

Building sustainable partnerships

Innovative Digital Technologies Assessment

Short Term Consulting Assignment

INDO-GERMAN COOPERATION ON AGRICULTURAL MARKET DEVELOPMENT

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1. Executive Summary

Digitalization is the application of digital technologies as a part of business process improvement leading to significant value addition and improvement of efficiency and effectiveness of business operations. Indian Agriculture is predominantly smallholder agriculture with nearly 65% of the population directly or indirectly dependent on farming and allied activities. With an increasing young rural population in combination with penetration of smartphones, 4G/5G connectivity, fintech applications and geographical information systems, Indian agriculture has just started witnessing benefits of Digital technologies for transformation from a sub-optimal equilibrium towards a more inclusive and optimal equilibrium which generates higher sustainable profits.

To assess the current state of adoption of digital technologies in Indian Agriculture, a study has been undertaken through primary and secondary research as a part of Indo-German Cooperation project on agriculture market development. The project aims at a baseline study of the digital technology landscape in India in terms of understanding the evolving ecosystem and on how the adoption of new digital technologies is making a difference to the lives and livelihoods of Indian farmers. While the assessment considers various examples all over India, it focuses on specific projects being undertaken in the States of Uttar Pradesh, Odisha, and Rajasthan.

As per Digital innovations assessments, the innovations can be broadly classified into three areas, viz., (i) Agri-fintech innovations, (ii) Innovations in Agri-production systems and (iii) Innovations in Agri-supply chains. Some innovative solutions may cross over across three dimensions.

- a) The key technologies underlying the innovations are as follows,
 - a. Farm management systems focused on management of farm operations,
 - b. E-commerce platforms for selling agri-inputs and food products,
 - c. e-Business systems for enabling B2B transactions,
 - d. Electronic content and document management systems for automation of transactions,
 - e. Mobile based applications for dissemination of technical and agri-advisory information,
 - f. Social media channels for exchange of market pricing and product information,
 - g. Remote sensing and climate sensor-based information on climate,
 - h. Sensor based information directly from farms connected to internet as part of Internet of Things (IoT) devices,
 - i. Deciphering data patterns from multiple sources including IoT devices, sensors, spectral imaging for enabling Artificial intelligence/machine learning (AI/ML)
 - j. Developing traceability and transaction systems using AI/ML and blockchain technologies
 - k. Farm mechanization and automation solutions using AI/ML technologies.
 - I. Data analytics, predictive analytics and decision support systems
 - m. Digital platforms for procurement and bidding
 - n. Digital technology linked spectral imaging-based devices and databases for traceability, crop diagnostics and quality assessment
 - o. Digital platforms linked to fintech apps, devices, gateways, APIs, wallets and payment interfaces for facilitation of digital payments
 - p. Infrastructure management solutions for warehousing, cold chains and logistics
 - q. Robotics using IoT and farm automations for enabling precision farming and site-specific application of agri-inputs.

- r. Standards based data exchanges for escrow based real-time transactions and quality conformations.
- s. Vertical farming and hydroponics-based technologies integrated with IoT and AI for improved operational efficiencies.
- t. Smart farming and smart operations for Dairy, poultry and fisheries.
- u. 4G and 5G wireless technologies coupled with Virtual reality and Augmented reality system for developing crop simulation models.

The approach and methodology for conducting the baseline study for understanding the key innovations and the ecosystem was through secondary research involving various sources in public domain. The specific case studies identified as per the five areas of innovation were based on personal interviews with the founders, key management personnel and industry experts.

In terms of adoption, the financial technology-based applications have a lead due to widespread penetration of online/digital payments in India. The rapid spread of 4G /5G communication technologies and smart phones are fundamental to adoption of digital financial tools in agricultural value chains. The demonetization in 2016 and the restricted mobility during pandemic also contributed to the extensive use of fintech applications and digital innovations ranging from online money transfers using Universal Payment Interfaces (UPI), to use of digital applications for availing loans and services.

The convergence of one or more of the above three areas and business process innovations have already proven as successful business models in agri-commodity value chains, GIS based crop-insurance management, real-time disease surveillance, e-Commerce platforms, real-time climate data, transparency in agri-commerce and trade, access to finance, digital advisory services, social media-based market intelligence, robotics based farm machinery, lot based devices, etc., Select case studies have been described in the report on each of the abovementioned innovative digital technologies.

Distributed ledger technology (DLT) or Blockchain is one of the most popular and emerging technologies in the recent few years. Block chain in agriculture can revolutionize transactions and traceability in agricultural trade and commerce. The technology is being piloted for agricultural commodity trading and financing by a few organizations. Further opportunities in agricultural finance, insurance, product quality regulatory enforcement and product traceability show a great promise for application of blockchain in Agriculture and allied sectors.

In line with the insights generated from both primary research in the form of interviews with industry experts and technology managers and secondary research and location specific information collected from the three States Uttar Pradesh, Odisha and Rajasthan, an analytical framework for design of solution architecture for concept, design and development of digital technologies based on the IDEA consultation paper of Government of India has been included in the report. Following are the key findings and recommendations provided in the report.

The digital innovations and solutions are all part of a larger ecosystem and therefore need to be looked at as an "Agri Stack" of solutions to solve various business process challenges in Agriculture. The solution architecture for different components of an Agristack has been defined by Government of India as InDEA architecture, as mentioned in the report.

The key recommendations in line with the assessment of digital innovations implemented and required for unlocking the value from Indian Agri and allied sectors are as follows.

a) Implementation of Agricultural reforms for of access to markets, technology and credit is a complex process due to conflicts of interests between various stakeholders including Government. Digital innovations solving business challenges can provide an opportunity to circumvent the long drawn legislative and reform process if value is realized in an optimal way by majority of stakeholders.

