide ranges of resource saving package of practices, which ensures acceptable levels of profits/income, make the whole system economically sustainable, ecologically renewable, socially acceptable, minimise the negative impacts of intensive farming and preserve as well as improve the environment. In IFS approach emphasis is given on diversification of cropping systems in general and farming systems as a whole has been found successful to bring improvement in economic conditions of small farm families. This could be possible by intervening most appropriate cost-effective technologies for narrowing yield gaps and through integration of less-input requiring enterprises for holistic development of farms and ensuring livelihood and nutritional security as well. The approach applied on small land holdings varying from 0.4 to 1.5 ha of land has been successful to meet household food, fodder, feed, fuel requirements of a family, and achieve other goals including reduced production cost, increased profits, nutritional security, more employment opportunity, regular income and environmental safety. Horticultural crops mainly fruits and vegetables and dairy and goatry are among promising enterprises which integrate with existing farming systems to enhance income manifold.

iii) Conservation Agriculture (CA)

CA is a concept for optimising crop yield, economics and environmental benefits. The key features of CA are 3 basic principles: 1) Minimum soil disturbance, 2) Maximum soil cover by leaving and managing the crop residues on the soil surface, 3) Crop diversification. The main advantages of CA are reduction in cost of production, reduced incidence of weeds, saving in water and nutrients, increased yields, environmental benefits, crop diversification opportunities, improvement in resource-use efficiency, etc.

iv) Organic Farming

Organic farming in India has been reinvented and getting more popular with each passing day. Farmers, entrepreneurs, researchers, administrators, policy makers and of course consumers are showing increasingly greater

interest in promotion and development of organic farming in the country. Organic food products are considered to be much safer and nutritious than the products produced by the conventional farming. Organic farming also helps to restore the soil health, protect environment, enhance biodiversity, sustain crop productivity and enhance farmers' income. Organic produces are being sold at premium price which increase farmers' income. Seeing the long-term benefits of organic farming, the Government of India has taken many important steps for its promotion in the country. With the support of all kinds of stakeholders and the Government, the scope of organic farming movement has widened tremendously in India.

Based on the above-mentioned discussion, it may be concluded that innovative approaches will find their due for smart agricultural practices, increased productivity, resource use efficiency, and profit to the farmers and environmental safety.

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Sustainable Crop Production

Dr. Subhashisa Prabhara and Prof. Souvik Ghosh

Sustainable crop production refers to crop production practices that ensure high and stable yield over time, without affecting soil and ecosystem health. Sustainable crop production practices must be promoted among farmers. As some sustainable crop production practices may require high initial cost, hence, financial assistance may be given to farmers.



Agriculture plays a vital role in India's economy with more than half of the population being engaged in agriculture and allied activities and contributes about 17 percent to the total GDP. The agriculture and allied sector witnessed a growth of 5.6 percent in 2013-14, -0.2 percent in 2014-15, 0.6 per cent in 2015-16, 6.3 per cent in 2016-17, 5.0 per cent in 2017-18 and 2.9 percent in 2018-19 at 2011-12 base prices. As per the estimates of National Income released by the Central Statistics Office (CSO), Ministry of Statistics and Programme Implementation, the agriculture and allied sectors contributed approximately 16.1 percent to India's GVA at current prices during 2018-19 (DAC & FW, 2020).

Agricultural growth has been volatile having an impact on farm incomes as well as farmers' ability to invest that can be sustained by promotion

of sustainable crop production practices. India's food grains production has been increasing over the years. India is the largest producer (25 percent of global production), consumer (27 percent of world consumption) and importer (14 percent) of pulses in the world. It is also the largest producer of jute and the second-largest producer of rice, wheat, sugarcane, cotton and groundnuts, as well as the second-largest fruit and vegetable producer, accounting for 10.9 percent and 8.6 percent of the world fruit and vegetable production, respectively (FAO, 2020). However, the agricultural yield is found to be lower due to several issues like decreasing sizes of agricultural land holdings, erratic rainfall, changing climate, inadequate irrigation, imbalanced use of fertilizers resulting in loss of soil fertility, etc. Therefore, sustainable crop production intensification is being emphasised to produce more from the same area of land while reducing negative environmental impacts.

