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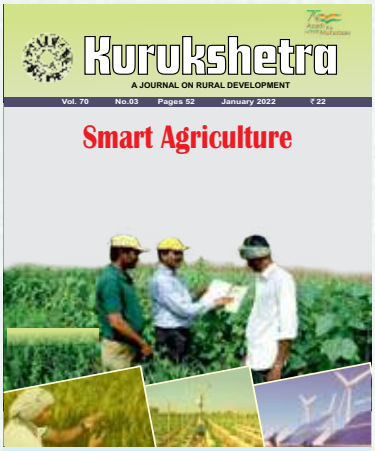

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EDITOR
Shiela Chaudhary
Pankhuri Awasthi

PRODUCTION OFFICER
D.K.C. Hrudhainath

COVER DESIGN
Rajender Kumar

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

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EDITORIAL

India is predominately an agricultural country and the sector has been providing stability and boost to the economy as well as is a major source of livelihood for 54.6 percent of the total population. Agriculture has been the brightest spot in the economy despite COVID-19 as the share of agriculture in GDP has reached 20 percent in the FY 20-21.

The Government of India is making a series of progressive efforts to further improve the agriculture sector by launching several programmes and schemes. The government is committed to make agriculture sector a flourishing sector and truly a source of AatmaNirbharta. New and emerging technologies are providing better opportunities for the agriculture sector.

In this issue of Kurukshetra, we have published articles on various subjects like Agri-Startups and Enterprises, e-Nam, Climate Smart Agriculture, and Renewable Energy. In these articles, the readers will find information about new developments in the sector.

The article named Agri-Startups and Enterprises highlights that agritech startups are not only creating new employment avenues but are also leaving a ripple effect on the socio-economic fabric of Indian demography in which they are operating. Today, the era of social apps, digital media and pure internet companies which were part of first and second generation revolution are being taken over by sectors viz. FinTech, CleanTech, Cybersecurity, Blockchain etc. With this rise, India has become the third largest startup ecosystem hub. India is home to highest number of unicorn startups after the US and China.

The Indian agricultural sector is diverse, vivid, and dynamic. The development of the sector, naturally, has been a key priority for the Government of India. The Government of India has multiple, overarching programmes to deliver CSA elements to Indian farmers in an affordable, accessible, and adaptable manner. The article named Prioritising Climate Smart Agriculture throws light on various such programmes.

This issue also gives an insight on the new developments and efforts taken by MNRE to provide clean energy support to various development programmes and improve the quality of life of millions of rural dwellers.

We have also carried an article on Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY), which aims at building the placement-linked skills of the poor rural youth and provide them employment across various sectors of the economy. The programme has an outcome led design with guaranteed placements for at least 70 percent of the trained candidates.

With this issue of our journal, we wish our readers a very happy and prosperous New Year.

Agri-startups and Enterprises

Manjula Wadhwa

Agri-startups are not only creating new employment avenues but are also leaving a ripple effect on the socio-economic fabric of Indian demography in which they are operating. Today, the era of social apps, digital media and pure internet companies which were part of first and second generation revolution are being taken over by sectors viz. FinTech, CleanTech, Cybersecurity, Blockchain etc. With this rise, India has become the third largest startup ecosystem hub. India is home to highest number of unicorn startups after the US and China.

India's digital ecosystem is witnessing healthy tailwinds such as affordability and availability of high speed internet and maturing digital content ecosystem. The confluence of these factors presents an exciting opportunity for innovation in agriculture, wherein market players can leverage next generation technology such as data digitisation, data platforms, data analytics, AI, ML, the IoT and Software as a Service (SaaS) to disrupt the status quo.

Increasing demand of innovation in agriculture and declining last mile delivery to farmers has put up a pressure on the public extension system to perform beyond its designated role of disseminating information on technologies. The new role demands organising user/producer groups, linking farmers to markets, engaging in research, planning and technology selection, enable changes in policies and linking producers to a range of other support and service networks. However, the Indian extension system has been considerably weakened over the last two decades in terms of human resources and capacity. Huge vacancy levels in public extension system particularly in remote and disadvantaged regions have further constrained the extension support and services to farming community. The lack of these support and service networks is one of the major factors behind the agrarian distress in our country. In the current backdrop, when every other day we find new agritech startups emerging, it again kindles our ray of hope in Indian agriculture. Agri-startups are providing relevant and innovative solutions to a number of challenges faced all across the agricultural value chain. A new wave of budding entrepreneurs and emerging startups in the country is leading the way in disrupting the age old agriculture system with innovative ideas and affordable solutions. These have become the missing link between the farmers, input dealers, wholesalers, retailers and consumers; connecting each of them and providing strong marketing linkages and quality produce on time.

These startups are not only creating new employment avenues but are also leaving a ripple effect on the socio-economic fabric of Indian demography in which they are operating. Today, the era of social apps, digital media and pure internet companies which were part of first and second generation revolution are being taken over by sectors viz. FinTech, CleanTech, Cybersecurity, Blockchain etc. With this rise, India has become the third largest startup ecosystem hub. India is home to highest number of unicorn startups after US and China.

Before delving deeper into the subject, let us comprehend the concept itself. A startup is a company, a partnership or temporary organisation designed to search for a repeatable and scalable business model. Through the startup phase, new ideas are brought to the market and transformed into economically sustainable enterprises. New firms are artefacts for transforming entrepreneurial judgement into profit.

Undoubtedly, India is an agrarian economy, with Agriculture sector contributing to more than 15 percent of the country's GDP. Also, it is one of the biggest employers with approximately 70 percent of the rural population employed in the agricultural space. However, despite the sheer scale of it, one of the key drawbacks is that the sector has been considerably slow in the adoption of technology, largely due to insufficient penetration and those engaged in agriculture being unaware of existing technological advancements. More often than not, farmers lack sufficient information regarding farming inputs for increasing their yield. Apart from this, the vast unorganised credit structure and absence of proper market linkages add to their woes by contributing to their meagre income. This is where agritech startups come into the picture. With a huge potential to address these challenges, they are the knights in shining armour for Indian farmers.

Let us look at how agritech startups are disrupting the agriculture and empowering farmers digitally. With the advent of agritech startups, the agriculture industry, classified into 4 broad divisions – agri-inputs, agri-financial services, food processing companies, and farm mechanisation, has seen several fundamental changes in the way it functions. Agritech startups with novel technologies such as AI, ML and data analytics are making it easier for farmers to improve their methods of farming such as identifying the right crop to be sown for better yield. Additionally, startups are also offering mechanised equipments that can be potentially unaffordable for farmers to purchase, on a rental basis thus making the equipments readily available to farmers. Besides, agritech startups are taking it up a notch with mobile applications, making it even more convenient for farmers to access information. It is the startups which enable the farmers to have direct access to the market without the need of intermediaries, leading to an increase in their income. For ages, the Indian farmers have been struggling to obtain credit due to the unorganised structure of credit system. Agritech startups ensure that there is financial inclusion by enabling farmers to upload their records digitally and apply for credit, freeing them from the clutches of local moneylenders who may charge unreasonable rates of interest. Based on their credit history, quality and quantity of produce, farmers can avail loans to achieve their growth objectives without any roadblocks. Farming-as-a-Service model (FaaS model) is also emerging as the future of agriculture. It offers innovative solutions for agriculture and allied services through a subscription-based or pay-per-use model which enables stakeholders to make effective data-driven decisions to help boost productivity and efficiency.

Current Landscape

Apart from government initiatives, significant impact is being created by startups in the agritech space. Investors pumped in $ 500 million to Indian agritech deals in 2020. It is estimated that $10 billion will be invested in Indian agritech startups over the next 10 years. Currently, 3.8 percent or 600+of the total recognised startups in the country are in this space as per the Economic Survey of 2019-20. Of these, 54 percent are classified as agritech while the rest are in the field of dairy farming, food processing and others.

India continues to be among the top six countries globally, with the highest number of deals in agricultural technology. (The US, Canada, the UK, Israel and France comprise the other five countries.) In 2016, within global investments, Indian agritech startup firms contributed around 9 percent, valued at $ 313 million. In 2020 alone, over 20 agritech startups have together raised more than Rs. 920 crores across venture debt, equity and conventional debt rounds. According to a NASSCOM report, the Indian Government specifically supports agritech startups through its Startup India Program.

To name a few players, SatSure, founded in 2016 strives to create a positive impact on the lives of farmers by helping them improve crop insurance, innovate on agri-lending services and improve market linkages by creating intervention and decision intelligence frameworks for agri-value

The focus of agri-startups hovers around the following key sub-sectors

Supply chain	Infrastructure	Finance	Farm Data and Analytics	Information Platform
• E-distributor	• Growing system and components	• Payments	• Integrated Platform	• Information Dissemination
• Listing Platform	• Aquaponics	• Revenue sharing	• Remote sensing software	
• Marketplace	• Hydroponics	• Lending	• Farm Mapping	
	• Drip Irrigation		• Farm Management	
			• Field Operations	

chain stakeholders through the best practices of satellite image processing, big data capabilities and IT in agriculture. Nowadays, the solutions of this startup are being used by Andhra Pradesh government, large banks and insurance companies in India. Ministry of Agriculture and Farmers' Welfare supported the startups through initiatives like the Agriculture Grand Challenge which further validates our belief that data mining and analysis is of high value to the agriculture sector. Fasal's microclimate forecasts are tailored to each farm location and are performed at a point scale and not at a kilometer-wide spatial scale, so that farmers can benefit from real-time, actionable information relevant to day-to-day operations at the farm. Aibono, pegged as Agri 4.0, the collective provides precision farming technologies backed by real-time synchronisation of supply and demand. Bengaluru-based Cropin provides a full suite of farm management, monitoring and analytics solutions through its new product called 'Smart Risk' developed at $ 5 million, currently assisting over five million farmers towards farm management, crop cycle monitoring, harvest and brings in produce traceability from farm to fork. Similarly, Intello Labs positioned as India's most awarded agritech startup has developed computer vision based solutions that use images as key data for deriving insights and actionable recommendations for crop inspection and agricultural product grading.

Prime Minister Shri Narendra Modi, while realising his unwavering intent-farmers' welfare is India's welfare, gave a clarion call on February 28, 2016, for Doubling of Farmers Income (DFI) at the heart of which lies a simple, three-pronged principle- farmers' income increases when yields increase, cost of production reduces and farmers receive remunerative prices. Perceiving the truth that startups in India need a strong impetus for agri-sector to flourish, the Government of India has taken several initiatives to boost support to the agri-startups. From Information Communication Technologies (ICTs), mobile apps, farm automation, weather forecasting, and drone use to inputs retailing, equipment renting and online vegetable marketing, technology is pervasive. Multiple enabling policies have been implemented to support agri-startups, their early take-off and successful operations. India has already built a credible name for itself in the global startup community. Now, it is time to make agri-startups successful and propel India forward as a leader in the agri-technology sector too. Government schemes like setting up of the National Centre for Management and Agricultural Extension in Hyderabad (MANAGE) and the Department of Science and Technology have given a tremendous boost to the sector. The focus area of the latter was accelerating agritech startups by providing mentoring, industry networking and investor pitching guidance.

Startup India is a flagship initiative of the Government of India, intended to catalyse startup culture and build a strong and inclusive ecosystem for innovation and entrepreneurship in India. The three pillars of this action plan are as follows.

- Simplification and hand holding
- Funding and Incentives
- Incubation and industry academia partnerships

To be eligible under it, the Startup should be incorporated as a private limited company or registered as a partnership firm or a limited liability partnership. Turnover should be less than Rs. 100 crores in any of the previous financial years. Eligible startups are exempted from paying income tax for three consecutive financial years out of their first ten years since incorporation.

Since easy availability of capital is essential for entrepreneurs at the early stages of growth of their enterprise, the Department for Promotion of Industy and Internal Trade (DPIIT) has recently created Startup India Seed Fund Scheme (SISFS) with an outlay of Rs. 945 crore to provide financial assistance to startups for proof of concept, prototype development, product trials, market entry, and commercialisation. It will support an estimated 3,600 entrepreneurs through 300 incubators in the next four years. In order to promote entrepreneurship in agriculture, the Department of Agriculture, Cooperation and Farmers Welfare (DACFW) has launched a new component called 'Innovation and Agri-Entrepreneurship Development'. It has been launched under the Rashtriya Krishi VikasYojana (RKVY-RAFTAAR). Five Knowledge Partners (KPs) and 24 Agribusiness Incubators (R-ABIs) have been appointed by DACFW to advise on smooth and efficient execution of this programme in various states. Under this programme, for idea/ pre-seed stage, a selected startup shall be eligible for a maximum financial assistance of Rs. 5 lakh. For seed stage, Rs. 25 lakh. 346 start-ups in the agriculture and allied sectors have been selected for funding for a sum of Rs. 36.72 crore in instalments. The department has already released Rs. 16.01 crore as first instalment. These start-ups were trained for two months at various agribusiness incubation centres spread across the country. NITI Aayog runs a comprehensive Atal Innovation Mission. The Department of Biotechnology runs Biotech Parks and incubators programme. The CSIR, ICAR, State Agricultural Universities, public and private universities and private companies run their own versions. Startup India of the Ministry of Commerce and Industry and AGNIi-Accelerating Growth of New India's Innovations - under the Office of Principal Scientific Adviser are two powerful platforms, which help the innovation ecosystem through initiatives like award programmes, commercialisation etc. Similarly, Ministry of Development of North Eastern Region has launched Initiative for Development of Entrepreneurs in Agriculture (IDEA) which intends to promote agri-business ventures in the northeast region and assist in establishing agri-business as a profitable venture. It also provides gainful employment opportunities and makes available supplementary sources of input supply and services.

The latest milestone in the desired direction is Startup Accelerators of MeitY for Product Innovation, Development and Growth (SMRIDH) Scheme, introduced on August 25, 2021, designed to provide funding support to startups along with helping them bring skill sets together which will help them to grow successful. Here, the focus is on the acceleration of around 300 startups by extending them with customer connect, investor connect, and other opportunities for international expansion in the upcoming three years that will follow.

Further, GOI, in the Union Budget of 2017-18 announced the creation of Dairy Processing and Infrastructure Development Fund (DIDF) under the apex development bank, NABARD with the total corpus of Rs. 8000 crores over a period of 3 years (2017-18 to 2019-20). Milk unions, multi-state milk cooperatives, state dairy federations, milk producing companies, and NDDB subsidiaries meeting the eligibility criteria under the project can borrow loan from NABARD, with guarantee from the respective State government. The Dairy Entrepreneurship Development Scheme (DEDS) is yet another scheme implemented by the Department of Animal Husbandry, Dairying and Fisheries to generate self-employment opportunities in the dairy sector. These opportunities in the mentioned sector will comprise activities like the enhancement of milk production, procurement, preservation, transportation, processing, and marketing of milk by providing back-ended capital subsidy for bankable projects. Here also, the nodal agency is NABARD.

Key Challenges

These startup firms are making headway in the areas of farm management, field monitoring, crop monitoring, yield mapping, equipment guidance, precision farming and implementation of automation and electrification. Agrowave, BharatAgri, Bijak and Ergos are some of the companies working on data-science led personal advisory, logistics and marketplace models. But these companies unlike the tech sector have longer investment cycles and have a high need for patient capital, a need that social impact venture

funds are slowly addressing. The combined revenue of all agritech startups in India is estimated to be less than $ 100 million, which is a drop in the ocean in a market worth more than $ 350 billion. Thus, the opportunity to scale and disrupt is huge. The formidable challenges ahead are as follows.

- Small and scattered landholdings of farmers reduce the scope of technology scale up, leading to poor cost effectiveness.
- Rate of return on technology investment has not proven very profitable in case of agritech startups as compared to other IT-based startups.
- Agri startups and enterprises are finding it hard to retain technical talent working in this sector.
- Technology adoption and penetration is a very slow process which certainly diminishes investors' interest.
- High-priced technology solutions are unaffordable for a large user group, i.e. small and marginal farmers.
- Making farmers adaptive to the required skills for working on advanced technologies requires significant effort.
- Most of the technology solutions available are not localised to emerging markets.
- Regulations, though favourable, are complex in nature.
- Facilitating adoption of proven technologies through subsidy is yet to gain momentum.