- b) Government of India and State Governments along need to develop a mission-mode project on Blockchain to develop an end-to-end convergence project across agri-value chain.
- c) The agility and flexibility of startup ecosystem should be leveraged through public private partnerships to accelerate new business models in agriculture focused on solving key process constraints related to access of farmers to markets, technology and credit.
- d) The fintech interventions can play a pivotal role in accelerating the progress of growth in agriculture and allied sectors. A Centre for excellence for fintech in a public private partnership mode for development of data exchange standards and audit trail need to be developed.
- e) Crop and variety planning and moving from a supply driven agri-value chain especially in cereal cropping systems towards a demand driven value chain in line with market requirements is the major transition which needs to take place in all the states of India.
- f) Crop/commodity specific Processing clusters in each taluka/district of India linked to local/regional and international markets is the need of the hour. Local processing coupled with strengthening rural road and irrigation infrastructure, warehousing, cold chain, and digital assets is the key to the overall development through Digital innovations.
- g) There is a need to develop a 'Go-To" place for FPOs and farmer collectives at the village and Taluka level which provide integrated services to the FPOs/Farmer collectives and enable them to realize their aggregation potential. Such place may be a Rural Business Hub or a Krishi Value Hub or Village Business Hub, which enables comprehensive FPO engagement.
- h) Standards based IT architecture and business architecture model need to be developed for Agritech/Digital innovations in line with the InDEA framework.
- i) There is a need for upgradation for enabling a transaction centric eNAM platform to ensure that all mandi transactions happen in a digital mode.
- j) The private sector involved in agriculture and allied sectors should focus on digitalizing transactions to set the standard and pace of the digital transformation in the sector.
- k) Government should develop cloud based digital platform with provision for sharing APIs for private sector players for sharing information and data.

2. Scope of the Engagement

The scope of the short-term engagement on assessment of digital innovations for market development shall be limited to the following as per terms of reference.

- Baseline analysis of advanced technological innovations applied in agri-food value chains in India (and their integration with FPOs, where relevant) with special emphasis on the states of Uttar Pradesh, Rajasthan and Odisha.
- Consideration of the use of artificial intelligence, e-management systems for market data, application of geographic information systems and data, and other digital information services, block chain management and other e-business tools.
- Consideration of the current digital systems such as E-NAM, ReML and other publicly supported digital marketing platforms/tools
- Requirements and challenges for access and management of market data relevant for agri-food value chains in India including traceability & quality assurance challenges and opportunities
- Overview of existing or evolving (pilot) technologies (outline of the technologies, description of solutions and advantages for the actors of the VC, benefit for farmers and other actors of the VC, distribution areas in India, indicative costs involved, suppliers of these technologies etc.) Identification of Indian and international suppliers of these technologies, where relevant
- Consideration of systems to support access to training, knowledge and innovation providers in agri-food digital technologies and services
- Identification of possible initial pilot project ideas (e.g., block chain pilot)
- Use the findings to develop a detailed analytical assessment and submit recommendations

For systematic assessment of the baseline study and the innovative digital technology landscape, the overall technologies have been considered into the following five thematic areas.

- 1. Financial technology-based applications.
- 2. Remote sensing and Geographical Information System based technologies,
- 3. E-Business tools including e-Commerce, Analytics and Decision support systems
- 4. Robotics, Artificial intelligence, and machine learning,
- 5. Blockchain based transaction and traceability systems

The report shall also consider specific case studies on the following startups and Agribusiness organizations with respect to innovative use of digital innovations.

- 1. Quality and Traceability Agri-commodity value chains,
- 2. GIS based crop-insurance management,
- 3. Real-time pest and disease surveillance,
- 4. e-Commerce platforms,
- 5. Real-time climate advisory
- 6. Access to finance,
- 7. Digital advisory services, & social media-based market intelligence,
- 8. Precision farming and Robotics based farm machinery,
- 9. lot based devices
- 10. Block chain pilots

Based on the above a solution architecture across various techno-commercial dimensions for requirement and adoption of digital innovations and summary of recommendations is proposed.

3. Approach and Methodology for assessment of innovative digital technologies.

Digital innovations and technologies have made a significant impact in transformation of world economy and the society in innumerable ways. As a country which is an active participant in the Information Technology age, India has also contributed to an great extent to the global digital economy. Digital innovations have transformed the business landscape in different sectors like Communications, Banking, Payments, Travel, Energy, Healthcare, Taxation, Governance, etc., and in general the consumer has significantly benefited from deployment of digital solutions¹. As per the recent World Bank report 'The digital revolution—and the data it generates—are key to building an agriculture and food system that is efficient, environmentally sustainable, equitable, and able to link the world's 570 million farms with 8 billion consumers'. The adoption of mobile phones and smart phone penetration is an important development which has been the core foundation for adoption of technological innovations in agriculture².

However it should be understood, that digital innovations and technologies act only as enablers in orchestration of value chains and there cannot be a functional digital solution standing in isolation, without the an underlying physical infrastructure. Therefore all digital innovations and enabling mechanisms ultimately are part of the larger "phygital" ecosystem, where in legislative policy reform and business process changes are ushered in to align with digital transformation. Further as Agriculture as a sector is diverse, heterogeneous, complex, and an ecosystem sensitive to risks and uncertainties of environment. Any interventions in Agri-sector therefore have to be approached through ecosystems approach considering the complex interactions and dependencies.

The approach to the study shall include secondary research with referencing and primary research based on interviews and questionnaires to industry experts and technology managers. As this is a short-term consultancy, the respondents who shall respond to either questionnaire or email, shall be included as a part of case studies. For innovations and digital technologies where there is no response, the information from public domain will be considered.

The following criteria will be considered for assessment of innovative digital technologies or thematic areas describer in the report.