From subsistence farming to commercial farming, agriculture has evolved over time. Meeting the food requirement for ever increasing population under changing climatic scenario has been a challenging task. With the onset of green revolution, use of high yielding varieties, fertilisers and pesticide gained momentum and agriculture became input intensive. Intensive agriculture became the new normal. Though green revolution ensured higher production and helped achieving self-sufficiency in food production, it has always been under discussion for being unsustainable and unequitable. Practices like imbalanced use of fertilisers, over exploitation of ground water for irrigation, etc. have created several ecological issues in long run. For instance, the practices like over use of synthetic fertilisers and pesticides have led to environmental pollution, ground water contamination and health issues. These experiences have led agricultural research to explore alternative crop production practices that can ensure higher production and productivity without damaging the ecosystem and human health.

To be sustainable, agriculture must meet the needs of present and future generations for its products and services, while ensuring profitability, environmental health, and social and economic equity. Sustainable agriculture contributes to all four pillars of food security i.e. availability, access, utilisation and stability in a manner that is environmentally, economically and socially responsible over time (FAO, 2014). As conventional agriculture often focusses on high crop productivity only, without taking ecological consequences into account, hence ecosystem health is largely ignored. Such irresponsible practices often lead to natural resource depletion and/or degradation over time. However, sustainable agriculture ensures that natural resource is conserved and remains productive over time.

Sustainable crop production refers to crop production practices that ensure high and stable yield over time, without affecting soil and ecosystem health. Important sustainable crop production practices have been briefly discussed below.

Soil Health Management

Soil is a key natural resource for agriculture.

Managing and building the soil health is the most critical element of sustainable crop farming. Soil health is crucial for agriculture as a healthy soil acts as a dynamic living system delivering multiple ecosystem services. Soil also serves as a growth medium for the crops. Although India has diverse types of soil but most of them are deficient in nitrogen and phosphorus. The ideal NPK (nitrogen, phosphorous, potassium) proportion for the Indian soil is 4:2:1. The ratio of NPK in Punjab and Haryana was 19.2:5.5:1 and 20.6:5:1, respectively in 2011. The disparity in the prices of urea and P and K fertilisers led to a distortion in the consumption pattern of NPK fertilisers (NITI Aayog, 2018). With the increasing availability of low-cost fertilisers, the importance of organic manure is largely ignored by farmers. In addition to lower use of organic manure, practices like intensive cultivation and residue burning has further reduced the organic carbon content in soil. As carbon is very crucial for microbial growth, hence, the natural fauna and flora of soil are disturbed, which in turn affects the nutrient cycling in the soil. Poor organic matter content in soil negatively affect the physical, chemical and biological property of soil altogether.

Considering these facts, restoration of depleted soil nutrients and microorganisms by maintaining organic carbon content in soil is necessary for soil health. Organic amendments such as farm yard manure, green manure, compost, vermicompost, etc. need to be added to soil regularly to increase its organic matter content of the soil. Growing of legumes as green manuring crops or cover crops (sunn hemp, cowpea, sweet clover, lentil, etc.) protects soil from erosion by keeping the soil covered as well as adds organic matter, fixes nitrogen, improves soil structure and other beneficial effects. In addition to these, use of agro-chemicals should be monitored to avoid any toxic build up in soil.

The Government of India launched the Soil Health Card scheme in 2015 to give each farmer soil nutrient status of his holding and advise him regarding dose of fertiliser application and need of amendment to realise optimal yield and maintain soil health in a long run. Farmers get a printed report of soil health card for each of his holding containing the status of soil with respect to 12 parameters i.e. Nitrogen (N), Phosphorus (P),

Potassium (K), Sulphur (S), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), pH, electrical conductivity (EC) and organic carbon (OC). This initiative is a key step towards sustainable soil fertility management by promoting soil test based and balanced use of fertilisers to enable farmers to realise higher yields at lower cost and to aware farmers about the appropriate amount of nutrients for the concerned crop depending on the quality of soil (DAC & FW, 2015). Under this scheme, 10.74 crore soil health cards were issued during the first cycle (2015-16 to 2016-17), while 1156.29 lakh soil health cards were distributed to farmers during the second phase (2017-18 to 2018-19) (DAC & FW, 2020).

Conservation Agriculture

According to FAO (2017), Conservation Agriculture is a farming system that promotes minimum soil disturbance (i.e. no tillage), maintenance of a permanent soil cover and diversification of plant species.

The United States has been the pioneer country in adopting conservation agriculture systems with highest land under such system followed by Brazil, Argentina, Canada and Australia. In India, conservation agriculture is being promoted in the irrigated regions of Indo-Gangetic plains where rice and wheat cropping system dominates. Conservation agriculture addresses several challenges like increasing soil carbon storage and decreasing greenhouse gas emission, promoting sustainable agriculture, preserving environment and natural resources (soil, water, air) and preserving biodiversity.