Path Forward

More than 25 percent of farmers in India today have access to smart phones. There is a need to develop mobile training programmes for the capacity building of farmers and help them adapt and adopt to new technological advancements. Globally, agri-startups have come a long way both in terms of investment and technology. Increased and timely support to early stage start-ups will boost the sector further in India. Funding in the Indian agritech sector is 10 percent of global funding but startups struggle to scale up. There is a need for large companies to effectively collaborate with startups. Only 9 percent of all funding in the last 5 years was focused on growth-stage startups. This emphasises the need for corporate and government accelerators to help agritech startups grow to the next level. There is also a need for the government to help set up agritech-focused incubators and grants. Also, academia should encourage more entrepreneurs to focus on this growing sector. Other Indian States need to come up with favorable policies to attract startups and investors similar to Karnataka (home to 70 percent of agritech startups).

Moreover, banks and financial organisations also need to step up to the challenge and offer more creative models of financing for farmers, entrepreneurs, incubators, and accelerators. Schemes like the government's Startup Agri India scheme, the DigiGaon (Digital Village) initiative, and BharatNet Project can all work together to address the situation. Initiatives like agri-hackathons can also bring together aspiring entrepreneurs from diverse sectors. In order to make agri-startups successful, it is crucial to enable seamless hybridisation of relevant technology by building a promising 'new-age distribution model'. We need to develop a new way for the farmer to buy products and get information as well as credit on one unified platform. Merely providing content on an app is not going to solve the issues of the farming community. Technology is just one component; an evolved distribution system with a human touch is what will make the model scalable over time. In addition, Agri-startups need to customise suitably before entering a market that has a very low technology adoption rate (due to limited budgets and inconvenience with usage) and re-orient their methods of selling, which essentially will be different from urban India and start-ups operating there.

To conclude, let every startup and enterprise not only remember the following words of Swami Vivekananda but also strive hard to translate them into reality:

*"**Take up one idea. Make that one idea your life, think of it, dream of it, live on that idea, let the brain, muscles, nerve, every part of your body be full of that idea and just leave every other idea alone. This is the way to success.**"*

(The author is AGM, NABARD, Chandigarh. Email: manjula.jaipur@gmail.com. Views expressed are personal)

e-NAM: Helping Farmers to Earn Better

Dr. Ishita G. Tripathy

The framework of e-NAM can be potently evolved from being a marketing portal to a one-stop information centre for accessing government policies, prices, weather conditions and early warning systems, and extension services; for exchanging planting strategies; links to financial institutions for credit, insurance; etc. True to its name, e-NAM needs to have a national character and be linked to all States/UTs. The objective of the portal is to create a unified national virtual market for agricultural commodities and to aid farmers in getting better price discovery on a real time basis and providing them with marketing options. By doing away with information asymmetry, the e-NAM portal has adequately demonstrated its latent characteristic to enhance efficiency. The positive consequences of trading on the platform take different manifestations: ranging from price discovery to improved livelihood; social benefits to economic benefits; prompting efficiency to reducing wastage; and promoting digital to financial inclusion.

With its overpowering presence in every sphere of life and its inherent advantages, including the ability to provide quick solutions at the click of a button, it is no surprise that technology has entered the oldest economic sector, viz. agriculture. It has been five years since the National Agricultural Market (e-NAM), an electronic trading portal which connects buyers and sellers, was launched on 14th April, 2016. The objective of the portal is to create a unified national virtual market for agricultural commodities. It is also aimed at aiding farmers in getting better price discovery on a real time basis and providing them with marketing options. Further, it underscores one of the important recommendations of the Ashok Dalwai Committee on doubling farmers' income and strives to ensure increased income through appropriate and transparent price discovery of farm products.

On behalf of the Ministry of Agriculture and Farmers Welfare, the Small Farmers' Agribusiness Consortium (SFAC) acts as the leading implementing agency of e-NAM. It operates and maintains the platform with the help of a strategic partner, NFCL. Under the e-NAM, the Government provides free software and one time assistance of Rs. 75 lakh per *mandi* for computer hardware and IT infrastructure. The hardware includes quality assaying equipment and creation of infrastructure like cleaning, grading, sorting, packaging and compost unit, etc[1].

e-NAM increases the choices which the farmer has when he brings his produce to the mandi for sale. While local traders can bid for the produce, the traders of other States/UTs/ mandis can also bid through the electronic platform and it is up to the farmer to accept either the local offer or the online one. The issue of perishables needs to be dealt by having cold chain-like transportation and storage facilities. The transportation cost needs to be transparently built into the bidding system. A multi-pronged approach would go a long way in ensuring better incomes for farmers and through them a better developed rural economy.

Portals similar to e-NAM exist in other parts of the world too. For example, Virtual Farmers' Market is an app-based e-commerce platform for farmers. In 2016, a prototype of this app was piloted for farmers in three rural districts of Zambia. As per United Nation's Food and Agriculture Organisation[2], market prices are unpredictable for most farmers in developing countries. Such applications instill price stability by assuring the right price for the farm produce and through direct

connect between the farmers and farm-product buyers/traders/wholesalers.

Out of the various forms of market structures which economic theory offers, perfect competition refers to the one which has a large number of buyers and sellers; homogeneous products; all buyers and sellers having perfect information about the price of the product; no transaction costs; and no entry or exit barriers. In this context, while perfect competition may not exist in its purest form in the real world, by attempting to do away with information asymmetry, e-NAM has brought Indian agriculture closer to the perfect competition market structure.

The following paragraphs review the achievements of e-NAM and assess what more needs to be done.

Integration

Considering that digitally connected markets are most appropriate for maintaining the much-needed social distancing in the current pandemic situation, factors which deter online integration need to be studied and suitably addressed. There are a large number of stakeholders on the e-NAM portal (Table-1). These include States/UTs, traders, Commission Agents, Service Providers, Farmer Producer Organisations (FPOs) and farmers. Stakeholders on e-NAM are not spread evenly and skewness is definitely evident across States/UTs.

Table 1: Stakeholders on e-NAM

Stakeholders	Number (As on 30th November, 2021)
States/UTs	21
Traders	2,05,521
Commission Agents (CAs)	1,00,671
Service Providers	0
FPOs	2,009
Farmers	1,72,23,072
Total	**1,75,31,273**

Source: https://enam.gov.in/web/dashboard/stakeholder-data

There are 2,239 regulated markets and 4,276 sub-market yards. All States and UTs are not yet on the e-NAM portal. Moreover, not all *mandis* are engaged in online trading. 1,000 *mandis* of 18 States and 3 UTs are on the e-NAM platform (Table 2). Some other States, including the ones from the North East, are conspicuous by their absence. In the Budget 2021-22, an announcement had been made to integrate another 1,000 *mandis*[3]. As on 31st October, 2021, 1.7 crore farmers and 1.98 lakh traders have registered themselves on the e-NAM portal[4]. The total value of agri-produce traded on e-NAM is Rs. 1,50,664 crore. Besides e-NAM, the Ministry of Rural Development also stresses on the need for developing rural *haats* into Gramin Agricultural Markets and linking rural markets through Pradhan Mantri Gram Sadak Yojana.

Agriculture being in the State List of the Constitution, States have their own Agriculture Produce Market Committee (APMC) Acts. These Acts are not uniform. Agricultural markets are fragmented and this is an obstacle in the free flow of agricultural commodities. A number of intermediaries between the primary producer and the final consumer means multiple levies and a colossal gap between the price paid by the latter and the one received by the former.

Integration with the online system has entailed the adoption of amendments in the APMC Acts of various States. These amendments involve provisions for e-trading; single point levy of market fee; and unified single trading license for the States/UTs. Online trading does away with the role of the intermediaries. This helps in better price discovery, but may also be one of the reasons which has delayed its whole-hearted adoption. Another hurdle is ensuring availability and accessibility of internet connectivity so that the extant digital divide does not widen further.

A 'Frequently Asked Question' on the e-NAM portal clarifies that e-NAM increases the choices which the farmer have when he brings his produce to the *mandi* for sale. While local traders can bid for the produce, the traders of other States/UTs/*mandis* can also bid through the electronic platform and it is up to the farmer to accept either the local offer or the online one. The transaction, whether local or online, is on the books of the local market.

There are 26 food grains/ cereals, 14 oilseeds, 31 fruits, 50 vegetables, 16 spices and another 38 miscellaneous commodities which are presently

Table 2: State-wise Number of APMCs

State	Number of APMCs
1. Andhra Pradesh	33
2. Chandigarh	1
3. Chhattisgarh	14
4. Gujarat	122
5. Haryana	81
6. Himachal Pradesh	19
7. Jammu & Kashmir	2
8. Jharkhand	19
9. Karnataka	2
10. Kerala	6
11. Madhya Pradesh	80
12. Maharashtra	118
13. Odisha	41
14. Puducherry	2
15. Punjab	37
16. Rajasthan	144
17. Tamil Nadu	63
18. Telangana	57
19. Uttar Pradesh	125
20. Uttarakhand	16
21. West Bengal	18
Total	**1,000**

traded on e-NAM. Table 3 depicts the complete list of such commodities.

For the success of e-NAM, it is imperative to train the stakeholders and make them aware of its advantages. The government has been taking various measures to encourage more number of farmers to register. For example, online registration is possible through mobile apps. A toll free number and customer helpdesk support resolve queries of farmers and aid them to register. Successful integration of e-NAM will be able to attract the much needed investment into this sector. Some States like Andhra Pradesh, Chhattisgarh, Gujarat, Rajasthan and Uttarakhand have introduced payment related incentives, which include rebate on *mandi* fee for the trader, cash prizes to best farmers and traders, attractive gifts for farmers, etc. Besides, some States like Haryana, Tamil Nadu, Telangana and Uttar Pradesh operate trade related State incentives. These include prizes for best participating farmer, certificates awarded to top traders and top farmers, exemption of market fee, annual cash prize for famers and traders in each commodity categories, etc.

Price Discovery

The lack of a mutually agreeable price discovery, essentially caused due to information asymmetry, always makes the farmer/ producer feel that the price received is less than optimal, while the consumer invariably perceives the price paid to be on the higher side. The issue is further complicated by the presence of middlemen and adoption of malpractices.

The e-payment facility of e-NAM ensures quick and transparent transfer of sales proceeds to farmers. The competitive bidding process addresses this issue. There are some private banks, viz. Axis Bank Limited, Kotak Mahindra Bank Limited, HDFC Bank, IndusInd Bank Limited and ICICI Bank which have been empanelled by SFAC under the aegis of Ministry of Agriculture and Farmers Welfare for provisioning of payment and settlement services for e-NAM transactions.

The e-NAM portal enlists a number of success stories, one of which is about how a company after registering on the portal started earning Rs. 70 to 150 extra per quintal.

Transportation and Marketing

Ensuring quality, especially those of perishable commodities, is indeed challenging. As evident from Table 3, some commodities being traded on e-NAM have relatively shorter shelf lives. A competitive pricing arrived at after a bidding process may not be able to do justice if the delivery point is far away. Adequate and state-of-the-art storages at collection points, bolstered marketing infrastructure and quality testing facilities may mitigate this issue to a large extent. The cost of transport, especially inter-state, for delivery of the produce is an added cost to be borne. These issues underscore the need for having well equipped cold chains, storage and facilities as envisaged in Kisan Rail and Krishi Udaan, which were announced in Budget 2020-21. While Kisan Rail has an objective of building a seamless national supply chain for perishables, especially fruits and vegetables, through PPP model, Krishi Udaan aims at transporting agricultural produce to various national and international destinations.

Table 3: List of Commodities Being Traded on e-NAM

Food Grains/ Cereals	Fruits	Vegetables	Miscellaneous
1. Arhar	1. Amla	1. Aloe Vera	1. Anthurium
2. Arhar Dal Split	2. Apple	2. Banana Raw	2. Areca Nut
3. Bajra	3. Apricot	3. Beetroot	3. Bamboo
4. Barley	4. Banana	4. Bhindi/ Okra	4. Betel Leaves
5. Basmati Rice	5. Ber	5. Bitter Gourd	5. Carnation
6. Buck Wheat	6. Cherry Red/ Black	6. Bottle Gourd	6. ChhappanKaddu
7. Chakhao or Black Rice	7. Custard Apple	7. Brinjal	7. Chironji
8. Chana Dal Split	8. Grapefruit	8. Broccoli	8. Chrysamthemum
9. Chana Whole	9. Grapes	9. Button Mushroom	9. Coconut
10. Horse Gram	10. Guava	10. Cabbage	10. Coconut with Husk
11. Jowar	11. Jackfruit	11. Capsicum	11. Cotton
12. Kabuli Chana Whole	12. Jamun	12. Carrots	12. Gerbera
13. Lobia	13. Kinnow	13. Cauliflower	13. Gladiolus
14. Maize	14. Lemon	14. Cluster Beans	14. Groundnut with Pods
15. Masoor Whole	15. Litchi	15. Colocasia Vegetable	15. Guar Seed
16. Moong Dal Split	16. Mango	16. Coriander Leaves	16. Hilsa
17. Moong Whole	17. Musk Melon	17. Cucumber	17. Isabgol
18. Moth	18. Orange	18. Curry Leaves	18. Jaggery
19. Oats Raw	19. Papaya	19. Drumstick	19. Jute Seeds
20. Paddy	20. Papaya Raw	20. Fenugreek Leaves	20. Lily
21. Ragi	21. Passion Fruit	21. Garlic	21. Mahua Flower
22. Rajma	22. Peach	22. Gherkin	22. Mahua Seed
23. Urad Dal Split	23. Pear	23. Ginger	23. Marigold
24. Urad Whole	24. Pineapple	24. Green chillies	24. Nutmeg Whole
25. Wheat	25. Plum	25. Ivy Gourd	25. Persimmon
26. White Peas	26. Pomegranate	26. Jimikand	26. Raisins
	27. Raw Mango	27. Lobia Pods	27. Raw Cashew Nut
	28. Sapota	28. Mint Leaves	28. Raw Jute
	29. Strawberries	29. Mustard Leaf	29. Rithha
	30 Sweet Orange	30. Onion	30. Rose Cut Flower
	31. Watermelon	31. Oyster Mushroom	31. Safed Musli
		32. Pea	32. Saffron
Oilseeds	**Spices**	33. Pointed Gourd	33. Spray Chrysanthemum
1. Castor seed	1. Ajwain	34. Potato	34. Tamarin
2. Cotton seed	2. Black Pepper Whole	35. Pumpkin	35. Tender Coconut
3. Kusum seed	3. Cardamoms Whole	36. Radish	36. Tuberose
4. Linseed	4. Cloves Whole	37. Ribbed Celery	37. Tulip
5. Mustard seed	5. Coriander Whole	38. Ridge Gourd	38. Walnuts in Shell
6. Neem seed	6. Cumin	39. Safed Petha	
7. Nigar seed	7. Dried Raw Mango Slices	40. Sem	
8. Peanut kernel	8. Dry Ginger	41. Snake Gourd	
9. Pongam seed	9. Fennel Seed	42. Spinach	
10. Rapeseed	10. Fenugreek Seed	43. Sponge Gourd	
11. Sal seed	11. Large Cardamom	44. Spring Onion	
12. Sesame seed	12. Mace Whole	45. Sugar Snap Peas	
13. Soyabean	13. Poppy Seed	46. Sweet Corn	
14. Sunflower seed	14. Red Chilli	47. Sweet Potato	
	15. Tejpata	48. Tapioca	
	16. Turmeric	49. Tinda	
		50. Tomato	

Source: https://enam.gov.in/web/commodity/commodity-list

FPOs provide for online uploading of pictures, which checks for the quality of the produce. The agricultural market infrastructure, particularly the rural infrastructure, needs to be strengthened. For this purpose, besides interventions through e-NAM, schemes like Rashtriya Krishi Vikas Yojana and Agriculture Market Infrastructure also work towards a similar objective. In this context, Agriculture Infrastructure Fund plays an important role in providing financial support in terms of interest subvention and credit guarantee for projects for post-harvest management and building community farming assets such as warehouse, cold storage, silos, e-marketing, etc. To strengthen the APMC infrastructure, they have recently been recognised as an eligible entity under Agriculture Infrastructure Fund.

During the lockdown in 2020, the Ministry of Agriculture & Farmers Welfare had launched a mobile application, viz. 'Kisan Rath' to facilitate farmers to find suitable transport vehicles for transportation of their agriculture and horticulture produce. Under Mahatma Gandhi National Rural Employment Guarantee Act, the Ministry of Rural Development has taken measures for development of physical infrastructure in developing and upgrading existing rural *haats* under the control of Panchayats into Gramin Agricultural Markets through States/Union Territories.