- 1) Innovation potential and relevance of the innovation and use of digital technologies to agriculture and allied sectors
- 2) The core business problem addressed by the innovative Digital technology and its impact on the outcomes related to agriculture business.
- 3) The target consumers and the intended benefits in commercial terms and value addition in a business process framework
- 4) Inter-operability and standards
- 5) API integrations to other applications
- 6) Scalability
- 7) Current adoption status and access to technology
- 8) Key challenges in implementation and commercialization
- 9) Prospects and way forward

¹ <u>https://www.fao.org/family-farming/detail/en/c/1028927/</u>

² <u>https://ageconsearch.umn.edu/record/155478/files/2_Mittal.pdf</u>

Further to the above assessment is also made on whether the digital technology is innovative in the first place, in terms of whether it is an incremental innovation or a disruptive innovation, which targets a solution to a business problem. For example, mere establishment of a e-Commerce website would not amount to innovation, however, an innovative delivery mechanism for order fulfilment coupled with digital commerce, which may be an improvement over the existing methodologies with respect to overcoming a significant busines problem, can be considered as an innovative digital technology. It is the time now for utilization of the digital innovations in Indian Agriculture for enabling its transformation towards overall sustainable developmental goals.

With respect to the study in the three states, secondary research on the extent of use of innovative technologies shall be assessed as per data in public domain related to transactions and published case studies. With reference to case studies, selected cases where innovation with a potential or which has already clearly established an impact will be showcased.

4. Technological Innovations in Agri-value chains in India

Agriculture is the mainstay of Indian economy with nearly 65% of the population dependent directly or indirectly on farming and allied activities³. The share of agriculture and allied sectors to the Gross Value Added to the economy stood at 18% in 2020 ⁴.

Indian agriculture predominantly comprises smallholder farms with nearly 85% of farmers holding less than 2 ha of land. The unit economics of smallholder farms brings its own challenges towards achieving economies of scale and scope, operational efficiencies, and profitability in agriculture. Smallholder farmers often operate at a sub-optimal economic equilibrium and are trapped in a vicious cycle of low-intensity, subsistence-oriented farming, lower yields, limited access to markets and insufficient profits to further make beneficial investments in agriculture.⁵

Innovative business process improvements and technology interventions including digital technologies enable uplifting of farming and other allied agricultural activities as a commercial enterprises from a sub-optimal to optimal equilibrium with higher productivity and better operational efficiencies. From a micro-economics perspective of considering farm as a firm or an independent business enterprise, the optimization of production function leading to profit maximization and cost minimization through improvement of operational efficiencies can be possible only through scientific and technical interventions. Process and product innovations in inputs like quality seeds of improved plant varieties, balanced nutrition, farm mechanization, etc., lead to certain improvements in productivity. However the enabling infrastructure mechanisms on both physical and digital dimensions are vital to further unlock value of agriculture especially in smallholder context given the technical and process constraints. Some of the challenges and constraints of the smallholder agriculture which open up as opportunities for innovation are as follows⁶.

- i) Need for large scale crop-planning in alignment with domestic and international market demand and quality/commercial requirements
- ii) Improvement of sub-optimal storage and distribution network in line with the high cereal food production
- iii) Design, development and implementation of improved access mechanisms to agriinputs, finance, markets and technology especially focused on small and marginal farmers.
- iv) Need for breaking yield plateaus in crops like pulses and oilseeds through a combination of improved plant varieties and agronomical practices.
- v) Optimization of R&D cycle time for development of better plant varieties with tolerance to biotic and abiotic stresses
- vi) Development of suitable irrigation mechanisms coupled with improved plant varieties and agronomic practices for dryland and rainfed agriculture
- vii) Solving the contrasting challenge of food sufficiency and nutritional deficiency
- viii) Aligning rural infrastructure to urban market demand for management of postharvest losses through rural processing clusters
- ix) Building resilience into soil eco-systems and management of soil degradation

³ Indian Agriculture - <u>https://www.fao.org/india/fao-in-india/india-at-a-glance/en/</u>

⁴ <u>https://www.ibef.org/industry/agriculture-india.aspx</u>

⁵ <u>https://www.pnas.org/content/117/1/259</u>

⁶ IDEA paper of MoAFW,

https://agricoop.nic.in/sites/default/files/IDEA%20Concept%20Paper_mod31052021_2.pdf

- x) Reduction of information asymmetry for improved price realization for the producers and inclusive alignment of incentives of all the value chain participants.
- xi) Developing a value chain perspective across various agricultural commodities to build business process efficiencies and effectiveness.
- xii) Tackling climate change phenomenon, through multi-pronged interventions and approaches.
- xiii) Improved feed and yield management mechanisms in poultry, dairy. livestock and fisheries.
- xiv) Leverage technological innovations including digital innovations in agriculture into successful business process models by enabling convergence.
- xv) Development of site-specific nutrition and precision based input management systems for realization of higher levels of productivity.
- xvi) Developing distributed and scalable farm mechanization systems aligned to smallholder agriculture to solve the issues of labour scarcity.

Various digital innovation themes structured around agriculture and allied sectors are presented below.

Impact on farm economics	Innovation theme	Challenges that start-ups are solving	Some examples
	Enable farmers' access to market	Connecting farmers to markets through demand led models	Ninjacart, Jumbotail, Bigbasket, ShopKirana, WayCool, MeraKisan, Kamatan, DeHaat, KrishiHub, Agrowaves, Loop, Crofarm, FreshoKartz, Himkara
Increasing income		Post-harvest interventions by building near-farm storage, warehousing, and processing units	Our Foods, Agri Bazar, Star Agri, Arya Collateral, Ecozen
		Price forecasting	Credible
		Innovations in allied sector such as dairy, animal protein, hydroponics	Country Delight, Farmery, Zoofresh, Sattvaponics, Clover Ventures
		Measurement of soil moisture and nutrition to optimise use of water and fertilisers	EasyKrishi, BharatAgri, Satyukt Analytics, Flybird, Kritsnam, Agrirain, KrishiTantra
Reduce cost of production	Optimisation of input cost	Mechanisation to reduce cost of labour	Sickle innovations, Distinct Horizon, Goldfarm, EM3
		Access to timely agricultural inputs at advice	Agrostar, BigHaat, Behtar Zindagi, Unnati, Gramophone
Reduce cost of financing and	Enabling real-time and accurate data and business model	Access to reliable, accurate and real-time data for KYC, credit scoring, risk assessment for purpose of lending	Cropln, SatSure, Farmguide, Niruthi, AgRisk, Skymet
De-nsk larming	innovation	Business / channel innovation for financing farmers	Samunnati, FarMart, Jai- Kisan, PayAgri
	Enabling crop insurance	Data to optimise crop cutting experiments, yield estimation	Same as data start-ups for lending

All the above challenges and constraints which are key to the sub-optimal nature of the Indian agrarian economy need to be resolved to move towards a more optimal equilibrium for improvement of efficiency and effectiveness in farming. The resolution involves multiple approaches and mechanisms, coupled with legislative reforms and Government policy support with participation from both private and public sector.