For minimum soil disturbance, farmers follow zero tillage or controlled tillage which allows direct planting without ploughing or soil preparation. Seeding is done directly through surface residues of previous crops using a seed drill. The benefits of minimum soil disturbance include: reduced soil erosion, reduced greenhouse gases (GHG) emission, improvement in soil fertility and soil structure, increased biological activity, avoids soil compaction and soil surface sealing. Reducing tillage (low- or no-till practices) increases organic matter and sequestration of carbon in soil, as well as improves its structure and water retention capacity.

A permanent soil cover is maintained through retention of adequate level of crop residues on soil



surface. Maintaining a soil cover helps reducing the deleterious impact of rain drop and wind on soil, thus reducing soil erosion. Moreover, the surface residue allows more water to infiltrate into soil rather than freely flowing to river or sea. Surface cover also adds high amount of soil organic matter to soil, thus improving physical, chemical and biological properties of soil.

Another key principle of conservation agriculture is crop diversification or sensible crop rotation. A sensible crop rotation is an economically viable diversified crop rotation that helps in moderating weed, disease and pest problems, takes advantage of biological nitrogen fixation when legume is included in the rotation and minimised risk. As only cereal based crop rotation results in pest build up and reduces soil fertility to a great extent, thus replacing them with a more sensible system helps minimising the negative impacts.

Crop Residue Management

The problem of residue management has gained attention in recent times as the problem of stubble burning has resulted in an uncomfortable public life. Burning of crop residues removes huge amount of nutrient from the soil. In addition to this, generation of smoke, carbon monoxide, carbon dioxide and other toxic gases cause air pollution leading to multiple health issues. The greenhouse gas emitted also contributes to global warming and climate change. Despite the ban being imposed on residue burning, there is residue



burning across states causing severe pollution. Considering this, an ecologically sustainable and economically viable alternative method of residue management is the need of the hour.

In situ management of crop residue can be done through conservation agriculture practice. Instead of burning crop residues, the crop residues can also be used for alternate beneficial use. Such alternate beneficial uses of crop residue include compost production, bioenergy production (through gasification or bio-oil production), biochar production, in pulp and paper industry, etc. Use of crop residues as compost, soil cover or even biochar can help in improving soil fertility and productivity. Hence such alternate economically viable and ecologically beneficial uses of crop residues can be promoted.

A Central Sector Scheme on 'Promotion of Agricultural Mechanisation for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi' was approved for the period from 2018-19 to 2019-20. The scheme aimed at protecting environment from pollution, preventing loss of nutrient and soil micro-organisms caused by burning of crop residues, promoting in-situ management of crop residue, promoting farm machinery banks for custom hiring of in-situ crop residue management machinery and creating awareness among stakeholders (DAC & FW 2018).

Integrated Nutrient Management

Integrated Nutrient Management (INM) refers to maintenance of soil fertility and plant nutrient

supply at an optimum level for sustaining desired productivity through optimisation of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner. INM helps in reducing the dependence on synthetic fertilisers, thus reducing the cost of cultivation for farmers. INM may help in the optimised use of all available resources with farmer to maintain or improve soil fertility. The components of INM include:

Soil Source

Soil contains a large amount of nutrient. The inherent fertility of soil is an important component of INM. The nutrient status of soil must be monitored at regular interval. Any unfavourable soil conditions like high soil acidity or soil salinity should be reclaimed to improve the nutrient availability to plant.

Mineral Fertilisers

A part of the nutrient requirement of crop can be met by using synthetic fertilisers like urea, SSP, DAP etc.

Organic Sources

Farm Yard Manure (FYM), compost, sewage, sludge, crop residues, etc. can be used as organic source of nutrient. In addition to supplying nutrient, organic sources also improve soil organic carbon content of soil.

Biological Sources

Biofertilisers can be used as a source of nutrient. They can supply nutrient either by fixing nitrogen from atmosphere or by increasing the

availability of soil nutrient through solubilisation and mobilisation.

Integrated Pest Management

Food and Agriculture Organization (FAO) defines Integrated Pest management (IPM) as careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and environment (FAO, 2017).

IPM considers all available control options such as cultural, physical, chemical and biological methods to control pests. It also focusses on prevention, monitoring, forecasting and early diagnosis as tools for pest control. As IPM reduces dependence on chemical pest control, hence, risks to human health and environment is reduced. IPM also helps delay the risk of pesticide resistance development. In addition to ecological benefits, IPM can also give economic benefit as the cost of pest control is reduced in this approach.