Concluding Remarks

The Government of India has initiated a number of reforms to make the agriculture sector vibrant and sustainable. World Banks' 'Enabling the Business of Agriculture' reviews regulations which affect farmers, and in 2019, India was ranked 49. Development of agricultural markets has enhanced agricultural food grain production. The 3rd Advance Estimates for 2020-21 indicate that the total food production of the country increased from 297.50 million tonnes in 2019-20 to 305.44 million tonnes in 2020-21[5].

While the supply of agricultural production, in terms of quantum and quality, is governed by agro-climatic and geographical conditions, the demand for the same is spread across the country. Led by the need to provide a platform to bring the producers and consumers together, the e-NAM portal was launched in 2016. Undoubtedly, the success of agriculture depends excessively on information and a prudent use of the information can allow buyers and sellers to reach market equilibrium. By doing away with information asymmetry, the e-NAM portal has adequately demonstrated its latent characteristic to enhance efficiency.

There is tremendous potential of e-NAM. The positive consequences of trading on the platform take different manifestations: ranging from price discovery to improved livelihood; social benefits to economic benefits; prompting efficiency to reducing wastage; and promoting digital to financial inclusion. The framework of e-NAM can be potently evolved from being a marketing portal to a one-stop information centre for accessing government policies, prices, weather conditions and early warning systems, and extension services; for exchanging planting strategies; links to financial institutions for credit, insurance; etc. True to its name, e-NAM needs to have a national character and be linked to all States/UTs. Besides, the issue of perishables needs to be dealt by having cold chain-like transportation and storage facilities. The transportation cost needs to be transparently built into the bidding system. A multi-pronged approach which incorporates these points would go a long way in ensuring better incomes for farmers and through them a better developed rural economy.

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[The author is Additional Development Commissioner in DC-MSME, Ministry of Micro, Small and Medium Enterprises. Email: igtripathy@gmail.com. Views expressed are personal.]

Agriculture Beckons Digital Transformation

Balendu Sharma Dadhich

This decade could be the best time for a digital revolution of Indian agriculture for a multitude of factors including the futuristic vision for agriculture at the apex level in the Government of India. Digital technologies, which are bringing about a revolution in almost all aspects of our lives today, are poised to play a crucial role in our journey towards modernisation of Indian agriculture. Agricultural practices empowered by digital technologies are also being referred to as smart farming, digital agriculture and precision agriculture. This is an agricultural concept in which various types of data is used to build new methods for planning, production, management and sale of agricultural produce.

Agricultural practices have largely been conventional in India. However, after the Green Revolution, we have been slowly moving towards mechanisation and modernisation of agriculture. The change has been happening at an understandably slow pace due to the vast diversity of Indian agriculture, socio-economic conditions and in some cases lack of general awareness. After liberalisation, things are changing at a faster rate as we are seeing strong growth in per capita income, better literacy levels, and a policy level intent to bring the benefits of advancements in science and technology to the Indian farming community.

Mechanisation had a great potential to benefit Indian farming in many ways including an increase in production, efficiency, per capita productivity, crop yield and farm income. It also had a great potential to bring down expenses involved in farming processes, reducing the number of labour resources required in the farms and reducing the farmers' dependence on animals. Overall, this was a route to more efficient, convenient and profitable farming. While we are continuing on our journey towards mechanisation of agriculture, another big opportunity is knocking our door in the form of digital technologies. In a few years, we will see them transforming the face of agriculture in the country. They are not about large machines and equipment. Digital technologies are about smart devices, applications, softwares, services and communication systems where information is gathered, processed, distributed and utilised.

Countries like the US and Israel have successfully adopted digital technologies such as artificial intelligence, IoT, remote sensing, big data and machine learning. They are building solutions to transform agriculture and many associated activities. Even though India is still at the initial stage in this regard but we are taking steps in the right direction. We have successfully implemented many important digital initiatives in the country including Aadhaar, the unified payments interface, the Jan-Dhan Yojana and government apps such as CoWIN. All of these have contributed to establish a very positive sentiment and belief among the

citizens of this country for things which are digital in nature.

With the increasing adoption of smartphones, computers and broadband Internet connections in the country and specifically the rural households, we have an informal digital eco-system in place which can be leveraged for reaching out to people at large, delivering information and services and even skilling people. Such a system was not possible earlier as putting up a nationwide physical network in a large and diverse country such as India is not an easy task at all. Things have changed for sure and now it's up to us to make good use of all that we have.

The agriculture sector, currently valued at USD 370 billion, is one of the major contributors to the Indian economy. The sector is already in growth mode but digital technologies have the potential to further accelerate the growth.

We are passing through an era of digital transformation, better known in technology circles as the 4th Industrial Revolution. This revolution is about use of the amazingly powerful and intelligent digital technologies (such as artificial intelligence, Internet of things, Cloud computing, Blockchain, Nano Technology and modern information and communication technologies) and their ability to work together to create innovative new ways to empower society. India is a major participant in the process as almost every Indian household today enjoys some kind of connection with the digital technologies, and this includes the farming and labour communities as well.

Digital Agriculture

Digital technologies, which are bringing about a revolution in almost all aspects of our lives today, are poised to play a crucial role in our journey towards modernisation of Indian agriculture. Agricultural practices empowered by digital technologies are also being referred to as smart farming, digital agriculture and precision agriculture. This is an agricultural concept in which various types of data is used to build new methods for planning, production, management and sale of agricultural produce. They help farmers take informed decisions based on authentic data and overall trends. When the power of agricultural technologies is combined with the power of data, it can result in optimisation of resources and achieving better, sustainable results which include resource, time and cost efficiency, increased production and lowering the impact on environment. The term precision farming is used because use of quality data and efficient technologies driven by AI can help in farming to the extent that the farmer can take precise and independent decisions for every square meter of farm-land instead of an entire field or fields.

Some usage of digital technology include remote sensing, soil sensors, unmanned aerial surveying, weather information systems and market analysis and insights. They help the farming community to collect data to analyse crop and soil health conditions at different stages of production, in a convenient and cost-effective way. Farmers can plan their farming activities based on crop yield patterns, seed effectiveness and suitability patterns, and demand supply trends. They can also identify potential challenges and have their responsive strategies in place.

With the help of actionable data, the power of Artificial Intelligence, Machine Learning algorithms, and modern predictive analytics farmers can even be informed about the potential success of a particular crop. Many of such predictions are available in real time so the farming community can be sure about the right amount of water to be used for irrigation as well as the need for pesticides and fertilisers. The challenge is to develop simplified versions of applications and solutions which the farmers can easily learn to use and access without feeling intimidated by the advancements in technology. It's the interface that matters.

We need to look at a few other challenges as well. For example, the large number of small and marginal farmers in the country makes precise data gathering difficult. Small and marginal farmers with less than two hectares of land account for 86.2 percent of all farmers in India, even though they own just 47.3 percent of the land holdings. This makes collection of precision data difficult for various reasons including the variety and diversity of crops and inability to scientifically build, access and provide quality data. Other major challenge is the cost of technology which may be unaffordable for most farmers and hence,

there is a need to bring down the cost involved in the entire exercise. While the government has the most prominent part to play here, the Public Private Partnership (PPP) model could work out well to benefit everyone involved. Going by what has been done in this space already, we can safely believe that the government is cognizant of these challenges.

The Prime Minister's Vision

This decade could be the best time for a digital revolution of Indian agriculture for a multitude of factors including the futuristic vision for agriculture at the apex level in the Government of India. The Prime Minister, Sh. Narendra Modi, who has already outlined his vision to make India a five trillion dollar economy, considers agriculture as a major contributor to India's economic goals. In his words, "modernisation in the field of agriculture is the need of the hour. It is already late. We have already lost a lot of time. Adopting new alternatives, new innovations, along with traditional farming, are equally important to create new opportunities for employment in the agriculture sector; to increase the income of farmers. The country has experienced it during the white revolution."

Digital technologies are expected to play an important role in realisation of Prime Ministers' vision for agriculture as well as his goal of doubling farmers' income. They surely have a potential to contribute to all the major sources of growth within the agriculture sector including improvement in productivity, resource use efficiency, increase in cropping intensity and diversification towards high value crops. Most important element in these technologies is 'information' which is relevant in most of the cases. Importance of digital technologies in achieving the goals has also been recognised by the NITI Aayog which believes that in order to double the farmers' income, we need to take action in three categories: development initiatives; technology generation and dissemination; and policies and reforms.

Even though the government is playing a critical role in the transformation process, its efforts are also being complimented by various other stakeholders such as the industry, technology companies and startups. Many Indian companies are taking interest in utilising modern digital technologies with an objective to bring about a change in the way farming is carried out and to make it more profitable. At the same time, the vast business potential in Indian agriculture has attracted multinational organisations such as Microsoft, Amazon and IBM. This is very promising from the standpoint of business growth as well because the opportunity to serve crores of Indian farmers is huge. This is an opportunity that no private and foreign entity having a foothold in the agritech space would like to ignore.

All this bodes well for India which is now promoting the PPP route to make things happen at a faster rate and in an efficient manner. A few projects have already been started in partnership of various government agencies and private sector players and the results appear promising.

India's National Strategy on AI aims to realise the potential economic and social benefits the technology offers in diverse areas including agriculture. Likewise, the National Strategy on AI recognises agriculture as one of the priority sector areas for implementation of AI driven solutions.

Comment of the World Bank

As mentioned above, countries such as the US and Israel are at an advanced stage of leveraging digital technology and what is happening in India is not in isolation. Countries like Australia and the Netherlands have also successfully built solutions which are contributing in reshaping the agriculture economy in those countries. In fact, there is a worldwide realisation that a sustainable positive growth in agriculture cannot be achieved without taking help from the digital technologies.

According to the World Bank, "The digital agriculture revolution holds a promise to build an agriculture and food system that is efficient, environmentally sustainable, and equitable, one that can help deliver the Sustainable Development Goals. Unlike past technological revolutions in agriculture, which began on farms, the current revolution is being sparked at multiple points along the agri-food value chain. The change is driven by the ability to collect, use, and analyse massive amounts of machine-readable data related to practically every aspect of the value chain, and by the emergence of digital platforms disrupting existing business models. All this allows for drastically reduced transaction costs and

pervasive information asymmetries that plague the agri-food system.

As mentioned earlier, the power of information in its various forms and shapes, can be put to use in diverse situations and scenarios linked with agriculture. The World Bank explores this further by saying- "Digital Transformation of the Agri-food System investigates how digital technologies can accelerate the transformation of the agri-food system by increasing efficiency on the farm; improving farmers' access to output, input, and financial markets; strengthening quality control and traceability; and improving the design and delivery of agriculture policies. It also identifies a key role for the public sector in maximising the benefits of this process while minimising its risks, through enabling an innovative ecosystem featuring open datasets, digital platforms, digital entrepreneurship, digital payment systems, and digital skills and encouraging equitable technology adoption."

Government Initiatives

A variety of schemes, plans and initiatives have been taken up by the central and state governments to explore use of digital technology in agriculture but also to sensitise farmers regarding its benefits and popularising its use. In September 2021, the Union Minister of Agriculture and Farmers' Welfare, Narendra Singh Tomar, announced the initiation of the Digital Agriculture Mission 2021–2025. The Mission aims to support and accelerate projects based on new technologies, like AI, blockchain, remote sensing, geographical information systems, and use of drones and robots.

National e-Governance Plan in Agriculture (NeGPA) also needs specific mention as a prominent vehicle for promoting digital agriculture in the country. NeGPA is already in the second decade of its existence and covers all states and two union territories. This aims to achieve rapid development in India through use of Information and Communication Technology (ICT) for timely access to agriculture related information for the farmers. Under the scheme, 60 percent contribution comes from the Centre while 40 percent of the funds are contributed by the states. For north eastern states, the ratio of contribution is 90:10 while for the union territories the entire funding is done by the Centre.

As mentioned earlier, the government is taking bold and structured steps towards doubling the farmers' income. The Committee on Doubling Farmers' Income recognises the importance of smart farming. The committee, in its report appreciated the role of digital technology, which can play a transformational role in modernising and organising how rural India performs its agricultural activities. The committee lists the possible components for modern management of agriculture as the following:

i) Remote Sensing
ii) Geographical Information System
iii) Data Analytics
iv) Artificial Intelligence and Machine Learning
v) Internet of Things

The committee has made recommendations regarding use of AI and ML, Big Data Analysis and Internet of Things in agriculture. To incorporate these recommendations in the scope of the NeGPA, the guidelines of the later have been revised in June 2020. The revised NeGPA guidelines say that funds from 2020-21 will be released to the States/UTs only for the projects involving use of modern information technologies such as Artificial Intelligence and Machine Learning, Block Chain Technology, Internet of Things, Robotics etc., and for customisation/shifting of web and mobile applications already developed by the States, to the platform to be developed using digital technologies mentioned above.

Many projects have come out from this initative such as the Direct Benefit Transfer (DBT) Central Agri Portal which is serving as a unified central portal for agricultural schemes across the country. The portal helps farmers adopt modern farm machineries through government subsidies.

One Stop Window-Farmers' Portal, the mKisan Portal and mobile applications including Kisan Suvidha are other examples of work being done in this space. They are contributing to the use of modern digital technologies for the benefit of the farming community. Another important solution is the pan-India electronic trading portal called National Agriculture Market (eNAM) that links the existing Agricultural Produce Market Committee (APMC) *mandis*. This helps farmers in selling their products directly to the buyers, without being dependent on the middlemen.

Partnership with the Private Sector

According to the Department of Economic Affairs, India has systematically rolled out a PPP program for the delivery of high-priority public utilities and infrastructure, and over the last decade or so, developed what is perhaps one of the largest PPP Programs in the world. India is one of the leading countries in terms of readiness for PPPs. This is also reflecting in the government's plans for digital agriculture where partnerships with major Indian and international corporations have taken place.

In June 2021, The Ministry of Agriculture and Farmers' Welfare signed an MoU with Microsoft to run a pilot programme for 100 villages in 6 states. Under the MoU, Microsoft will create a 'Unified Farmer Services Interface' through its cloud computing services. 10 districts of 6 states (Uttar Pradesh, Madhya Pradesh, Gujarat, Haryana, Rajasthan and Andhra Pradesh) will be covered under the plan to develop farmer interface for smart and well-organised agriculture, including post-harvest management and distribution. Under the MoU, various tasks will be taken for the betterment of farmers in the selected 100 villages, which are expected to enhance their income. This project will reduce the input costs for farmers and make farming easy.

During last September, the Ministry of Agriculture and Farmers' Welfare had also signed 5 MoUs for pilot projects with five private companies — CISCO, Ninjacart, Jio Platforms Limited, ITC Limited and NCDEX e-Markets Limited (NeML). The Jio Platforms Limited will conduct its pilot project to provide advisories to farmers in two districts of Maharashtra– Jalna and Nasik. The company's JioKrishi platform launched in February 2020, digitises the agricultural ecosystem along the entire value chain to empower farmers. The core function of the platform uses stand-alone application data to provide advisory, the advanced functions use data from various sources, feed the data into AI/ML algorithms and provide accurate personalised advice.

The ITC Limited has signed the MoU for building a Customised 'Site Specific Crop Advisory' service. According to the ministry, the proposal will be implemented in identified villages of Sehore and Vidisha districts of Madhya Pradesh. ITC has proposed this service to turn conventional crop-level generic advice into a personalised site-specific crop advisory for farmers, using a digital crop monitoring platform, hosted on ITC's e-Choupal 4.0 digital platform.

Under the MoU with the ministry, Cisco will conceptualise a 'Proof of Concept' in effective knowledge sharing between farmers, administration, academia and industry in two districts–Kaithal (Haryana) and Morena (Madhya Pradesh). Cisco had developed an Agricultural Digital Infrastructure (ADI) solution in August 2019, that enhances farming and knowledge sharing.

The NCDEX e Markets Limited (NeML) will work on four services–Market Linkages, Aggregation of Demand, Financial Linkages and Data Sanitisation–across three districts – Guntur (Andhra Pradesh), Devanagere (Karnataka) and Nasik (Maharashtra). Similarly, Ninjacart will develop and host the Agri Marketplace Platform (AMP), which will enable bringing together all the participants in the post-harvest market linkage.