Some of the Government support programs promoting Agri-startups and entrepreneurial programs are, Startup India mission, Atal Innovation Mission, NewGen Innovation and Entrepreneurship Development Centre (NewGen IEDC) under National Science & Technology Entrepreneurship Development Board (NSTEDB), Dairy Entrepreneurship Development Scheme promoted by National Bank for Agriculture and Rural Development (NABARD), Aspire (MSME), Venture Capital Finance Assistance (VCA) Scheme promoted by Small Farmers' Agri-Business Consortium and SIDBI.

Apart from Government support programs, different incubators such as Agri UDAAN, Centre for Innovation, Incubation and Entrepreneurship, Agri-Tech Startup Accelerator, Agribusiness incubator-ICRISAT, MANAGE Centre for innovation and Agripeneurship in collaboration with Universities and Governments are also supporting entrepreneurial development.

In line with the scope, this report shall specifically focus on innovations in digital technologies implemented in agriculture and allied sectors of India. The following sections of the report described specific digital innovations deployed in Indian Agriculture economy aimed at solving business process challenges for unlocking value to the producer-farmers, value chain participants and end consumers.

a) An overview of emerging Agri-tech landscape in India:

Adoption of digital technologies in Agriculture and allied sectors started two decades back with advisory and extension services portals for dissemination of improved package of practices and information on Government schemes by both public and private sector organizations. This was followed by national and state level level digitally enabled Call Centres for farmers as a part of Government and private sector organizations, especially Agri-input companies.

The adoption of crop and climate advisory services along with market price information was another model which integrated multiple services as a part of value chain development through the e-Choupal business model. This was followed by use of digital tools by similar Agri-value chain aggregation and disintermediation models leading to benefitting farmers for solving the problems relating to technical information on crop production and market information for better price realization. Web-based static information service, SMS based information services in addition to call services were the key business and communication models during this phase.

The rapid growth of mobile phones in general and internet-based smartphones as a platform for multiple applications, opened a new phase in the past decade leading to three developments, (i) proliferation of large number of mobile applications providing various services to farmers (iii) development of digital banking and payments and (ii) increase in social media adoption and information sharing through social media.

As per NASSCOM study the following are the emerging Agritech trends in India

- 1) Both farmers and Agritech startups have evolved in the past 5-6 years keeping abreast with the dynamic technology developments in the space globally.
- 2) B2B segment is the key revenue generation segment especially in farm mechanization, crop diagnostics, agri-commodity sales and agri-finance.
- 3) Unlike other sectors, Agritech can leverage "Make in India" opportunity much better given the natural competitive advantage as a leading agrarian economy with a high growth potential.

- Improving operational efficiencies in market linkages by compressing the agri-value chains through innovations which reduce transaction costs and also inefficiencies in supply chain management.
- 5) Driving transparency, traceability, and real time access to information through various interventions which help improve productivity and profitability of the farmer and also meet consumer requirements effectively.
- 6) Better access to Agri-inputs through digital innovations and e-Commerce portals
- 7) Farming as a service including use of precision farming tools for farm mechanization.
- 8) Increase in global partnerships along with public-private partnerships
- 9) Increased funding in agritech space but investor confidence yet to improve in the space.
- 10) There is a need to develop agritech policy framework for enabling growth of the ecosystem.

As mentioned in the above trends, the bridging of digital divide, through proliferation of 4G wireless telephony and adoption of internet-based applications in rural India has been a critical driver in technology adoption and diffusion of digital innovations in rural India.

As per the report on mobile connectivity by GSMA⁷, globally smartphones accounted for 68% of total mobile connections in 2020, compared to 64% in 2019 and 47% in 2016. South Asia has seen the strongest growth in smartphone adoption in recent years, increasing from 30% of connections in 2016 to 63% in 2020. India has been at the forefront of this growth, with smartphone adoption among adults increasing from 22% in 2017 to 51% in 2020. India's smartphone users are also among the largest users of data worldwide, due in part to near-universal 4G coverage and affordable data and smartphones, as well as the introduction of the JioPhone (an LTE- enabled handset launched by Jio), which was followed by other service providers such as Airtel.The rural urban gap between smartphone usage has also quickly come down in India from 46% in 2018 to 26% in 2020 as per GSMA report, indicating increase in rural smartphone penetration in India. Out of the total rural smartphones.⁸

Further internet usage per user in India is among the highest in the world in India driven by an increasing number of 4G users and more affordable handsets and data plans. Although data demand is primarily in urban India, rural India accounted for 45% of total traffic in India at the end of 2020, compared to 40% before the pandemic⁹.

As of March 2021, there were 1.18 billion wireless subscribers in India, according to the Telecom Regulatory Authority of India (TRAI). It comprises 645 million urban and 535 million rural subscribers (TRAI, 2021). By 2030, India will add 140 million middle-income and 21 million high-income households in both urban and rural India creating a big push for Indian Fintech sector, which will also give a fillip for all the convergence applications in Agriculture¹⁰.

¹⁰ <u>https://www.ey.com/en_in/consulting/the-winds-of-change-trends-shaping-india-s-fintech-sector</u>

^{7 &}lt;u>https://www.gsma.com/r/wp-content/uploads/2021/09/The-State-of-Mobile-Internet-Connectivity-Report-2021.pdf</u>

⁸ <u>https://www.forbes.com/sites/suparnadutt/2018/01/08/for-indias-farmers-its-agtech-startups-not-government-that-is-key/?sh=460634271c6e</u>

⁹ <u>https://economictimes.indiatimes.com/tech/internet/rural-india-beats-urban-in-data-usage/articleshow/79253465.cms?from=mdr</u>



As per the PwC-FICCI report of 2018 the rising trend of internet connectivity and smartphone access is provided below, which has become a key driver to the beginning of a digital economy in Indian agriculture¹¹.