Inclusion of Legumes in Cropping System

Legumes belong to family Leguminosae or Fabaceae and are known for their nitrogen fixing ability. As cereal based intensive cropping systems have been found to be unsustainable in a long run, hence, inclusion of legume in the cropping system can be helpful in improving soil fertility and making the production system sustainable. Legumes add nitrogen to the soil through nitrogen fixation, improves phosphorus availability through rhizosphere modification and helps in nutrient cycling by bringing the subsoil nutrient to the top soil through its deep root system. For complete recycling of nutrients, legumes can be used as green manuring crop. Legumes also supply good amount of organic matter to soil. Legumes are close growing and have dense canopy. This is the reason that Legumes serve as cover crop. They help in reducing soil erosion by increasing infiltration and reducing runoff. Moreover, the dense canopy of legumes helps in reducing the impact of falling rain drops on soil, thus minimising erosion. Legumes when grown as intercrop can improve productivity as well as soil fertility. In addition to this benefit, they can act as weed suppressant.

Legumes, because of their fast-growing habit and dense canopy can suppress weed effectively.

In addition to these benefits, legumes provide the necessary dietary diversity. Pulses are good source of protein and contains amino acid lysine, that most cereals are deficient of. Legumes also act as biological plough and reduces the subsoil compaction through its deep root system. Legumes, are usually high value crops, which can generate profit for farmers.

Climate Smart Agriculture

Climate Smart Agriculture (CSA) is an approach for developing strategies to secure sustainable food security under changing climatic scenario. It integrates three dimensions of sustainability i.e. social, ecological and economic dimensions by addressing the issues of food security and climate change simultaneously. Climate smart agriculture has three main pillars i.e. sustainably increasing agricultural productivity and income, adapting and building resilience to climate change and reducing and/or removing greenhouse gas emissions to a safe level (FAO, 2013).

More productive and more resilient agriculture requires efficient utilisation of land, water, soil nutrient and genetic resources. The vast genetic resources can be utilised to develop varieties which can perform well against the uncertainties of climate change. On-farm diversity can also provide resilience to the agricultural system.

Whenever and wherever possible, climate smart agriculture also targets at reducing GHG emission from agriculture sector by efficient management of nutrient, water and soil. Carbon sequestration approach can be effectively implemented to remove carbon dioxide, a greenhouse gas, from atmosphere as soil and trees can act as a carbon sink.

Climate change is being considered as a serious threat to the livelihood of Indian farmers with about 82 percent of farmers from small and marginal category (FAO, 2020). In spite of a record food grains production estimated for 2019-20 i.e. 291.95 million tonnes (MoA&FW, 2020) in the context of projected requirements of 337 million tonnes of food grains by 2032-35 (NITI Aayog, 2018). To meet the challenge of climate change on sustainability of Indian agriculture, Indian Council of Agricultural Research (ICAR) has

launched National Innovations on Climate Resilient Agriculture (NICRA) in 2011 that has been evolving climate resilient agricultural technologies and also demonstrating the best practices that can help farmers to cope with current climate variability.

Resource Conserving Technologies

Injudicious or over use of resources not only adds unnecessary cost to the production process but also negatively affects environment. Resource conserving technologies (RCTs) can help achieve higher productivity in resource poor areas. RCTs help in improving input use efficiency and minimises loss of inputs.

Resource conserving technology like zero tillage reduces the cost of tillage, gives similar or higher yield, reduces weed infestation in the field, etc. Use of seed drill can help reduce seed rate and ensure uniform plant stand. Direct seeded rice holds promise of saving irrigation water and labor requirement. Use of Hydrogel (a water absorbing material) in dry land or limited water conditions can improve water use efficiency. Irrigation practices like, drip or sprinkler methods also shows high water use efficiency and can save irrigation water. For improving nutrient use efficiency, site specific nutrient management can be followed. Right source, right time, right dose and right place (4R) approach of fertilizer application can improve nutrient use efficiency. Use of GIS and GPS for precise agricultural input management (precision farming) can also be considered as a resource conserving technology. Permanent raised bed or furrow irrigated raised bed will reduce the cost of land preparation in long run, result in higher yield, reduce water loss and show high input use efficiency. Similarly use of laser land leveler improves water use efficiency.

Considering these benefits, a single RCT or a suitable combination of RCTs may be used for growing a crop, thus saving resources, increasing efficiency and getting higher economic benefit without negatively affecting the environment.

Apart from the aforementioned practices to ensure sustainable crop production, there are multiple initiatives that have been taken up by Government of India to promote sustainable agriculture practices. Some of these initiatives are:

- National Mission on Sustainable Agriculture (NMSA) seeks to address issues regarding

sustainable agriculture in the context of risks associated with climate change by devising appropriate adaptation and mitigation strategies.