All of this is indicative of the fact that the Indian agriculture is set to experiment a big change. It will be a long process though, but if successful, the farming sector in India may get transformed resulting in the financial empowerment of the Indian farmer and a significant growth in the contribution of Indian agriculture to our economy.

(The author is an expert in digital technologies. Email: balendu@gmail.com. Views expressed are personal)

Agriculture Sector Contributing in Rural Development

Dr. H.L. Sharma

Agriculture and allied sectors play a vital role in a developing economy like India in reducing poverty, unemployment, inequality, ensuring food security and achieving inclusive growth. Despite a decline in the share of agriculture in gross value added, employment generation and foreign exchange earnings, it still remains the single largest employment provider sector and primary source of livelihood to a large proportion of population. To improve production and productivity of agriculture, adoption of quality inputs including high yield variety seeds, agricultural machinery and efficient use of chemical fertilisers and pesticides is critical. To attract unemployed educated youth into agribusiness and agripreneurship, special impetus on creating scientific temper and fostering innovative spirit among the rural youth is also required. An appropriate policy coupled with a strong strategy to strengthen the rural non-farm sector deserves to be the top priority of government and policy makers.

Agriculture and allied sectors play a crucial role in the process of economic development of a country like India where the mainstay of large proportion of population is agriculture. As per the latest census data, 68.8 percent of the country's total population and 72.4 percent of the workforce reside in rural areas. More than 50 percent population of the country is directly dependent on agriculture and allied sectors for the livelihood. Agriculture in India plays a vital role in gross value addition, employment generation and foreign exchange earnings.

Agriculture is of so much importance in the Indian economy that any positive or negative change in this sector exerts a significant effect on socio-economic conditions and political stability in the entire country. In fact, there is a strong linkage between agriculture and other sectors (industry, trade and services) of the economy. The large scale industries of the country like sugar, tea, jute, textile (cotton, woolen and silk), paper, and food processing etc. directly depend upon agriculture and allied sectors for the supply of raw materials. On the other hand, agriculture also draws inputs like chemical fertilisers, pesticides, power, agricultural machinery (tractors, harvesters, combines, pump sets), tools and implements from industry. This interdependence between agriculture and industry becomes strengthened

through the appropriation and generation of various production and demand linkages in these sectors. Thus agriculture, industry and trade are mutually supporting and complementary to one another.

Role of Agriculture in Rural Economy

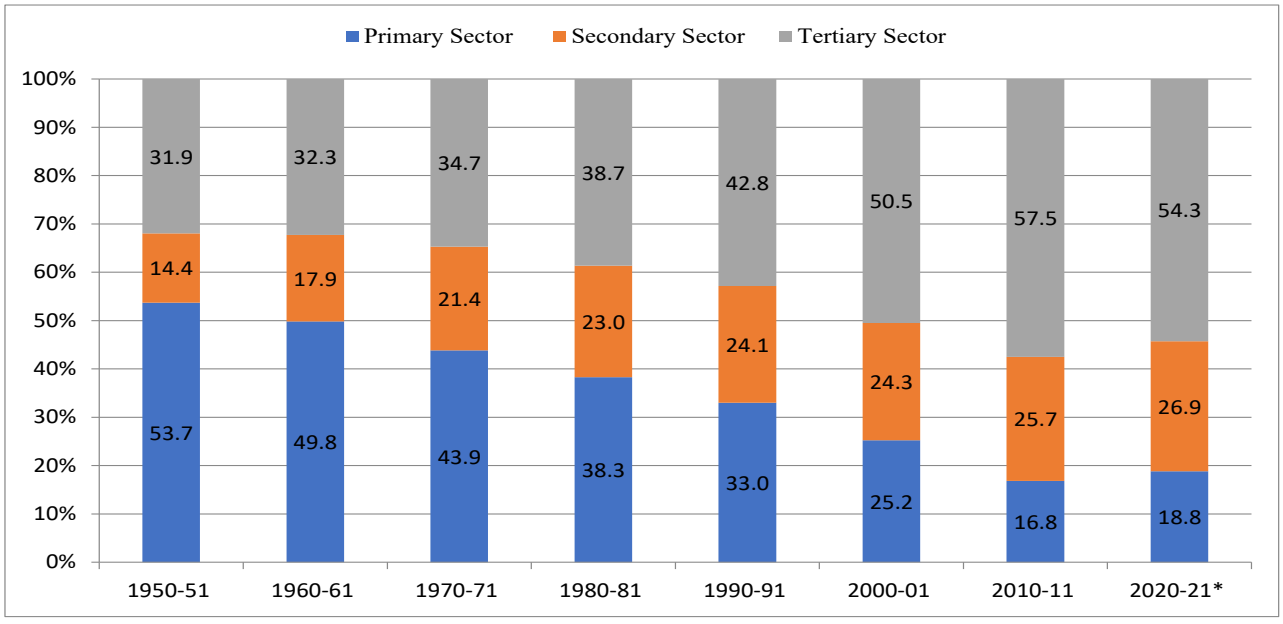
There has been a tremendous increase in production of agriculture and allied sectors during the planned era of development. The real gross value added (RGVA) at constant prices by primary sector (including agriculture, forestry, fishing, mining and quarrying) which was to the tune of Rs. 1,50,191 crore in 1950-51, shot up to Rs. 23,25,548 crore in 2020-21, registering a compound growth rate of 3.99 percent per annum (Table 1). On the other hand, RGVA by secondary sector witnessed the highest annual compound growth rate (ACGR) of 6.51 percent, closely followed by tertiary sector (6.48 percent) during the past seven decades. Due to structural changes in the economy, the contribution of the primary sector to gross value added has steadily declined from 53.71 percent in 1951 to 18.85 percent in 2020-21(Fig 1). However, the declining share of this sector does not undermine its significance in employment generation, foreign exchange earnings and providing food security to the ever increasing population of the country. Agriculture emerged as the bright spot, while

Table 1: Sector Wise Real Gross Value Added at Factor Cost (Rs. Crore)

Year	Primary Sector	Secondary Sector	Tertiary Sector	Total
1950-51	150191	40138	82591	279618
1960-61	204340	73555	123872	410279
1970-71	258665	126356	196158	589787
1980-81	305906	183970	300613	798506
1990-91	444880	325450	573465	1347889
2000-01	592227	570571	1185683	2348481
2010-11	828431	1262722	2827380	4918533
2020-21(AE)	2325548	3319280	6694347	12339175
ACGR (%)	3.99	6.51	6.48	5.56

Source: Economic Survey: 2020-21, Vol. 2, Table 1.3

Figure 1: Sector Wise Share in Real Gross Value Added (Percent)



Source: Economic Survey: 2020-21, Vol. 2, Table 1.3

all other sectors including manufacturing, construction and services were hit the hardest during the lockdown forced by the COVID-19 pandemic. It is the only sector which contributed positively to the overall Gross Value Added during the COVID-19 pandemic in 2020-21.

Role of Agriculture in Employment Generation

Agriculture not only makes the country secure in terms of food, fodder and raw-material for industries, it along with the allied sectors also serves as the source of livelihood for the large proportion of rural population of the country. The proportion of population depending directly or indirectly on agriculture for employment opportunities is more than that of any other sector in India. The significance of agriculture and allied sector is brought out by the fact that as per census 2011, of the 313 million main workers in the country, 166 million (56.6 percent) were engaged in these activities. As high as 70 percent, of rural households still depend on agriculture for their livelihood in India. During the past seven decades particularly after the adoption of new agriculture strategy, there has been a perceptible change in the structure of rural employment. The share of agriculture in total employment was nearly 69 percent of the workforce in 1950-51. It steadily came down to 59 percent in 1990-91 and further decelerated to 38 percent in 2020-21.This is in sharp contrast with rural non-agricultural employment, which increased from 31 percent to 62 percent during the same period.

The Periodic Labour Force Survey (PLFS) conducted by the National Statistical Office (NSO) for the year 2018-19, estimated the size of labour force to be 51.82 crore persons (48.79 crore employed and 3.04 crore unemployed) in India. Industry and activity wise estimates on workforce exhibit that more than 21.51 crore persons were employed in agriculture sector in 2018-19. Thus, agriculture with 42.5 percent of workforce is still the largest employer in the country (Table2). Among the total employed persons, self-employment is the major source with close to 52 percent of the employed workforce in India.

Agricultural Trade

Role of agriculture in internal as well as external trade can hardly be over-emphasised. The total

Table 2: Industry Wise Employment (PS+SS) in India: 2018-19

Industry	(No of workers in crore)		
	Rural	Urban	Total
Agriculture	19.5	0.97	21.51
Manufacturing	2.56	3.67	5.9
Construction	4.04	1.63	5.71
Mining & quarrying	0.13	0.08	0.02
Electricity, water etc	0.13	0.19	0.29
Trade, hotels & restaurants	2.59	3.53	5.85
Transport, Storage & Communition*	1.31	1.72	2.88
Other services	2.59	4.18	6.24
TOTAL	32.83	15.96	48.78

Source: Economic Survey 2020-21, Volume 2, p. 363.

food grain production in India has increased from 50.8 million tonnes in 1950-51 to 308.65 million tonnes 2021-21. India is the largest producer (25 percent of global), consumer (27 percent of global) and importer (14 percent of global) of pulses in the world. It is the second-largest producer of rice, wheat, sugarcane, cotton and groundnuts. India has emerged as the second largest producer of fruits and vegetable in the word after China. The country occupies first position in the world in the production of fruits like mango, banana, sapota, pomegranate and aonla and vegetables like peas and okra. Further, it occupies second position in the world in production of brinjal, cabbage, cauliflower and onion. The country has the honour to be the largest producer, consumer and exporter of spices and spice products. India has been the largest producer of milk in the world continuously for last more than two decades with over 198 million tonnes of production and per capita availability of 407 grams per day as against the world average of 299 grams. Nearly 19 percent of the world's total milk production is contributed by India.

Today, India is not only self-sufficient in respect of demand for food, but is also a net exporter of agri-products occupying seventh position in the world. India's export of agricultural and allied products (such as rice, pulses, fruits, vegetables, tea, coffee, tobacco, spices, sugar and molasses,

cashew, raw cotton, fish, meat and processed food etc.) which were worth Rs. 6,013 crore in 1990-91, went up to Rs. 2,40,729 crore in 2020-21 (Table 3 and Fig. 2). The agricultural exports upsurged by more than 40 times witnessing a compound growth of 13.09 percent per annum during the last 30 years. On the other hand, agricultural imports showed a faster and steep increase of more than 123 times to reach at Rs. 1,47,975 in 2020-21 from Rs. 1,206 crore in 1990-91,witnessing a compound growth rate of 17.39 percent per annum. It is noteworthy that whereas the overall balance of trade of India has always been negative, the trade balance of agricultural goods has not only been positive but also increased nearly by 19 times during the last three decades, which reflects the significance of agriculture in generating foreign exchange for the country.

The agricultural export-important ratio (Agri E-I Ratio) of India was 499 percent in 1990-91. But, it steadily decelerated and finally stood at 163 percent in 2020-21. This means that the country's agricultural exports which were nearly 5 times of imports in 1990-91, remained only 1.6 times of imports in 2020-21. India's agricultural exports as percentage of total export showed a declining trend during the last 30 years (Fig. 3). On the contrary, its agricultural imports as percentage of total imports witnessed an increasing trend during the same period, which is a matter of concern to the country. Due to structural changes in the economy, the contribution of agricultural and allied products to foreign exchange earnings (share in exports) has slid down from 44.24 percent in 1960-61 to 19.91 percent in 1990-91 and further to 11.15 percent in 2020-21.

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

The Challenges

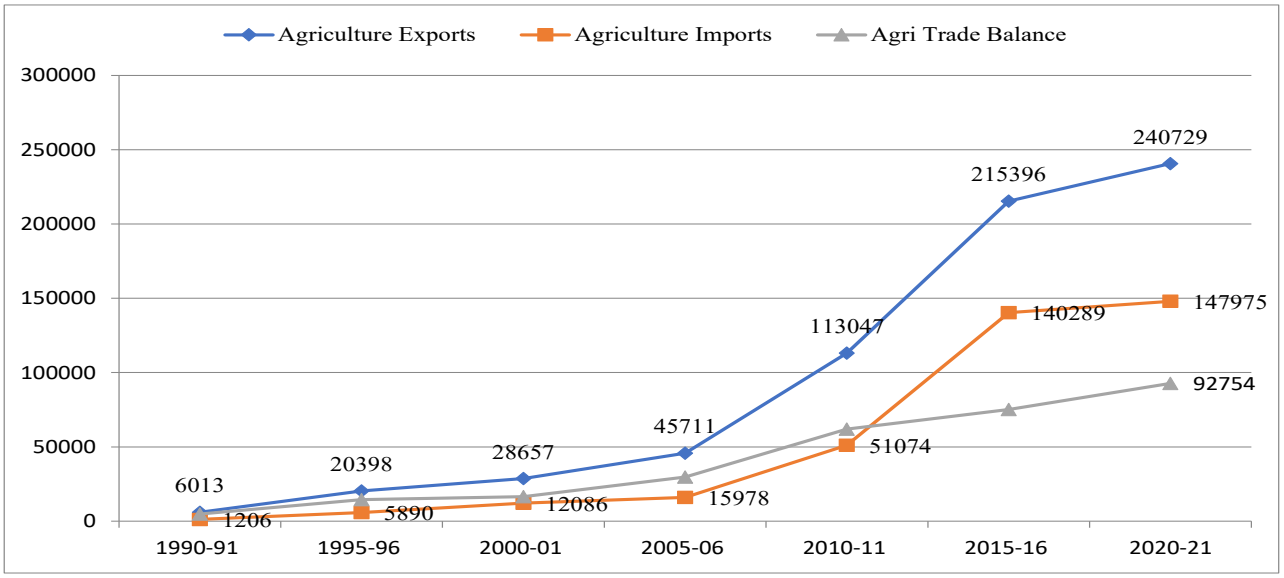
India, being the second largest agro-based economy in the world, is poised to be the agricultural powerhouse of the world. However, the agriculture sector is plagued by several challenges with low productivity, inadequate capital inflow, environmental issues and operational gaps etc. The country has achieved self-sufficiency in food grains but the production is lopsided being cereal centric, regionally biased and resource intensive. The resource intensive ways of Indian agriculture

Table 3: Patterns of Agricultural Trade of India (Rs. Crore)

Years	Agriculture Exports	Agriculture Imports	Balance of Agri Trade	Agri E-I Ratio (%)
1990-91	6013	1206	4807	499
1995-96	20398	5890	14508	346
2000-01	28657	12086	16571	237
2005-06	45711	15978	29733	286
2010-11	113047	51074	61973	221
2015-16	215396	140289	75107	154
2020-21	240729	147975	92754	163
ACGR(%)	13.09	17.39	10.37	-3.66

Sources: (i) Ministry of Agriculture, & Farmers Welfare, Agricultural Statistics at a Glance-2020
(ii) Director General of Commercial Intelligence & Statistics, Kolkata

Figure 2: Patterns and Contribution of Agricultural Trade in India (Rs. Crore)



Sources: (i) Ministry of Agriculture, & Farmers Welfare, Agricultural Statistics at a Glance-2020
(ii) Director General of Commercial Intelligence & Statistics, Kolkata

has raised serious sustainability issues. Increasing stress on water resources of the country is also critical one which definitely needs the realignment and rethinking of policies in this context. Agriculture crop residue burning and demolition of waste also continues to be a major concern. Reducing rural poverty and inequality through a socially inclusive employment strategy encompassing both farm as well as non-farm sector is also a major challenge before the policy makers and the government.