Source: Industry estimates and PwC analysis

With the above background on the evolving technology landscape in agriculture buttressed firmly with positive network externalities in terms of robust adoption of ICT and smartphones across the country, the emerging digital innovations can be categorized in several ways. As per the IT industry association, NASSCOM, the digital innovations can be categorized as below¹². Based on the underlying business problem addressed by the digital innovations, the Federation for Agritech innovations has classified as below¹³.

¹¹ <u>https://ficci.in/spdocument/23343/Ushering-in-a-new-growth-wave_Online1.pdf</u>

¹² <u>https://community.nasscom.in/communities/agritech/digital-transformation-agri-sector-india</u>

¹³ https://fedev.org/wp-content/uploads/2020/03/AI-TIA%20Report%20V7.pdf

Area	Applications
Big Data	 Farm management solutions Risk mitigation and forecasting solution CRM and Input channel solutions Traceability and compliance Crop diagnostics
Marker linkage facilitation	 Marketing platforms for Agri-inputs Real-time market pricing solutions for farmers Farm to fork supply chain visibility Quality and price checks
Farming as a Service	 On demand harvesting Digital payments/bidding platforms Farm mechanization/Automation/Al
IoT (Internet of Things) enabled technologies	 Vertical farming, Hydroponics, Aeroponics Sensor based farm activity scheduling Farm operations automation

The innovations can also be classified as below.

- 1) Upstream supply chain Agri tech (Agri-inputs)
- 2) Downstream supply chain Agri tech (Agri Output)
- 3) Agri-Fintech
- 4) Robotics, Precision Agri-tech including IoTs and Artificial Intelligence
- 5) Farm management systems and Decision support systems.

Considering various classification approaches to digital innovations, the Digital innovations in Agriculture and allied sectors for the purpose of this report have been classified into three dimensions, keeping in view the nature of technologies and unique nature of agricultural production systems.

- 1) Agricultural finance solutions: All finance and insurance solutions linked to agriculture and allied sectors fall under the purview of this category.
- 2) Agri-input supply chain, Farm management, advisory & automation solutions: All advisory solutions, Agri-inputs supply management, smart farming, crop diagnostics, climate risk management, farm mechanization and precision agriculture
- 3) Market linkage and Agri-output Supply chain effectiveness solutions: All products and services linked to post-harvest, post-production supply chains including agricultural infrastructure, logistics, warehousing, etc.

In all the above three dimensions, convergence solutions which are cross-cutting innovative mechanisms spanning one or more dimensions may also exist A few examples of startups and organizations which have implemented innovations as per the above emerging agritech trends are as follows¹⁴.

SNo	Digital innovations made as a solution to	Name	of	the	Start-up or
	a business process challenge	Organizations		implementing	
		digital i	nnov	ations	

¹⁴ https://fedev.org/wp-content/uploads/2020/03/AI-TIA%20Report%20V7.pdf

1	Access to finance, insurance and integrated services	Farmart, Jai-Kisan, Gramcover, NCPI, PSBs,Dehaat, KissanDhan,Nurture.trade, Samunnati,AnanyaFin,
2	Agri-input supply chain, Farm management, advisory & automation solutions	Agrostar,Aquaconnect, Livestoc, BigHaat,Gramophone,Plantix, DeHaat, Bayer, EM3, TRRINGO,Mahindra & Mahindra, Escorts Tartansense, Terracroft, Satsure
3	Market linkage and Agri-output Supply chain effectiveness solutions	DeHaat, WayCool, Jai- Kisan,Crofarm ,Our Food, SourceTrace, Foodprint, TracX, Agnext, BigBasket,eNAM

In addition to the above there are several enterprises working on digital innovations in Government, and private sector which are at various stages of their technology and commercial readiness. As per the E&Y report 2020 on Agritech space the following are the key business models emerging around the enterprises working around digital innovations.

- Margin-based models where players create market linkages on the input or output side, and earn margins on the buy-sell spread
- Subscription-based models where players offer a mix of software, hardware and services to help farmers improve crop yields, track quality of produce or trace the produce across value chain
- Transaction-based models where players charge based on the number of transactions served such as loans or insurance policies

The digital innovation space in general in synonymous with Agritech space and shall be referred to as an alternate term in the report. As India marches towards becoming a UDS 3 trillion economy presently, the food processing, agriculture and allied sectors also proportionately moving towards becoming USD 500 billion worth economy in the next one decade. The agritech opportunity driven by digital innovations is currently at its nascent stage and will become USD 25Bn in the next 5-10 years, with 65% of contribution from market linkages and supply chain business and financial business. Currently the Agritech business is less than 1% of the estimated market size and rapid growth is possible in the next few years.

b) Adoption of new technologies in Agri-value chains in India:

While the launch of the new Digital innovations has been successful for many startups, their adoption by the farmers and consumers and various stakeholders is based on the value generated by the innovations. At times, even there is a clear value proposition, the uptake is slow, due to lack of awareness or interest or change management issues at the grassroots level. However, in certain technologies the adoption is high due to immediate gains realized by farmers. The following is the baseline assessment of the innovative digital technologies.

1) Access to finance, insurance and integrated services: The computerization of Bank accounts in India followed by online digital transactions is one of the major business

process transformations to happen both in urban and rural areas ¹⁵. This is followed by the computerization of post offices and launch of Citizen Service Centres (CSC) in rural areas. All these digital infrastructure solutions led to exposure of rural population to digital solutions.

The initiation of digital payment services through usage of e-wallets, Universal Payment Interface (UPI) based applictions such as PhonePe, NPCI, PayTM, GooglePay, Bharatpe, Rupay, QR code based payments, BHIM app, online banking payment gateways, PoS machines and payment portals,etc., is a step further in adoption of digital technologies in rural areas and more particularly for agricultural transactions. However key challenges to adoption are financial illiteracy, digital illiteracy, mistrust and systemic vulnerabilities on data privacy, inadequate infrastructure and selective non-acceptance of digital transactions as a resistance to change.