- Paramparagat Krishi Vikas Yojana (PKVY) aims at development of sustainable models of organic farming through a mix of traditional wisdom and modern science to ensure long term soil fertility build up, resource conservation and helps in climate change adaptation and mitigation.
- Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) seeks to extend the coverage of irrigation with improved access to irrigation and water use efficiency.
- Soil Health Card Scheme is aimed at improving soil fertility on a sustainable basis.

Conclusion

The issues of high cost of production due to over reliance on purchased inputs, environmental pollution, groundwater contamination, deterioration of soil structure, herbicide/pesticide resistance development, outbreak of insect-pest-diseases, declining under groundwater table (due to over exploitation of ground water for irrigation), etc. raises concern over the sustainability of conventional input intensive agriculture systems. Under such circumstances, a paradigm shift is required for enhancing system productivity and sustainability. Sustainable crop production practices must be promoted among farmers. Farmers' feedback on these technologies/ practices should be taken into consideration and necessary changes must be made to address the farmers' concern. As some sustainable crop production practices may require high initial cost, hence, financial assistance may be given to farmers. Sustainable agriculture not only helps achieving the ever-existing target of food and nutritional security, but also aims at ecological balance and social security. It not only cares for the needs of present generation but also for the generations to come.

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BOOK RELEASE

Connecting, Communicating, Changing.....A chronicle of VP's third year in Office

The book titled 'Connecting, Communicating, Changing' by the Publications Division chronicling the third year in office of the Vice President of India Shri M. Venkiah Naidu was released at Upa-Rashtrapati Nivas in New Delhi on 11 August, 2020. This release was in the presence of Union Ministers, Shri Rajnath Singh and Shri Prakash Javadekar. The book which runs into more than 250 pages has been brought out by the Publications Division of the Ministry of Information and Broadcasting. The book captures through words and pictures the varied activities of the Vice President, including his travels in India and abroad. It provides a glimpse of his interactions with farmers, scientists, doctors, youth, administrators, industry leaders and artists, among others. IEB Secretary Shri Amit Khare was also present on the occasion.



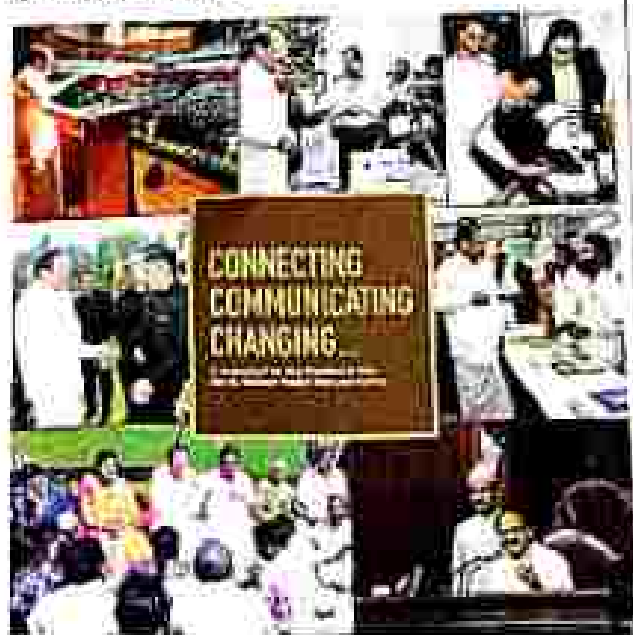
OUR BOOKS

**Connecting, Communicating, Changing.....A chronicle of
VP's third year in Office**

Author – Vice President Secretariat

ISBN- 978-93-5409-000-4, Price- Rs 1500/-

This coffee table title highlights the important events of the Vice President's third year in office. The book also covers events relating to the Vice President's foreign visits, his interactions with the world leaders and his addresses to the Indian diaspora in different countries. The changes Shri Naidu introduced for effective functioning of the Rajya Sabha and the resultant improvement in the productivity of the Upper House are also mentioned in the book. In the final chapter, the book narrates how the Vice President effectively used the time during the pandemic and embarked on 'Mission Connect' to enquire about the well-being of his friends, teachers, long-time associates, acquaintances—old and new, relatives, MPs, spiritual leaders and journalists, among others.



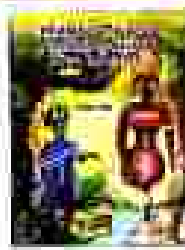
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