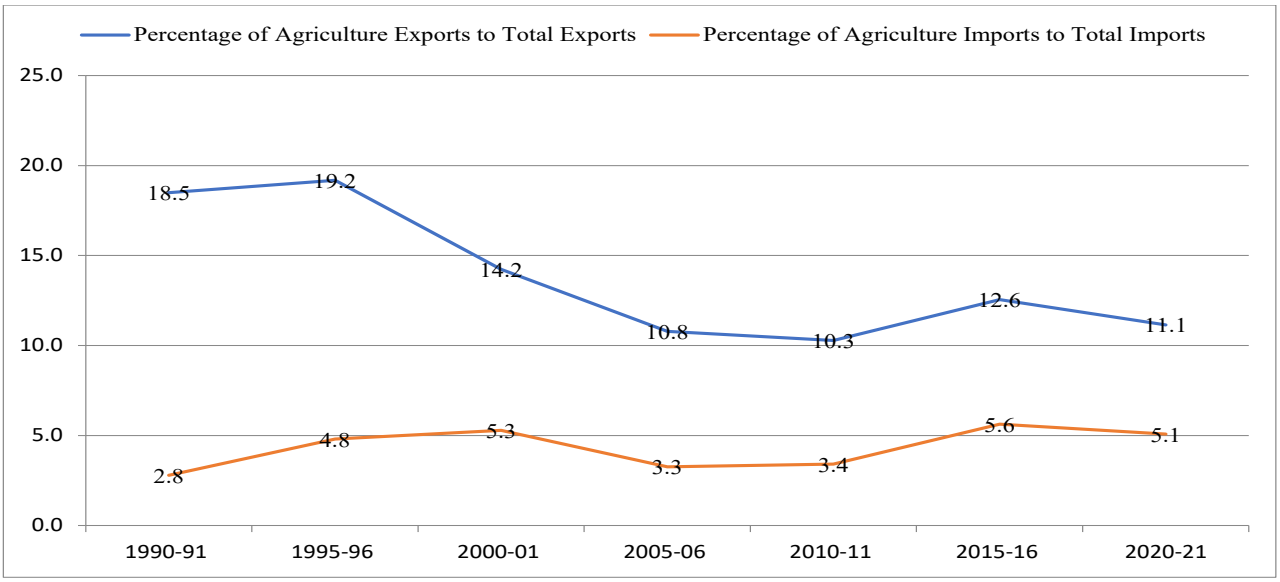
Government Initiatives

Realising the significance of agriculture in socio-economic structure of the country, Government of India has taken several steps for its sustainable development. The main focus has been on raising productivity, cutting down costs and going for diversification towards high value agriculture crops. In this direction with a view to improve soil fertility on a sustainable basis, the Soil Health Card Scheme was launched in February 2015. Under this scheme, samples of soil are taken and tested in the labs to assess the health of soil in the form of presence/absence of required micro-nutrients. Thereafter, the experts suggest the farmers the measures to improve productivity of their soil through the judicious use of inputs.

Presently net irrigated area in the country is only 68.38 million hectare which is nearly 48 percent of net sown area. Thus, more than 50 percent of net sown area is dependent on rain for cultivation. This substantial dependence on rainfall makes cultivation a high risk and less productive profession. In order to provide improved access to irrigation and enhanced water efficiency, Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) was launched on 1st July 2015 with the motto of *Har Khet Ko Paani.* The scheme aims at the expansion of net irrigated area, reduce wastage of water and improve efficiency in the use of water. It also focuses on creating sources for assured irrigation through rainwater harvesting to ensure 'Per Drop More Crop'. In the Union Budget 2021-22, Rs.4,000 crore were allocated towards implementing Pradhan Mantri Krishi Sinchayee Yojana (PMKSY-PDMC).

Of late, demand for organically produced food grains, fruits, vegetables, and drinks etc. is growing rapidly across the globe. In order to promote organic farming in the country, a new scheme named Pramparagat Krishi Vikas Yojana (PKVY) was launched in 2015 by the Government of India. Under this scheme, the willing farmers are required to form a group of minimum 50 farmers with total area of not less than 50 acres. Each farmer enrolling in the scheme is provided a sum Rs. 20,000 (spread over three years) per acre by the government. This fund can be utilised for

Figure 3: Contribution of Agricultural Trade to total National Trade



Sources: (i) Ministry of Agriculture, & Farmers Welfare, Agricultural Statistics at a Glance-2020
(ii) Director General of Commercial Intelligence & Statistics, Kolkata

obtaining agriculture inputs and transporting the produce to the market.

Agriculture in India is highly susceptible to the natural calamities and risks like droughts, floods, landslides, inundation, hailstorms, cyclones, typhoons, tempests, hurricanes, tornadoes, natural fire, lightning, pests, diseases and so forth. In order to stabilise the income of farmers by protecting them from the natural calamities a scheme, Pradhan Mantri Fasal Bima Yojana (PMFBY) was launched in February 2016. Under the scheme, in event of any loss to the notified crop (food crop, commercial/ horticultural crop and oil seeds) due to any natural calamity, pest or disease, eligible farmers are paid compensation based on the difference between the threshold and actual yield. The extent of compensation is set according to the degree of loss to the notified crop. The scheme is compulsory for farmers availing institutional loans but optional to others.

The mechanisation of agricultural plays a vital role in optimising the use of land and other inputs like water, seed, fertilisers, pesticides and manpower etc. In order to strengthen the agricultural mechanisation in the country, a scheme named as Sub-Mission on Agricultural Mechanisation (SMAM) was launched in 2014-15 by the Ministry of Agriculture and Farmers' Welfare. It aims at increasing the reach of farm mechanisation to small and marginal farmers and to the hinterland where the use of agriculture machinery is low. The scheme endeavours to create awareness among the stakeholders through demonstration, capacity building activities, performance testing and certification of agricultural machines at designated centres located all over the country.

In February 2019, Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) yojana was launched to augment the income of farmers with land holding up to 2 hectares, subject to certain exclusions. The scheme aims at supplementing the financial needs of the of families of small and marginal farmers to enable them to take care of expenses related to their occupation as well as domestic needs. In the union budget 2021-22, a major allocation of Rs. 65,000 crore was allocated for PM-KISAN, under which the government provides Rs. 6,000 to each beneficiary in three equal installments to the eligible farmers.

With a view to modernise the agriculture, the union government has initiated Digital Agriculture Mission for 2021-25 for agriculture projects based on new technologies such as artificial intelligence, block chain, remote sensing and GIS technology, drones, robots and others modern digital devices.

In 2019, the Government of India came out with Transport and Marketing Assistance (TMA) scheme to provide financial assistance for transport and marketing of agriculture products in order to boost agriculture exports. It is likely to mitigate disadvantage of higher cost of transportation of agriculture exports due to trans-shipment and to promote brand recognition for Indian agricultural products in the overseas markets.

In order to promote Indian brands of food products in the international market through the creation of global food manufacturing champions commensurate with India's natural resource endowment, the Government of India has approved the Production Linked Incentive (PLI) scheme for the food processing sector in April 2021. With an incentive outlay of Rs. 10,900 crore over a period of six years starting from FY 2021-22, the scheme has been formulated under AatmaNirbhar Bharat Abhiyaan for enhancing exports of agriculture products.

Concluding Remarks

In nutshell, agriculture and allied sectors play a vital role in a developing economy like India by reducing poverty, unemployment and inequality, ensuring food security and achieving sustainable development. The dynamics of agricultural growth in India reflect a decline in the share of agriculture in national gross value added, employment generation and foreign exchange earnings. But, it still remains the single largest employment generation sector and source of livelihood to a large proportion of population. To improve productivity in agriculture the focus of policies has been on the rational use of inputs like seeds, water, fertilisers and agriculture machinery.

To improve production and productivity of agriculture, adoption of quality inputs including high yield variety seeds is critical. There is an urgent need to expand the area under irrigation by adopting the appropriate technologies like sprinkler, drip irrigation and rainwater harvesting. The rational and efficient use of fertilisers and pesticides is also essential in order to increase productivity and avoid crop yield losses due to pests and diseases. In order to supplement income from crop cultivation, the focus of attention should be on promoting ancillary industries, non-farm activities and service units in rural areas so that the surplus manpower can get gainful employment during the slack season. Access to institutional credit at affordable rate is also desired to purchase expensive agricultural inputs. Further, the significance of timely government intervention in agriculture marketing can also not be denied. To attract unemployed educated youth into agribusiness and agripreneurship, special impetus on creating scientific temper and fostering innovative spirit among the rural youth is also required. Last but not least, providing timely advisory services to farmers to adopt best farm practices, technology, through market information system is also essential. An appropriate policy coupled with a strong strategy to strengthen the rural non-farm sector deserves to be at the top priority of Government and policy makers.

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(The author is Associate Professor of Economics, Govt. P.G. College Bilaspur, District Bilaspur, H.P. Email: hlsharmablp@gmail.com. Views expressed are personal)

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Savitribai Phule Pune University Road, Pune – 411 007
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Renewable Energy: Transforming the Face of Rural India

Dr. Jagdeep Saxena

Amid current COVID-19 crisis, local renewable energy solutions in villages can generate new livelihoods for internal migrants. Apart from supporting jobs and entrepreneurship with better power supply, renewable energy has ample potential to address critical issues such as energy poverty, agri-productivity, food security, health and climate variability. Deployment of renewable energy in rural areas has impacted and energised lives of millions of rural dwellers including those living in remote and difficult areas.

Presently, when country is celebrating 'Azadi ka Amrit Mahotsav', its villages are beaming with unprecedented development, infrastructural facilities, access to basic services and prosperity for all. But at the time of independence, our villages were in deplorable state lacking basic services, infrastructure and connectivity. Targeted plans and programmes for rural development changed the face of rural settings, and renewable energy played a critical role in it. Renewable Energy (RE) provided clean energy support to various development programmes and improved quality of life of millions of rural dwellers. India was among the first countries in the world which institutionalised development and deployment of RE by creating an exclusive department under union government (1982). In due course, it evolved into a full-fledged ministry, now known as Ministry of New and Renewable Energy (MNRE). During initial phases, R&D efforts were primarily focused on assessment of potential of various RE sources in India. Very soon, Government of India launched ambitious programmes for development of appropriate technologies; creation of capacity; and deployment of RE devices in various socio-economic sectors. Core drivers for growth and expansion of RE in India have been energy security, energy access, increasing power demand and climate change. Various policy initiatives including central finance schemes helped proliferate RE at ground level, especially in rural areas. Government support and promotional measures for expanding business and marketing activities have catapulted India on global map with 4th position in terms of total installed RE capacity, 5th in solar power and 4th in wind power installed capacities. Recently, India has crossed the milestone of 100 Gigawatt (GW) installed capacity, while another 50 GW is under installation and 27 GW is under tendering. Country has also enhanced its target to install 450 GW of RE capacity by 2030. Additionally, India is also aiming to achieve 40 percent of installed electric power capacity from non-fossil sources by 2030. India has an estimated RE potential of about 900 GW from commercially exploitable sources; namely, Wind – 102 GW (at 80 metre mast height), Small Hydro – 20 GW, Bio-energy – 25 GW, and Solar – 750 GW (assuming 3 percent wasteland). All along the progressive journey of RE in India, 'Rural Transformation' remained a prime theme in government sponsored programs.

Biogas and Biomass – Energising Smiles

Biogas is the first clean and renewable source of energy that was developed specifically for rural areas and was promoted by union government during 1980s. Currently, MNRE is running a comprehensive 'New National Biogas and Organic Manure Programme' (NNBOMP) for dissemination and deployment of biogas plants in remote, rural, and semi-urban areas of the country. Under the programme, central subsidy is provided for installing biogas plants in the size range varying from one cubic metre to 25 cubic metre. Besides, financial support is also extended to beneficiaries for construction, supervision etc.

In rural and remote areas, biogas plants are reliable source of clean, low-cost and green (environment friendly) fuel for cooking, lighting and fulfilling small power needs of farmers, cattle owners and individual households. Digested slurry, obtained from biogas plants as a by-product, is an enriched organic fertiliser (NPK) with many advantages to fields and farmers. Use of slurry in farms causes reduction in cost, saving on an average by Rs. 9,000 to Rs. 12,000 per year (Biogas plant size 1 to 4 cubic metre). So far, over 50.58 lakh biogas plants have been set up under the programme with the support of State Renewable Energy Agencies, State Rural Development Departments, KVIC and NDDB. Initially, biogas plants were developed to use cattle dung as feed stock but in due course, biogas plants were improved to feed agriculture residues, garden waste, municipal waste, other organic waste and human excreta. Of late, toilet-linked biogas system has been developed that eliminates the task of frequent emptying of faecal sludge from septic tanks or twin pits and dumping in drains or landfill sites. This system is also economically viable as it saves the construction cost of septic tanks or twin pits. Large scale adoption of biogas plants, cattle dung based or toilet linked, has improved sanitation and hygiene in rural and semi-rural areas. Biogas plants have also mitigated drudgery of women and led to saving of time for them for other livelihood activities.

Biogas plants designs are now available from 0.5 cubic metre to 1000 cubic metre unit size, multiples of which can be installed for achieving higher production levels. However, the unit size of industrial and municipal waste based biogas plants may go up to 15,000 cubic metre to 20,000 cubic metre biogas production per day. MNRE has approved four types of basic models and 10 types of designs of biogas plants for financial subsidies and other supports.

Biogas is used as a source-fuel for power generation and thermal applications in rural areas to meet local needs. To promote it, MNRE is operating a 'Biogas Power Generation (Off-grid) and Thermal Energy Application Program (BPGTP)' for setting up biogas plants in the size range of 30 cubic metre to 2500 cubic metre per day for corresponding power generation capacity range of 3 kW to 250 kW. The installation of such systems replaces diesel in DG sets and also reduces electricity bills of the individual farmers and other beneficiaries and, thus, helping increase the income of farmers. Biogas systems are providing clean and cheap power to dairy plants, poultry farms and dairy cooperatives for operation of dairy equipments and meeting other electrical, thermal and cooling energy requirements for plant operation. Generally, biogas power is used for refrigeration of milk and other uses such as pumping, lighting, irrigation and sometimes for cooking as well. The farmers or enterprises can also sell out surplus biogas/electricity to other households in off-grid mode. A case study of 45 biogas plants (extrapolated for 163 projects) revealed: Annual energy cost saving of Rs.787 lakh; Annual CO_2 savings of 9587 tons; Annual bio-manure production of 35,582 tons; Direct employment of 63,438 man days; and Indirect employment of 53,894 days.

Biomass is another abundant source of clean power in rural areas which is being promoted by MNRE for large scale adoption. Gasifiers are generally installed to recover energy from biomass resources (agricultural residues/wastes, biowastes from industries, bagasse of sugar mills, etc) for power generation. It helps in environmentally safe utilisation of surplus agro-residues which if left unutilised will be disposed off by burning in open fields. The total estimated potential for biomass power is 26,000 MW – 18,000 MW from agricultural and agro industrial residues; and

around 8,000 MW from bagasse cogeneration in sugar mills. Over 800 biomass power and bagasse/non-bagasse cogeneration projects aggregating to 10,170 MW capacity have been installed in the country for feeding power to grid. In some villages, biomass power is being distributed to households based on a business model to meet individual needs. 'Waste to Energy' program is also under operation for feeding power into the grid or meeting captive power and thermal needs of rice mills and other industries in rural areas and villages. Following case studies demonstrate the positive impact of biogas utilisation on individual households and on village community as well:

In Khamtara village of Katni district in Madhya Pradesh over 150 biogas units were installed in households between 1995 to 2005 under a government programme. They range from two to four cubic metre in size depending on the number of animals in households and requirement. Most of these are functioning due to proper maintenance and have almost eliminated use of firewood in the village. There has been an estimated 80 percent reduction in the quantity of smoke in Khamtara's kitchens accruing health benefits, especially to women.

Methan village in Patan district of Gujarat has scripted a prominent success story by building India's largest biogas system in 1987. It supplies gas to over 325 households through underground pipe-system at a nominal fee per month. Nearly 2.5 tonnes of cattle dung is used to produce 630 cubic metre of biogas. This saves 500 tonnes of firewood each year, and provides clean fuel and reduces risk of diseases. Village avoids over 860 tonnes of CO_2 emissions per year.

Vivekananda Kendra – NARDEP, Kanyakumari, Tamil Nadu has developed an innovative low-volume fixed model for biogas production called 'Shakthi-Surabhi' plant. It uses chiefly cattle dung or kitchen waste as feed stock. One cubic metre biogas plant gives biogas for about 1.5 hours everyday. A household which earlier on needed LPG cylinder once in two months, now need it only once in six months. The diluted slurry acts as an excellent fertiliser in homestead garden to grow organic vegetables. The larger capacity plants have been installed in community institutions where large quantities of organic wastes are being utilised to produce power, and improve the sanitation level in localities.