The penetration of mobile technologies and implementation of AADHAAR (Unique Identity Number) over a decade back laid a foundation for digital financial transactions, The JanDhan Yojana of Government of India to provide bank accounts to the account less rural and urban poor was a massive drive which was also based on a strong digital foundation. Further AADHAAR linked social sector payments, Mobile and AADHAAR linked Public distribution payments in addition to Direct Benefit Trasnsfer (DBT) of subsidies to farmers have all enabled continuous exposure of digital technologies to agriculture and allied sectors.

As per RBI report, at end of October 2020, India had over 1.15 billion wireless telephone subscribers resulting in a tele-density of 84.90%. However number of unique users is not available. While urban India is covered at 136.65% of population, rural India has tele-density of 58.72%¹⁶. The growth of Banking Correspondents (BCs) in rural areas, White label ATMs and Micro ATMs have also led to increase in digital transactions¹⁷.

The demonetization of 2016 and promotion of digital cashless economy by Government indirectly and gradually led to adoption of digital transactions in rural India for agricultural purposes. SMS based finance information services, use of OTP for financial transactions, use of PoS terminals, use of e-wallets and credit cards also increased in rural India¹⁸. The Government of India is promoting the "DlgiDhan" program which is aimed to be "Paperless, Cashless and Faceless"¹⁹. The Government of India program which is also set to benefit rural areas and agriculture has the following features.

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https://rbidocs.rbi.org.in/rdocs/PublicationReport/Pdfs/CDDP03062019634B0EEF3F7144C3B65360B 280E420AC.PDF

¹⁸ Financial services, <u>https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/topics/start-ups/2020/09/ey-agritech-towards-transforming-indian-agriculture.pdf?download</u>

¹⁵ Digital Banking in rural areas <u>https://journals.sagepub.com/doi/pdf/10.1177/2394901519825912</u>

¹⁶ RBI Report on Digital Transactions.

https://rbidocs.rbi.org.in/rdocs/Publications/PDFs/PSSBOOKLET93D3AEFDEAF14044BC1BB36662 C41A8C.PDF

¹⁹ DigiDhan- <u>https://www.meity.gov.in/digidhan</u>

- 1) Bharat Interface for Money (BHIM) is a mobile app for easy and quick payment transactions using Unified Payments Interface (UPI). User can make instant bank-to-bank payments and Pay and collect money using Mobile number, Bank a/c and IFSC code, Aadhaar number or Virtual Payment Address (VPA).
- 2) BHIM-AADHAAR App: This Mobile base App would enable merchants to receive payments without installing any physical POS machine. Customers can make payment by using his biometric thumb impression, Aadhaar number.
- 3) Bharat QR code is an interoperable payment acceptance solution that supports Visa, MasterCard. Amex and RuPay cards & BHIM-UPI for wider acceptance. Bharat QR code will enable rapid rollout of digital payments acceptance infrastructure throughout the country, as it does not involve any upfront investment in Point of Sale (PoS) machine.
- 4) Immediate Payment service enabled a user to send money 24*7 using mobile number, Aadhaar number and Bank a/c, IFSC Code. IMPS service can be accessed using internet banking, mobile banking and ATM.
- 5) RuPay debit cards has been launched by Government to enable all users to make payment digitally. PMJDY account holders have been issued RuPay debit cards which can be used at POS devices or online for making e-commerce purchase.
- 6) USSD: *99# service, which works on Unstructured Supplementary Service Data (USSD) channel envisioning the potential of Mobile Banking and the need for immediate low value remittances which will help in financial deepening and inclusion of underbanked society in the mainstream banking services.

The Government of India, developed the DigiDhan dashboard which consolidates digital transaction data for 16 digital payment modes from 110 banks (public sector banks, private sector banks, payments banks, regional rural banks, and foreign banks), RBI, NPCI, City Corporations of 100 Smart Cities, State Governments and Ministries of Central Government. The dashboard also provides for POS Deployment Statistics as well as Aadhaar & Mobile Seeding Accounts both in urban and rural areas.²⁰ However in addition to digital and financial illiteracy, many merchants, especially in rural areas, remain unable or unwilling to accept digital transactions due to network connectivity issues and a reluctance to pay transaction charges for what are often low-value transactions. The fear of entering into the taxation net is also another important reason for continuation of cash based transactions largely in the unorganized sector of the rural economy.

The Government of India is also using digital dashboards, Mobile applications and digital assessment mechanisms for claim processing and settlement process for crop insurance under the Pradhan Mantri Fasal Bheema Yojana (PMFBY).

The National Informatics Centre (NIC) of Government of Inda also aims at development of Blockchain based payments validation for Banks and consumers using Kubernetes Service Clusters²¹. The above information portrays the overall direction in which the digital innovations are taking shape as promoted by the Digital India initiatives of the Government.

With respect to expansion of Agri-Fintech space driven by private and public sector banks, NBFCs and the new age startups, the fintech sector in India is booming with strong vibes, in terms of growth and also significant impact in easing out the way the business is carried out.

The following are the disruptive lending models for providing loans to farmers and rural population in general as per the E&Y report²².

²⁰ <u>https://digipay.gov.in/dashboard/BI/Modewise.html</u>

²¹ <u>https://blockchain.gov.in/digidhan.html</u>

- EMI / POS lending: lending for purchases at the point of sale on online or offline merchants
- Payday lending or salary lending: loans given out to individuals based on income flow for short duration of time
- Receivables/Working Capital (WC) financing: financing to help MSMEs tide over short term cash flow crunch
- BNPL (Buy Now Pay Later): online and offline purchase aggregation •
- P2P lending: peer-to-peer loans enabling individuals to obtain loans directly from other individuals, cutting out the financial institution as the middleman
- The Easy pay payment option, "EasyPay" payment API allows institutions to collect money from their customers through QR code for the merchants for collecting payment and updating the status of the transactions enables open banking integrations which have brought digital inclusiveness to smaller towns and rural regions²³.
- Banking as a service (BaaS) model enables a third party service provider paying a fees to a financial institution, for opening its Application Program Interface (API) to the fintech/third party provider, thereby granting access to systems and information that will be necessary to build a new financial or banking product for the end consumer, which will be a fillip for providing financial services to the rural areas which account to only 10% of the total credit disbursed in the country²⁴.