Solar Power: Lighting Lives

Solar energy/power is the chief renewable energy source driving transformation in rural areas by lighting lives of villagers. Solar energy based decentralised and distributed applications have benefitted millions of people in villages by meeting their cooking, lighting and other energy needs in a environment friendly way. The social and economic benefits include reduction in drudgery among rural women and girls engaged in collection of fuel wood from long distances and cooking in smoky kitchens. Wide scale adoption of solar applications/devices at household and community level has also enhanced employment generation and livelihood opportunities at village level. This has ultimately led to improvement in standard of living and creation of opportunities for various economic activities in villages.

MNRE runs a comprehensive Off-grid and Decentralised Solar Photovoltaic (PV) Applications Programme for deployment of solar street lights, solar study lamps and solar power packs to meet out the electricity and lighting needs in rural areas. Central Financial Assistance is provided to local communities, institutions and individual households for deployment of solar devices through State Nodal Agencies. So far (up to 31.12.2020), over 78,30,000 lanterns and study lamps; over 17,23,000 home lights; and over 8,13,000 street lights have been installed in rural areas. During 2020-21, over three lakh solar study lamps have been distributed to school going children in north-eastern states and left wing extremism affected districts. The single initiative has made on appreciable change in education and learning of students in the disadvantaged areas. Over one lakh solar street lights have been installed (2020-21), particularly in north-eastern states and hilly states to enhance security on otherwise dark streets. Under Atal Jyoti Yojana (AJAY), Phase-II (launched in 2018), the area of coverage was expanded to include north-eastern states, Jammu and Kashmir, Ladakh, Himachal Pradesh, Uttarakhand and Islands of Andaman Nicobar and Lakshadweep.

Over three lakh solar street lights were proposed to be installed. MNRE has started a pilot demonstration project of solarisation in sun temple town of Modhera in Mehsana district of Gujrat to meet up domestic and agricultural electricity needs of all the households of village. Over 5,700 SPV home lighting systems have been installed in un-electrified villages of all border districts of Arunachal Pradesh under Prime Minister's package. Solar electrification is driving a transformational change in basic services to citizens in rural areas. Some key examples are as under :

- The Chhattisgarh State Renewable Energy Development Agency (CREDA) collaborated with the State Health Department to install, operate and maintain solar PV systems in 900 health centres across the state. Most PHCs had no reliable source of power making it very hard to provide care at night, women were giving birth in dark and staff carried candles with them in case of power cuts. The solar PV systems were connected to energy-efficient equipments such as LED lighting, freezers, vaccine refrigerators, computers, centrifuges, body warmers, fans, etc. Systems were sized between 2 to 10 KWp depending on the size of health centre. There was a change over system to shift load to the grid when power supply is available. It assured 100 percent energy security. This initiative has transformed health care services in rural areas of the state benefitting thousands of patients every day with almost 80 percent reduction in energy costs.
- The Gosaba island situated in Sunderbans region of West Bengal is a remote village where irrigation of rabi crops (post monsoon period) was a challenge due to lack of irrigation facilities. Hence, crop area was limited restricting increase in income of farmers. To harness the solar energy for use in irrigation, solar panels were installed near a pond, and a nano-pump (0.1 hp) was used for lifting water from the pond to a tank during day-time. The stored water is applied to high value vegetable crops through drip irrigation system by gravity method. The economics of the cultivation of vegetables under solar drip systems (725 sq.m.) indicated that the system is quite profitable in terms of gross return (Rs. 25,679), net return (Rs. 13,876), and output ratio. The solar energy based drip irrigation is transforming agriculture scenario in Gosaba island.

Small Hydro Power – Big Impacts

MNRE runs a special Small Hydro Power (capacity up to 25 MW) Programme to meet power requirements of remote and isolated areas in a decentralised manner. Such projects also create employment opportunities to local people and enhance livelihood opportunities in rural areas. Special emphasis is being laid to north-eastern states which are beleaguered by large energy deficits and poor quality of energy services. SHP projects have been found effective in generating sufficient electricity to power domestic households, schools and clinics in rural areas and catalyse entrepreneurship activities. Against the target of 5,000 MW aggregate capacity by the year 2022, an aggregate capacity of 4,750.46 MW has been achieved (up to 31.12.2020). Under the PM's special package for Arunachal Pradesh, over 150 micro-hydel and small hydel projects have been installed in the region, that are pushing rural transformation activities. Several SHP projects have been completed in Ladakh and Kargil areas, where grid-connectivity is technically difficult.

The wide and vast renewable energy programme has improved quality of life; has created and strengthened livelihood resources; and has made dreams come true for disadvantaged people in rural areas. Supply of renewable power to schools, hostels, panchayats and other public service institutions is helping communities at large and also contributing in enhancing participation of women in education, social and livelihood activities. Amid current COVID-19 crisis, local renewable energy solutions in villages can generate new livelihoods for internal migrants. Apart from supporting jobs and entrepreneurship with better power supply, renewable energy has ample potential to address critical issues such as energy poverty, agri-productivity, food security, health and climate variability. Deployment of renewable energy in rural areas has impacted

and energised lives of millions of rural dwellers including those living in remote and difficult areas.

PM KUSUM – Growing 'Power' in Farmers' Fields

'Today farmers are being helped to set up solar plants on surplus lands through the 'KUSUM' scheme. Our farmers will not only be able to fulfill their personal needs to electricity through the power generated in fields but will also be able to sell the surplus power.'

-Shri Narendra Modi Prime Minister

Government of India approved 'Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM)' on February 19, 2019 with the objective to provide energy and water security to farmers, enhance farmers income, de-diesalise the farm sector and reduce environmental pollution. The innovative scheme in one of the largest initiatives of the world to provide clean energy to more than 35 lakh farmers by solarising their agriculture pumps. The scheme is being implemented through three major components.

Component – A, aims addition of 10,000 MW of solar capacity through installation of small solar power plants of capacity up to two MW. Individual farmers, co-operatives, panchayats and FPOs are being supported for setting up solar power plants on barren, fallow, marshy, pasture or cultivable lands. A farmer can also provide his land on lease to a developer for installing the plant. Power generated from plant may be used by farmer for his own requirement, and surplus power will be purchased by DISCOMs at tariffs determined by the respective State Electricity Regulatory Commissions. According to estimates, farmers will be able to earn up to Rs. 25,000 per acre per year if the plant is installed by developer, and up to Rs. 65,000 per acre per year if the plant is set up by farmers themselves. Being a priority sector lending, banks provide loan at competitive rates and on soft terms.

Under component–B, individual farmers and groups of farmers are being supported to replace their existing diesel pumps with solar pumps. Farmers are provided with Central Financial Assistance (30 percent of cost) and subsidy by State Government (30 percent of cost) to ease the financial burden. This component is likely to benefit 20 lakh farmers in off-grid areas, where there is no source of electric power for irrigation.

In component–C, Government of India is providing 30 percent subsidy for solarisation of agricultural feeders. It lowers the cost of capital and cost of power. Farmers are getting day-time reliable power for irrigation free of cost or at tariff fixed by their respective States.

Initially, the scheme aimed at adding solar capacity of 25.75 GW by 2022. The total central financial support provided under the scheme was over Rs. 34,000 crore. But, in the budget for 2020-21, an expansion was approved raising the target to 30.8 GW. On the basis of demand received from the states, sanction has been issued during 2019-20 and 2020-21 for installation of 4909 MW capacity of small solar power plants; installation of 3.59 lakh standalone solar pumps, and solarisation of over 10 lakh existing grid connected pumps.

Farmers have started getting benefits of the scheme which is adding to their income. Some responses are as under:

- Shri G. Arun of village Vriddhachalam in Cuddalore district, Tamil Nadu could not afford the cost of diesel for irrigating his 1.61 hectare land, therefore he did not raise the crop in his entire land and was raising pulses as rainfed crops. After installation of solar pump, he is now cultivating banana and expecting a good yield. He has also installed a drip irrigation system with the solar pump.
- Shri Raghu Nath, village Jai Singhwala, Block Sangat, District Bhatinda said, 'Government has provided me a solar pump of capacity 7-5 HP for irrigation under PM-KUSUM scheme. I am very happy with its result by getting hassle free irrigation during day time and also saving the cost of diesel. I am doing timely irrigation of my land which will increase production. I am thankful to the Government'.

(The author is Former Chief Editor, Indian Council of Agricultural Research, New Delhi. Email: jagdeepsaxena@yahoo.com. Views expressed are personal)

Transforming Lives of Rural Youth

Sandip Das

DDU-GKY aims to build the placement-linked skills of the poor rural youth and place them in wage employment across various sectors of the economy. The program has an outcome led design with guaranteed placements for at least 70 percent of the trained candidates. At present, DDU-GKY programme is being implemented in 27 states and 3 Union Territories (UTs). All the youth covered under DDU-GKY belong to the rural poor category.

India is one of the fastest growing economies in the world. The country is home to around a fifth of the world's youth. Half of India's population of more than 1.3 billion belongs to the age of 25. India's young population provides a unique demographic advantage. With the sustained growth in Indian economy, creating a competent and trained manpower pool for meeting the rising demand of industry assumes paramount importance. Sustaining economic growth and harnessing economic potential in the coming years, creating a competent and trained manpower in the country is a challenging task. Under Skill India Mission, the Government of India is implementing more than 40 programmes through more than 20 Central Ministries and Department for skill development for youths including youth living below poverty line especially in the rural areas.

The skilling of the rural youth population between 18-34 years, who constitute close to 69 percent (over 180 million) of the country's total population is a critical part of India's economic growth pattern. Of these, the bottom of the pyramid youth from poor families with no or marginal employment number about 55 million. Given this huge percentage of rural youth, any policy which targets youth needs to be rural centric, not only to harness and realise their potential, but also to help increase their contribution to India's economic growth.

The government's thrust on providing skills training to poor rural youth through Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY) has boosted rural income as more than seven lakh youth have gained employment in various sectors of the Indian economy.

A significant number of economically weaker sections of population live in rural areas. Many of these people work in casual labour markets in both agricultural and non-agricultural sectors where wages are less compared to incomes generated from skilled workforce engaged in various industries and services sectors. Skill development is an important driver to develop gainful employment opportunities for the rural youth. It will reduce poverty by improving employability, productivity and help to achieve sustainable enterprise development and inclusive growth.

Number of Rural Youth imparted training and provided placements (2014– 2015–2021-22*)

	Total no. of candidates trained under DDU-GKY	Total no. of candidates placed under DDU-GKY
2014-15	43,038	21,446
2015-16	2,36,471	1,09,512
2016-17	1,62,586	1,47,883
2017-18	1,31,527	75,787
2018-19	2,41,080	1,38,248
2019-20	2,38,336	1,50,199
2020-21	33,716	49,528
2021-22*	41,508	11,015
Total	11,28,208	7,03,618

*Source: Ministry of Rural Development, Lok Sabha statement on July 27, 2021, http://ddugky.gov.in, *till December 10, 2021-22*

India is facing a paradoxical situation, where on the one hand, youth entering the labour market are not able to find the suitable jobs matching to their qualification.

On the other hand, industries have been raising issues about unavailability of suitably skilled manpower. In India, the employment sector is posing a great challenge in terms of its structure which is dominated by informal workers. For dealing with these challenges concerning availability of skilled labour, the Government of India has taken several skill development initiatives in the recent years. It is a huge challenge not only for the government, but also for the private sector and educational institutions to rise up and specialise to make the country's youth employable and ensure that there is no mismatch between demand and the supply of skilled labour.

The Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY) launched on the 25th September 2014, is a nationwide placement-linked skill training program being financially supported by the Ministry of Rural Development (MoRD), Government of India (GoI). DDU-GKY was launched on 98th Birth Anniversary and was declared the 'Antyodaya Diwas' in honour of Pandit Deen Dayal Upadhyaya. The rural development ministry revamped its existing skill development program called *Aajeevika* Skills as DDU-GKY which emphasised on greater access, coverage and quality. In doing so, MoRD has used its knowledge gained over 15 years in implementing skill training programs under National Rural Livelihood Mission (NRLM). DDU-GKY is a demand driven scheme and under the scheme, funds are released to States as per demands against approved Action Plans.

DDU-GKY has its origin in the wage employment linked 'Special Projects' for skilling component of the Swarnajayanti Gram Swarojgar Yojana (SGSY), which was subsequently renamed as *Aajeevika* Skills when SGSY was converted as NRLM. To address the challenge of rural poverty, the Ministry of Rural Development conceived a mission mode scheme titled as National Rural Livelihood Mission (NRLM) in the year 2010. NRLM was renamed as Deendayal Antyodaya Yojana – National Rural Livelihood Mission (DAY-NRLM) on March 29, 2016. The mission of DDU-GKY is to reduce poverty by enabling poor households to access remunerative and sustainable employment that provides a regular salary. The aim is to diversify the income of poor rural families and cater to the professional aspirations of rural youth.

DDU-GKY aims to build the placement-linked skills of the poor rural youth and place them in wage employment across various sectors of the economy. The programme has an outcome led design with guaranteed placements for at least 70 percent of the trained candidates. At present, DDU-GKY programme is being implemented in 27 states and 3 Union Territories (UTs). All the youth covered under DDU-GKY belong to the rural poor category. Under the DDU-GKY, two special programs are being implemented. *Roshni* program is being implemented in 27 left wing extremist affected areas of nine States with mandatory residential courses with 40 percent coverage to women candidates. *Roshni* is oriented towards addressing the infrastructure, education, and health deficiencies in these areas, and leveraging the availability of natural resources, traditional skills and knowledge. *The Himayat* programme is being implemented for all the youth of the UTs of Jammu & Kashmir and Ladakh. The funding for the programme is shared by Centre and States with a 60:40 funding pattern. However, in the case of eight North-Eastern States, Uttarakhand and Himachal Pradesh, the funding is shared between

90:10 between Centre and State. All UTs and also *Himayat*, which is being implemented in UT of Jammu and Kashmir, receives 100 percent funding from Centre. More than 871 Project Implementation Agencies (PIAs) are training rural poor youth in close to 611 job roles through more than 2381 training centres. Cumulatively 11.28 lakh youth have been trained and around seven lakh youth have been placed in the various sectors of the economy till now.

Key features of DDU-GKY include ensuring market-led, placement-linked training programmes for rural youth undertaken in a Private Public Partnership mode, mandatory assured placement to 70 percent of the trained candidates and special focus on those rural youth who come from poor families in the age group of 15 to 35 years. The program also envisages social inclusion of candidates through mandatory coverage of socially disadvantaged groups belonging to Schedule Caste and Schedule Tribe (50 percent), Minorities (15 percent), and Women (33 percent), ensuring jobs with a minimum salary of Rs. 6000 per month (after a three month training course) to youth and provisions for post-placement support to candidates. The programme also has provision for career progression support to training partners and primacy to those training partners who can train and support overseas placement and captive placements.

DDU-GKY follows a three-tier implementation architecture in PPP mode, with the national unit responsible for policy, funding of central share and technical support, State Rural Livelihood Missions or State Skills Missions responsible for funding of state share, implementation and monitoring controls, and Project Implementing Agencies (PIAs), mostly private training partners, responsible for mobilisation, training and placements. The PIAs mobilise the eligible rural poor youth from different target districts and enrol them for training in the trade of their interest. After completion of the training, these agencies support the youth in successful placement and provide post placement support to the candidates within or outside the State.

For identification of beneficiaries, DDU-GKY programme aims at targeting rural youth from poor families belonging to categories including Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) worker household (if any person from the household has completed 15 days of work), Rashtriya Swasthya Bima Yojana (RSBY) households, Antyodaya Anna Yojana card households, BPL Public Distribution System card households, NRLM-Self Help Groups households, participatory process of Identification of poor and Households covered under auto inclusion parameters of Socio-Economic Caste Census, 2011.

Under the DDU-GKY, the duration of training courses ranges from 576 hours to 2304 hours based on courses aligned with the National Skill Qualification Framework. Trainees are trained through theory, practical, exposure and 'on Job Training' as per mandate of the course. For adding value to skill training, a special component of Soft Skills is included in the DDU-GKY training program. For 576 hours course,160 hours of Soft and Information Technology (IT) skill consisting of English (60 hours), Computer (80 hours) and Soft skill (20 hours) are there. For 1152 hours course, 320 hours of Soft and IT Skill consisting of English (120 hours), Computer (160 hours) and Soft Skill (40 hours) are there. For the 1728 hours course, 480 hours of Soft and IT Skill consisting of English (180 hours), Computer (240 hours) and Soft Skill (60 hours) are there and for the 12 month course, it should be at least 576 hours.