In addition to general service providers such as PayTM, Googlepay, PhonePe, JioPay, BHIM-UPI, etc. and several NBFCs which serve both urban and rural India some of the agencies are focusing exclusively on rural sector with particular services to Farmer Producer Organizations (FPOs).

The following are the key business challenges addressed in this dimension through innovative digital technologies.

- 1) Access to comparative information on credit and insurance
- 2) Ease of access to capital and finance in terms of information and convenience in application for loans and purchase of insurance
- 3) Unlocking efficiencies of bundling input supply and output procurement with financial instruments
- 4) Obtaining credit with mortgage of farm produce stored in warehouses
- 5) Automated payment interfaces for real-time and fast transfer of payments
- 6) Payments against receivables/invoices and payable finance
- 7) Working capital loans for Agri-enterprises and FPOs
- 8) Credit scoring and application validation for loans for financial institutions
- 9) Application of new innovations in blockchain for improvement of transaction credibility and traceability
- 10) Reduction of transaction costs for financing
- 11) Use of precision based risk management tools for insurance claim settlement
- 12) Ease of transaction and settlements at point of sales overcoming lengthy documentation.

²³ https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/topics/consulting/2021/ey-winds-of-change-india-fintech-report-2021.pdf?download

²⁴ <u>https://inc42.com/resources/pivoting-agritech-to-agri-fintech/</u>

The summary of the Agri-value chain players in the digital innovation landscape are given below²⁵.

Sno	Business process Challenge	Innovative Solution	Players
1	Financing FPOs, Agri-	Digital onboarding and loan	Samunnati
	enterprises and SMEs for	approval	Jai-Kisan
	fall outside the ambit of		NABKISAN
	Banking system		Ananya finance
			Bijak
			Nurture
2	Receivable finance for Small	Co-lending between public	Samunnati
	and medium enterprises	and private sector banks	Cred avenue
	transactions with high	providers	KissanDhan
	transaction costs of		Paisalo Digital
	verification		Vedika Credit
			Agri-wise Finserv
3	Agricultural Input linked credit	Direct channel financing by Agri-input companies	Netafim Agricultural financing agency (NAFA)
4	Credit scoring for digital consumer lending	Credit scoring	Bijak
			Zest money
			Lendingkart
5	Trusted intermediary services for trading	Escrow account	PaySafe of Arya Collateral
6	Easy access to finance in a short turnaround time	Buy Now Pay Later option	Bharat Khata of Jai- Kisan
7	Easy access to credit	Multi-channel loan applications and approvals	Origo
			KissanDhan
			DeHaat
			Bijak
8	Working capital using warehouse receipt system	Unique Blockchain system based validation of Warehouse inventory	Whrll
9	Fungibility on stock available at warehouses	Conversion of grains into digital assets	Ergos

Key examples of digital innovations implemented are presented below.

²⁵ <u>https://www.microsave.net/wp-content/uploads/2020/06/The-role-of-tech-enabled-formal-financing-in-agriculture-in-India-2.pdf</u>

a) Netafim Agricultural Financing Agency (NAFA) was promoted by Netafim Group, Israel, India's largest company in irrigation equipment to finance the stakeholders in micro-irrigation value chain. It provides (i) Agri-investment loans for purchase of Agriinputs including micro-irrigation equipment, (ii) Channel partner financing for working capital loans and (iii) Finance for small business units and SMEs involved in agriculture sector. NAFA uses E-signing, Digital KYC and stamping for hassle-free and quick loan disbursement to its customers.



This can be considered as a good practice for Agri-input linked loan disbursement to farmers, FPOs and SMEs, in terms of management of service levels for customers and effective risk management. As the company is also associated with its parent company which is an Agri-input company, loan utilization and repayment can be effectively tracked.

- b) Online Ioan applications: Online Ioan applications for commodity based finance, invoice finance, structured trade finance, working capital loans, etc., for customers such as Agri-enterprises traders, commission agents, farmers, FPOs, etc., are provided by organizations like NCML, KissanDhan, Origo commodities, Arya Collateral, etc. These agencies act both as commodity trading and also financing agencies leading to delivery of integrated services.
- c) Digital Escrow services: Arya Collateral offers Paysafe Escrow services for commodity trading for enabling a smooth transaction between commodity buyers and sellers. Such services are provided by Public and private sector banks also. However Arya Collateral in addition to being a commodity trading and warehousing company also provides innovative digital services as an integrated value chain services player.



- d) Transactions platform (Bharat Khaata app): Jai-Kisan, an Agri-startup has launched a comprehensive current account loan and account management app for farmers and small and medium enterprises called Bharat Kaatha (Indian Account). The app provides both Buy Now Pay Later (BNPL) and Supply chain financing products. Through the app, farmers can easily access finance and connect to the value chain within short turnaround time, in addition to tracking their expenses and knowing their credit limit. The innovation in this app is the BNPL facility targeted for FPOs, agribusinesses and farmers as a mechanism of short term credit.
- e) GrainBank by Ergos: Grain bank model by Ergos is a unique innovation which combines market linkage and credit. Grain bank has a network of warehouses and aims to convert grains as digital assets. The procedure for onboarding on Grain bank is provided below.
 - a) Farmers register on the mobile app/web
 - b) Farmers book space in the Grainbank for storage.
 - c) Grains are inspected for quality at the warehouse.
 - d) Grain bags are deposited into the Grainbank.
 - e) The information is digitised making the grain bags fungible as digital asset.
 - f) Farmers can access their digital inventory in one click.
 - g) Farmers can sell a single unit of grains in just one click.
 - h) Farmers can avail direct credit against their stored grains.