There is a provision of payment of post placement support of Rs. 1000 per candidate per month for two months if placed within district of domicile, Rs. 1000 per candidate per month for 3 months if placed within State of domicile and Rs. 1000 per candidate per month for 6 months, if placed outside State of domicile. For candidates of *Himayat* being implemented in the UT of J&K and Ladakh, there is a provision of post placement support of Rs. 2000 per candidate per month for six months.

At present, DDU-GKY imparts training in 82 sectors that covers 450 trades. As a part of the Skill India campaign, the programme plays an instrumental role in supporting the social and economic programs of the government such as the 'Make in India', 'Digital India', 'Smart Cities' and 'Start-Up India', 'Stand-Up India' campaigns.

As part of the *Azadi Ka Amrit Mahotsav* being commemorated to celebrate 75th year of India's independence, close to 1200 'mobilisation

camps' were organised across the country under the DDU-GKY programme recently. The scheme's target is to train and get jobs for 28,82,677 rural youth by March 2022. Over the period of time, DDU GKY has proven to be an effective rural development initiative for rural youths by providing both market linked skills and sustainable wage employment opportunities.

Several empirical studies and evidences from the ground state that that all the selected beneficiaries are from rural BPL families and the scheme has a considerable economic impact on the livelihoods of youth by enhancing their employment opportunities and earning levels which helps to contribute their family income. The increased household earnings have resulted in an increase in spending levels and ultimately to increase their standard of living.

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(The author is a Delhi based Journalist. Email: sandipdas2005@gmail.com. Views expressed are personal)

Smart Farming: Towards Sustainable Agriculture

Dr. Y. S. Shivay and Dr. Teekam Singh

Smart farming is performing agricultural operations smartly with more precision wherever required in certain quantity and it mainly relies on the use of artificial intelligence (AI) and Internet of Things (IoT) in cyber-physical farm management. Smart farming addresses many issues related to crop production as it allows monitoring of the changes in climatic factors, soil characteristics, soil moisture, etc. The Internet of Things (IoT) technology is able to link various remote sensors such as robots, ground sensors and drones, as this technology allows devices to be linked together using the internet to be operated automatically. The main idea of smart farming is improving the spatial management practices to increase crop production and avoid the misuse of fertilisers and pesticides.

Dwindling natural resources, increasing population pressure and food demand in the 21st century agriculture generate multiple challenges like production of more food and fibre to feed a growing population with a smaller rural labour force and more feedstocks for a potentially huge bioenergy market, especially in the many agriculture-dependent developing countries including India. Further, abrupt weather fluctuations around the world have put huge pressure on agricultural food products for quality and sustainable food production. The Food and Agriculture Organisation (FAO) has estimated that the world population would reach 9.73 billion by 2050, and the increase will continue till it reaches 11.2 billion by 2100 (FAO, 2017). There are many challenges pertaining to restricted agricultural production like soil degradation through salinity, nutrient deficiencies, low soil organic carbon content, lower ground water table, etc. More importantly climate change is also challenging agricultural productivity to sustain. Therefore, there is a need to make our agriculture smart so that crop productivity could be sustained through mitigation of such challenges. The FAO first time defined the climate smart agriculture as an approach that transforms agri-food systems towards green and climate resilient practices. It aims to tackle three main objectives: (i) sustainably increasing agricultural productivity and incomes; (ii) adapting and building resilience to climate change; and (iii) reducing and/or removing greenhouse gas emissions, wherever possible.

In India, the Green Revolution during 1960–70 advocated the use of mineral fertilisers as well as pesticides to increase agricultural production, parallel to the development of various agricultural machineries. During last two decades, globally, there is a significant development in information communication technology (ICT) and artificial intelligence (AI). The use of ICT and AI makes farming system smart with greater resources use efficiency. These technologies have facilitated controlling the equipments and devices remotely. Now robots are being used in agricultural operations such as harvesting and weeding, and also drones are being used to fertilise crops and monitor crop growth stages. Recently in India, the government has released standard operating procedure (SOP) for use of drones for the purpose of spraying pesticides on agriculture crops; this move is welcomed by industry body Crop Life India which is committed to advancing sustainable agriculture and it is an association

of 15 R&D driven member companies in crop protection.

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Understanding Smart Farming

In India the focus area of agriculture, in the recent times, has been on enhancing farmer incomes or doubling farmers income. Government of India has already launched digitalisation of all departments. One of ways of enhancing farmer incomes is through the use of Digital Technologies in agriculture to increase the overall efficiency of the agricultural production processes as well as the entire value chain. India's National Strategy on AI also aims to realise the potential economic and social benefits the technology offers. Further, the National Strategy on AI recognises agriculture as one of the priority sector areas for implementation of AI driven solutions. (NITI Aayog, 2019). Information technology-based farming system is also known by many names like digital agriculture/farming, precision agriculture, smart farming and AI in Agriculture. Thus, 'Smart Farming' in India is still as an emerging concept that refers to managing farms using modern information and communication technologies like IoT, robotics, drones and AI to increase the quantity and quality of products while optimising the human labour required by production. These include variable rate applicators, Internet of things (IoT), geo-positioning systems, big data, unmanned aerial vehicles UAVs (drones), automated systems, and robotics. Smart farming is based on a precise and resource-efficient approach and attempts to achieve higher efficiency on agricultural production with increased quality and safety on a sustainable basis. However, from the farmers' point of view, smart farming should provide added value in the form of more accurate and timely decision-making and more efficient exploitation operations and management. Smart farming technologies (SFTs) can be divided into three main categories: (i) farm management information systems (FMIS), (ii) precision agriculture (PA) systems, and (iii) agricultural automation and robotics.

FMISs represent mainly software systems for collecting, processing, storing, and disseminating data in the form required to carry out a farm's operations and functions. Smart farming also known as precision agriculture refers to the farming management concept aimed at optimising input use based on recording technologies to observe and measure inter-and intra-field spatial and temporal variability in crops, aiming to improve economic returns and reduce environmental impact. Precision agriculture is able to increase input efficiency for maintaining or even increasing production rate, using remote sensing technologies for data gathering with either satellite platforms for space imagery or aircrafts/UAVs for aerial applications, combined use of sensors for ground data acquisition, wireless networks for interconnecting them, geospatial data analytics coming from different sources, decision support systems (DSSs) for optimised farming decision-making, and others.

Agricultural automation and robotics are separate, but closely related ICT sectors. They are interconnected to cover the process of applying automatic control, artificial intelligence techniques, and robotic platforms at all levels of agricultural production. Automation technologies in agriculture found high research interest with machine learning being thoroughly used for agricultural purposes, as well as computer vision, artificial intelligence, three-dimensional (3D) imagery, and navigation systems for off-road agricultural vehicles. Based on these developments and on the industrial state-of-the-art robotics, agricultural robots of all types are applied with specific tasks, such as weed control, harvesting, etc in recent years. In this way smart farming is a futuristic technique for raising crops

and attention toward smart farming is growing rapidly in developed and as well as in developing countries including India.

Benefits of Smart Farming

There are various applications of use of digital technology in Agriculture. There are many examples in recent past in India where IT enabled applications have been used in management and monitoring of pests and diseases in different crops. Many ICAR Institutions have developed various mobile applications related to field crops, animals, horticultural crops etc. which helps in identification and subsequent diagnosis and treatment of plant diseases. Thus, advantages of smart farming can be summarised as follows: (i) Increasing the amount of real-time data on the crop; (ii) Remote monitoring and controlling of farms; (iii) Controlling water and other natural resources; (iv) Improving livestock management; (v) Accurate evaluation of soil and crops; (vi) Improving agricultural production; and (vii) eco-friendly farming.

Main Pillars of Smart Farming

Smart farming is mainly based on the Internet of Things (IoT) technologies related to all agricultural processes and practices in real-time, including irrigation and plant protection, improving product quality, controlling fertilisation process, and disease prediction, etc. Thus, the main pillars of smart farming include IoT, the role of internet connection, and smart sensors.

Internet of Things (IoT)

In the agricultural field, IoT technology has made significant development in helping farmers make the appropriate decision related to irrigation and fertiliser application. The smart systems enhance the accuracy of devices that monitor plant growth. Smart farm management requires using ICT, ground sensors, and control systems installed on robots, autonomous vehicles, and other automated devices. The success of smart systems depends on high-speed internet, advanced mobile devices, and satellites to provide images and positioning. According to the report of the Food and Agriculture Organization (FAO, 2017), about 20–40 percent of crops are lost annually due to pests and diseases and as a result of lack of good monitoring system of the state of the crop. Hence, the use of sensors and smart systems allows monitoring of weather factors, fertility status, and also determining the right number of fertilisers or pesticide necessary for crop growth.

Sensors

A sensor is a device that produces an output signal for the purpose of sensing of a physical phenomenon. In the broadest definition, a sensor is a device, module, machine, or subsystem that detects events or changes in its environment and sends the information to other electronic system, frequently a computer. In smart farming use of sensors play an important role for precise application of inputs as per the demand to avoid losses and misuse. Sensors are responsible for measuring and monitoring all factors in the smart system and major applications of sensors in monitoring and decision support system of smart farming are as follows:

1) **Soil Health Monitoring:** Monitoring of soil health with sensors saves the time for taking right decision as conventional method for soil health estimation is tedious and time consuming. Sensors can be used for estimation of nitrate concentration, phosphate content, soil moisture content, soil compaction, land classification and in general soil fertility status etc. On the basis of soil health monitoring by sensors, nutrient recommendation can be made for different crops and cropping systems.
2) **Smart Irrigation System:** Water is a precious input in agriculture and sensors help in deciding the right time and amount of water application for different crops to avoid loss of water. Smart irrigation system through use of sensors helps in monitoring water level, efficiency of irrigation pump, water scheduling, leakage detection and also climate driven irrigation.
3) **Leaf Disease Identification:** Sensors are helpful in quick identification of plant diseases like tomato yellow leaf curl virus, damage due to parasites, disease in paddy leaves and leaf-based identification of banana disease, etc.
4) **Improving Crop Yield:** In the present scenario improving crop yield and productivity are

the major concern considering the weather vagaries and increasing food demand. It is possible to increase productivity through use of sensors by recognising premature crops, estimation of fertiliser requirement, plant stress identification and infection of insect-pests and diseases. It helps in the timely action to overcome these stresses for better harvest.

5) **Improving Post Harvesting Activities:** Sensors also help in the improving the post-harvest activities viz., grain storage, inventory management, smart transportation and also freshness of crop (food), etc.

6) **Smart Animal Husbandry:** In agriculture, animal husbandry plays an important role and contributes significantly in the welfare of farmers in India. Sensors enable monitoring of cows in dairies, honey bee colony, poultry farms, and sheep location tracking, identification of goat diseases and horse activity recognition, etc.

Role of 5G Network in Smart Farming

The 5G network provides a very high speed internet to transform data in low time. The data transfer using the 5G network is faster than other networks as it increases download. There are many advantages of using a 5G network in smart applications as follows:

- High data transfer capacity, low latency.
- Very high connection density compared to another network.
- Spectral efficiency improvement.
- Smooth communication performance.
- Extensive coverage.
- High efficiency of network energy.

Application of Smart Farming in Indian Context

Internet of Things (IoT) Based on Drones

The Government of India has formulated standard operating procedures (SoP) for use of drones for the purpose of spraying pesticides and fertilizers on agricultural crops. Drones can perform numerous functions that lead to improving agricultural practices. Locusts have been attacking and destroying large swathes of India's crops on a regular basis since the winter months of 2019 and the attack is continuing. The Agriculture Ministries both at the central and the state levels have been using drones for anti-locust spraying. They are proving to be an effective solution in an otherwise challenging scenario where India suffers large amounts of crop loss in the states of Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh.

Drones are also used in irrigation, monitoring crop health, planting, crop spraying, crop inspection, and soil analysis. In addition, the drone equipped with several sensors, 3D cameras, thermal, multi-spectral, and optical imaging cameras can be used to monitor crop conditions and diseases, plant health indicators, vegetable density, pesticide prospecting, fertiliser use, canopy cover mapping, field prediction, plant count, plant height measurement, field water mapping, exploratory reports, nitrogen measurement. Furthermore, it can monitor the state of plants based on some vegetative indices that can be directly calculated by multi-spectral images, such as the Normalised Difference Vegetation Index (NDVI), which is considered very effective. Despite the many benefits of drone applications in agricultural operations, there are significant challenges which limit its use, especially in developing countries like India. Drones are expensive, especially those with good software, hardware tools, devices, high-resolution cameras, and thermal cameras. The drone can fly for a short time, reaching an hour or less; therefore, the flight line path must also be determined considering the overlap between the flight lines. Legal limitation of drone use needs permits for the operation due to security point of view. The operation of drones is affected by climatic conditions particularly wind speed and rains affect the drone performance, so the weather must be considered before using drones.

Robotics in Agriculture

The labour shortage is being considered as a major impediment in crop cultivation in recent years. To tackle this issue for sustainable food security, the agricultural robot can used to perform many agricultural practices. IoT has contributed to the development of robots to achieve multiple agricultural activities, where

robots can perform many functions instead of humans. The use of such modern technology in agriculture facilitates improved agricultural efficiency, reduced operating costs and time. In addition, the robots can reduce the environmental pollution of up to 80 percent caused by farm's pesticides. Agricultural robots can be practical tools to provide unconventional solutions to face labour shortages, especially in case the spread of pandemics like COVID-19. Several agricultural robots, such as robots for harvesting, seedling, weed detection, irrigation, and pest infestation, livestock applications, etc., can perform many functions. Moreover, robots are used successfully in several industrial applications; for example, quality control, packaging, material handling, transportation, processing, and inspection.

Grain Bank Model of ERGOS

Ergos has developed a unique model in the Agri-tech landscape called "Grain Bank Model" that is providing doorstep access to end-to-end post-harvest supply chain solutions to small and marginal farmers, i.e., enabling farmers to convert their grains into tradable digital assets, avail credit against those assets through partner NBFCs and Banks, and get better prices for their produce. The Ergos model offers farmers the flexibility to store/ withdraw even a single bag of grains. Farmers get immediate liquidity and better income as they don't have to sell all their produce at once at the prevailing market rates during harvest season. Through an efficient use of technology and direct farmer engagement, they provide storage, credit and market linkage services to farmers at the farm gate.

Smart Decision Support Systems (SDSS)

Smart Decision Support Systems (SDSS) in the agriculture sector aims to support farmers in making proper decision in irrigation management, fertilisation process, and others for service operations. In addition, a decision support system have been proposed for irrigation management, as the system includes spatial location data and crop characteristics in terms of crop growth stages, planting date and water requirements, precipitation, temperature, as well as soil characteristics and water holding capacity. It also includes an inference system that determines irrigation timing to maintain soil moisture within the appropriate limits; this system has positive impacts in terms of water use efficiency and quality of crop yield. The geospatial information is continuously provided by various means to a software system which makes all decisions based on these data.

Monitoring and Risk Management in Agriculture

Yuktix Technologies - an agritech startup based in Bangalore is providing handy digital tools for agriculture farm monitoring and risk management. These small digital tools help farmers to make decisions and implement best practices that increase yield and reduce losses. The tools are powered by their hardware and software solution that they call GreenSense IoT devices and GreenSense dashboard. GreenSense is an off-grid remote monitoring and analytics solution for agriculture. GreenSense nodes with dashboard provide an effective tool for monitoring and disease, pest, and irrigation management. Their solar powered weather stations provide real time weather conditions anytime from anywhere. In Odisha a micro-weather station of Yuktix collects data from different locations using existing indigenous knowledge, combine it with research to provide a digital tool that helps them distribute crop-specific advisory to a group of tribal farmers to use climate smart agricultural practices.

Automatic Watering and Irrigation

Water for irrigation is becoming scarce not only in arid and semi-arid regions but also in the high rainfall regions; because of the uneven distribution of rainfall pattern that is not suitable for most of the crops. In this modern age, subsurface drip irrigation (SDI) plays a vital role for judicious use of water as per the requirement of the crop. But this system still needs to be maintained by the operators. In order to improve its efficiency and ensure water demand of the crop, efforts for SDI assembling with moisture level detectors are helpful in better crop germination and yield.

Driverless Tractor

Automated tractors (driverless tractor) integrated with hardware and special-purpose designed software are working more efficiently, thus, changing agricultural machinery. However,

driverless tractors are operated by monitoring sensors that help to run and recognise a tractor to field boundaries i.e., GPS for mapping and navigation, IoT connected to remote sensors and monitoring system, and radars for object detection in the field. Driverless tractor can be very important to perform several practices, such as spraying of crop canopy for the management of insects, diseases and selective weed treatments, either these weeds are managed by spraying herbicide or by flame burning in the fallow land driven by automated tractor.

Challenges and opportunities

Without any doubt, smart farming is helpful for farming community with real-time alerts. It helps in management and precise use of agricultural resources for sustainable food production and increased profits. To understand the challenges associated with smart farming in India, we have to consider a typical Indian farm and accordingly design smart tools and techniques which mean that smart farming has to be customised according to typical Indian small and marginal farmers. Thus, main challenge is the small landholdings, fragmented farms and the farmers are unable to adopt smart farming with limited knowledge and skills. Apart from these, there are many other challenges which also need to be improved to make smart farming a reality in India.

Internet Connectivity: Smart farming mainly relies on the faster internet connectivity. Bridge between farmers, smart communication device and field-based sensors for real-time information and management is still a challenge. But most villages and farming communities do not have access to internet all the time. This makes the adaption of smart farming difficult.

Global Positioning System (GPS) Signals: GPS signal transmission is difficult in heterogeneous topography like hilly, forests and field with a dense tree planting.

Energy Requirement: Data collection and processing centres and many IoT based sensors need uninterrupted and continuous energy for a successful application. Whereas, developing countries like India are already running out of energy resources. So, this may be a major hindrance for large scale adaptation of smart farms in near future.

Smart farming is the need of hour, however to succeed in its fast adoption in India the innovations must be focused on low cost technology, simple and easily portable tools, and custom hiring system module and credit facility. Government of India has already started digitalisation of agriculture and all support of schemes is directly transferred in the bank accounts of farmers. Promotion of Farmer Producer Organisations (FPOs) might make smart farming a reality by enabling farmers to wear expensive tools. Finally, the biggest opportunity for smart farming/ digital agriculture across the entire agriculture value chain from the upstream (inputs and production processes) to the downstream (post-harvest and value addition/ food processing) is the emergence of FPOs in India.

Conclusion

The scenario for smart farming/ digital agriculture is promising in India. Smart farming aims to increase production and improve the efficient use of land, water and other resources used in agriculture. Therefore, smart farming is the future facilitating better utilisation of precious resources, inputs and environmental protection. The key factors to succeed in smart farming in India are affordability of technology, ease of access and operations, easy maintenance of systems, timely grievance redressal and appropriate policy support. Robust research and development in the field of smart farming is needed so that smart farming can empower Indian farmers to sustain their farm productivity and livelihood.

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(The authors are Principal Scientist and Former Professor, at Division of Agronomy, ICAR–Indian Agricultural Research Institute, New Delhi. Email: ysshivay@hotmail.com and Principal Scientist, at Division of Agronomy, ICAR–Indian Agricultural Research Institute, New Delhi. E-mail: ku_agron@yahoo.co.in. Views expressed are personal)

Prioritising Climate Smart Agriculture

Ankita Sharma and Deekhit Bhattacharya

Climate change is no longer a future possibility, but a reality which all of us are witnessing. Securing the financial future of Indian farmers, as also the food security of those dependent on them, is a crucial priority for the government. The urgency of the matter is not lost upon policymakers, and elements of CSA have been baked into most of the government's active schemes for agriculture and allied activities. Few points such as CSA linked credit, extension services and new innovations can be taken up more vigorously in the future to affect change at a faster pace.

The Indian agricultural sector is diverse, vivid, and dynamic. Its importance within the economy is highlighted by the fact that around 54.6 percent of India's total workforce is engaged in agriculture and allied activities. The development of the sector, naturally, has been a key priority for the Government of India. Climate change, however, has emerged as a matter of concern to Indian agriculture.

The interaction between agriculture and climate change is multifaceted, and plays out in India's climatically diverse regions differently. Overall, the countrywide decline in major crop yields due to climate change effects between 2010 and 2039 could be as high as 9 percent, worsening further with time. The estimated impacts of both historical and future climate change on cereal crop yields in different regions indicate that such yield loss can be up to 35 percent for rice, 20 percent for wheat, 50 percent for sorghum, 13 percent for barley, and 60 percent for maize depending on the location, future climate scenarios and projected year. Higher temperature eventually reduces yields of desirable crops while encouraging weed and pest proliferation. Perceptions of worsening yields, diseases, pests, and rainfall have been documented across the Indian subcontinent in a number of studies, indicating the real, present, and ongoing threat which climate change possesses.

In human terms, this could make large swathes of small farmers' landholdings unviable due to the following factors.

- **Water Conflict:** Around 80-90 percent of the country's water consumption occurs within the agriculture and allied space. Despite such an outsized water consumption pattern, roughly half of the country's agriculture is rainfed, vulnerable to weather patterns and having

volatile yields. The practice of flood irrigation makes Indian agriculture's water efficiency poor, where Indian agriculture requires 2-3 times water consumption compared to other major agricultural countries.

- **Land Fragmentation:** Studies have placed the root cause of poverty in India to be land fragmentation- the average size of landholdings have come down to 1.08 hectares, with two-thirds of all holdings being below 1 hectare. Incomes from cultivation tend to follow fragmentation measures, whereby average monthly per capita income from agriculture ranges from Rs. 2,311 in Punjab to Rs. 250 in West Bengal. Such fragmentation prevents economies of scale and holdings below and around 1 hectare (i.e. marginal holdings) tend to be insufficient to provide for a family's consumption needs. Marginal holdings are particularly vulnerable to the effects of climate change.
- **Soil Chemistry:** The incorrect use of fertilisers as also changing climatic patterns have been changing soil chemistry across India. The problems of salinisation, desertification, and degradation are direct consequences of poor agricultural practices. These processes would be intensified by climate change, adversely impacting productivity and arable land.

At the same time, agriculture is also a major contributor to the climate problem. Agriculture is a fuel and water intensive business and generates 19-29 percent of total global greenhouse gas emissions. It is further to be noted that around one-third of all produce is wasted, which in and of itself embodies a large carbon footprint.

Concomitantly, addressing these key issues require not only a flexible policy framework, but close coordination with all stakeholders. The issue is wide-ranging in not only its incidence but also implications- employment, food security, migration. The variance in institutions, practices, and agro-climatic zones necessitate grassroots engagement to address climate change risks.

Climate Smart Agriculture (CSA)

The Food and Agriculture Organisation has developed the concept of Climate Smart Agriculture, which was presented at the Hague Conference on Agriculture, Food Security and Climate Change in 2010. The FAO describes the concept as follows:

"Climate-smart agriculture (CSA) is an approach that helps guide actions to transform agri-food systems towards green and climate resilient practices.

It aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible.

What constitutes a CSA practice is context-specific, depending on local socio-economic, environmental and climate change factors.

FAO recommends the approach is implemented through five action points: expanding the evidence base for CSA, supporting enabling policy frameworks, strengthening national and local institutions, enhancing funding and financing options, and implementing CSA practices at field level."

Three Pillars of CSA

- **Productivity:** CSA aims to sustainably raise agricultural productivity and incomes from agricultural and allied activities while balancing concerns relating to the environment. A central focus of this endeavour is to promote food and nutrition security. A key concept related to raising productivity is sustainable intensification, described as "an approach using innovations to increase productivity on existing agricultural land with positive environmental and social impacts. Both words, 'sustainable' and 'intensification', carry equal weight. Sustainable intensification takes into consideration the impact on overall farm productivity, profitability, stability, production and market risks, resilience, as well as the interests and capacity of individual farmers to adopt innovations. It is not limited to environmental concerns, but also includes social and economic criteria such as improving livelihoods, equity and social capital."
- **Adaptation:** CSA aims to reduce the exposure of farmers to short-term risks, while also strengthening their resilience by building their capacity to adapt and prosper in the face of shocks and longer-term stresses. Particular attention is given to protect the ecosystem services which ecosystems provide to farmers and others. These services are essential for maintaining productivity and our ability to adapt to climate changes.

- **Mitigation:** The minimisation of emissions and the maximisation of carbon capture is a core concern of CSA. This implies a reduction of emissions for each calorie or kilo of food, fibre and fuel that is produced. The prevention of deforestation, adoption of sustainable practices, and the management of soils and trees in ways that maximises their potential to act as carbon sinks and absorb carbon from the atmosphere is a part of mitigation.

Characteristics of CSA

CSA differs from conventional agricultural paradigms due to the following.

- CSA attempts to address climate change's causes and effects: Contrary to conventional agricultural development, CSA systematically integrates climate change into the planning and development of sustainable agricultural systems.
- CSA integrates multiple goals and manages multiple trade-offs: CSA's three primary pillars are interrelated concerns- increased productivity, enhanced resilience and reduced emissions. However, the resultant trade-offs often cannot maximise the pillars simultaneously, only optimise them. Thus, costs and associated benefits must be weighed situation to situation, based on stakeholder objectives and identifying underlying synergies.
- CSA maintains ecosystem services: Ecosystems provide the agricultural sector with a number of 'unpaid' services-clean natural water, materials, food, sunlight, etc. CSA attempts to ensure the sustainability of these services, preventing their degradation.
- CSA has multiple entry points at different levels: CSA is not a rigid set of particular practices, technologies, or methodologies- it is only a concept amenable to adaptation. It has multiple entry points, ranging from the development of technologies and practices to the elaboration of climate change models and scenarios, information technology, insurance schemes, value chains and the strengthening of institutional and political enabling environments. As such, it goes beyond single technology at the farm level and includes the integration of multiple interventions at the food system, landscape, value chain or policy level.
- CSA has context-specificity: What is appropriate sustainable practice in a marshland may prove inappropriate in an arid land. According to the context of the situation, interventions must take into account how different elements interact at the landscape level, within or among ecosystems and as a part of different institutional arrangements, social realities and political structures. This reduces the scope for transference of lessons from one place to another.
- CSA involves the marginalised: The vulnerable and marginalised, inclusive of women, often possess the marginal lands which are most vulnerable to climate events like drought and floods. They are, thus, most likely to be affected by climate change. The relevant sub-goal is to build up the adaptive capacity of these vulnerable stakeholders so that they can build their capacity to endure natural disasters. Naturally, the governing systems of the place and the relative bargaining powers of stakeholders must be taken into account.

The Mitigation of Climate Change in Agriculture (MICCA) programme of the FAO generates technical knowledge, working on the ground and with partners within the United Nations Framework Convention on Climate Change. It offers a macro framework to address CSA through the following:

- Monitoring and assessing greenhouse gas (GHG) emissions and the mitigation potential in agriculture;
- Developing the capacity of stakeholders working on national GHG inventories and farmers using CSA practices;
- Carrying out life cycle assessments to guide decision making;
- Giving guidance on climate change mitigation and adaptation options, including for peatlands and organic soils;
- Mainstreaming gender in CSA, facilitating online communities of practice, and running online learning events.

Key Government Initiatives on CSA

The Government of India has multiple overarching programmes to deliver CSA elements to Indian farmers in an affordable, accessible, and adaptable manner. Besides the following, a number of pilot projects and studies are carried out

from time to time, an example being the National Institute of Rural Development and Panchayati Raj (NIRDPR) coordinated a pilot project on 25 'Climate Smart' Agricultural Techniques in Bihar and Madhya Pradesh–States considered vulnerable to the effects of climate change–between 2015 and 2019.

National Innovations on Climate Resilient Agriculture (NICRA)

Indian Council of Agricultural Research (ICAR) launched a flagship network project 'National Innovations in Climate Resilient Agriculture' (NICRA) in 2011. The project aims at strategic research on adaptation and mitigation, demonstration of technologies on farmers' fields and creating awareness among farmers and other stakeholders to minimise the climatic change impacts on agriculture.

In the strategic research, the main thrust areas covered are (i) identifying most vulnerable districts/ regions, (ii) evolving crop varieties and management practices for adaptation and mitigation, (iii) assessing climate change impacts on livestock, fisheries and poultry and identifying adaptation strategies.

So far, 7 climate resilient varieties and 650 district agricultural contingency plans have been developed besides assessing the risk and vulnerability of Indian agriculture to climate change.

Under technology demonstrations, location specific technologies have been demonstrated in 151 climatically vulnerable districts.

In the past nine years, 16,958 training programs have been conducted throughout the country under NICRA project to educate stakeholders on various aspects of climate change and resilient technologies, covering 5,14,816 stakeholders so as to enable wider adoption of climate resilient technologies and increase in yields.

National Mission for Sustainable Agriculture

NMSA derives its mandate from Sustainable Agriculture Mission which is one of the eight Missions outlined under National Action Plan on Climate Change (NAPCC). The NMSA aims at promoting sustainable agriculture through a series of adaptation measures focusing on ten key dimensions encompassing Indian agriculture namely; 'Improved Crop Seeds, Livestock and Fish Cultures', 'Water Use Efficiency', 'Pest Management', 'Improved Farm Practices', 'Nutrient Management', 'Agricultural insurance', 'Credit Support', 'Markets', 'Access to Information' and 'Livelihood Diversification'.

NMSA architecture has been designed by converging, consolidating and subsuming all ongoing as well as newly proposed activities/ programmes related to sustainable agriculture with a special emphasis on soil and water conservation, water use efficiency, soil health management and rainfed area development. The focus of NMSA will be to infuse the judicious utilisation of resources of commons through community based approach.

National Adaptation Fund for Climate Change

The overall aim of NAFCC is to support concrete adaptation activities which mitigate the adverse effects of climate change. The activities under this scheme are implemented in a project mode. The projects related to adaptation in sectors such as agriculture, animal husbandry, water, forestry, tourism, etc. are eligible for funding under NAFCC. National Bank for Agriculture and Rural Development (NABARD) is the National Implementing Entity (NIE). The dedicated window for climate finance fosters a spirit of competitive federalism among states and encourages enhanced climate action.

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) has been formulated with the vision of extending the coverage of irrigation '*Har Khet ko pani*' and improving water use efficiency 'More crop per drop' in a focused manner with end to end solution on source creation, distribution, management, field application and extension activities. The Scheme contains within itself a Micro-Irrigation Fund (MIF), a focus on protective irrigation, and water use efficiency interventions to not only expand India's irrigation networks but improve its efficiency in a climate conscious manner.

Zero Budget Natural Farming (ZBNF) and Organic Agriculture

There has been a conscious effort from the government to promote ZBNF, and other kinds of organic farming across India. Use of high yield variety (HYV) seeds, pesticides, and fertilisers in modern agriculture have long term impacts on soil, human, and environmental health. These inputs are also costly for small farmers, who are forced to take on debt for the same. The result is that during times of climate change, when the farmers' vulnerabilities are increasing, they are faced with the possibility of debt traps owing to falling yields and extreme weather events. Zero Budget Natural Farming, as also other indigenous kinds of organic farming techniques, offers a commercially viable and environmentally friendly alternative. The use of such techniques intrinsically causes farming systems to align with the local climatic conditions, and may offer better climate adaptation compared to conventional agriculture.

Way Forward

Climate change is no longer a future possibility, but a reality which all of us are witnessing. Securing the financial future of Indian farmers, as also the food security of those dependent on them, is a crucial priority for the government. The urgency of the matter is not lost upon policymakers, and elements of CSA have been baked into most of the government's active schemes for agriculture and allied activities. The following few points can be taken up more vigorously in the future to affect change at a faster pace.

- CSA linked credit: The provision of agricultural finance to farmers willing to adopt, or those having adopted CSA techniques will be a key catalyst in accelerating the process of adoption. Specific concessions and offers in this regard can set up positive incentives for farmers.

- Extension Services: The proper adoption of CSA requires consistent, comprehensive, and grassroots extension services for the farmers. The adoption of new systems, in break with what they have done for decades, can be a possible deterrent which should be attenuated through clear and verifiable information being provided to the farmer in his own language. The proliferation of mobile services can be a key enabler, where CSA is prioritised in existing and upcoming tele-extension services.

- Innovation: Indian agri-startups have been providing affordable, scalable solutions in the field of soil testing, disaster early warning, and farm management, etc. Holding contests with possible procurement tenders for such products by the government can incentivise scientific innovation in the field.

(The authors are Assistant Vice President–Policy, Strategy and Research at Invest India, Email: ankita.sharma@investindia.org.in and intern with the Strategic Investment Research Unit (SIRU) at invest India respectively. Views expressed are personal)

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