The illustration of the process of Grain bank is given below



f) Whrrl- a blockchain based model: Another interesting model is the Blockchain led innovation for warehouse receipt (WR) financing. The Whrrl is a B2B2C Blockchain startup building a blockchain based app for Warehouse Receipt Finance that helps Farmers, Traders & Producer Companies in raising working capital to tide over lengthy crop cycles ranging from 6-12 Months.

Whrrl collects data from warehouses with the help of IoT devices and puts that data on Blockchain creating an immutable record of Collateral and its attributes like Ownership, Quality and Location. This helps lenders in making informed decisions, cuts the role of intermediaries and reduces the risk of fraud.

- g) Financing Livestock and Dairy industry: Stellaps the one-stop Dairy supply chain digitization application coupled with IoT devices also provides for MooPay financing platform especially targeted towards the financial needs of Dairy farmers at their doorstep. Moopay combines loans to farmes at attractive interest rates along with reduced premium for animal insurance. Similarly DGV provides for a digital platform for financing Dairy industry including cooperative societies, Dairy farmers, etc. AquaConnect is an App which provides AI based services to Aquaculture farmers in addition to credit.
- h) Satellite based Risk management solutions: For many of the insurance agencies and banks involved in agribusiness, startups like GeoBotanics provide risk management solutions with innovative tools such as index based and claim based automated engine, underwriting and pricing engine and fully automated claims processing and credit risk score generation, Other startups provding such services include WRMS, SatSure,Skymet,AgRisk,etc.

The lending to agriculture and allied sectors in India is at USD 220 Bn in the current year. Given that institutional credit reaches only one third of all farmers, the potential for lending to agriculture and allied sectors, the lending potential is pegged at USD 750bn²⁶. The agri-fintech

²⁶ Agri-Fintech market size: <u>https://inc42.com/resources/pivoting-agritech-to-agri-fintech/</u>

companies have a huge opportunity to become a key enabler for funding the agricultural growth in India. Innovation involving digital technologies along with policy and legislative reform is the key to unlock the true potential of Indian agriculture.



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2) Agri-input supply chain, Farm management, Advisory & automation solutions:

The agricultural production and farm management is the area where innovative digital technologies were deployed earliest in terms of providing farm advisory services by both Government, private sector and more lately startups. The past few years saw explosion in social media especially adoption of Whatsapp, Telegram, Facebook and Youtube in rural and semi-urban India.

As per a study there are 450 million millennials in India, out of which around 300 million are in rural and semi-urban areas²⁷. Many of these millennials are linked directly or indirectly to agrarian economy supporting their families in various businesses. The rapid spread of social media has led to exponential increase in information dissemination on agricultural advisory services and market price information and more importantly through individual reviews, peer to peer information sharing, etc

The following are the key business challenges addressed in this dimension.

- 1) Availability of credible information on standard package of practices for farm production of various crops, livestock, poultry, etc., at one place.(Eg:FarmRise, mKisan)
- 2) Information on pricing, quality and type of Agri-inputs and their timely availability during the season (eg: BigHaat,Agrostar, Livestoc)
- 3) Farm management applications for Agri-input companies for seed production, product evaluation and R&D services (eg: Crop-In,Arnetta)
- 4) Real-time information on crop pests and diseases and abiotic stresses and information on their management. (Eg: Plantix,Fasal)
- 5) Availability of credible analytical information on soil nutrient and health status and need for timely recommendation for application of right amount of crop nutrition. (Eg:KrishiTantra)
- 6) Solving the problem of labour scarcity and high costs of labour in total cost of cultivation. (Eg: EM3 services)
- 7) Improving the efficiencies of farm labour by partial or complete replacement with automated tools and farm mechanization (Eg: Mahindra Krishe, TAFE FtoF)
- 8) Implementing the best practices of precision agriculture and site-specific input application through use of Artifical intelligence, robotics and farm mechanization. (Eg: Tartansense,)
- 9) Management of agri-input channels for agri-input companies for improved operational efficiencies. (Eg: Bayer,Corteva,Syngenta, UPL,etc)
- 10) Information on climatic conditions for taking timely action at various stages of production. (Eg: AgRisk, AccuWeather, Skymet, DeHaat, Fasal, Crop-In)
- 11) Effective management of farm and irrigation infrastructure through irrigations scheduling (Eg: NetMaize, NetBeat by NetaFim)

The key innovations in this dimension of Agritech including Farm management, Agri-input supply chains, advisory and automation solutions, fall into the production related activities in Agriculture and allied sectors. These include technical information on package of practices, farm mechanization and automation of operations, selection and purchase of agri-inputs, crop planning, farm management applications for improving productivity and quality and various other knowledge inputs into agriculture starting from climate advisory, crop diagnostics, disease surveillance to soil health status. Given below is the status of various digital innovations implemented under this dimension.

²⁷ Rural millennials- <u>http://www.businessworld.in/article/How-Rural-Millennials-Are-Choosing-Their-Smartphone/24-04-2020-190228/</u>

Sno	Business process Challenge	Innovative Solution	Players
1	Farm management solutions	End to End integrated solutions for farm management, product evaluation, R&D companies linked to Agri-production process flow with dashboards/analytics hosted on Cloud	CropIn Arnette Gramophone Nurture.farm Fasal mKisan
2	Agri-input procurement- Reduction of search costs to farmers for quality agri-inputs	Multi-modal E-Commerce platforms through Portal/App/Social media/Missed call services/Phygital models	BigHaat AgroStar Livestoc AquaConnect Bayer
3	Crop/Plant diagnostics	Real-time diagnostics of crop conditions linked to Agri-input sales	Plantix Farmart Gramaphone
4	Climate risk advisory	Providing real-time climate data and predictive analytics for crop management, insurance and risk management to FPOs,Farmers, Agri-input companies.	Satsure Skymet GeoBotanics AgRisk CropIn WRMS Meghdhoot
5	Agri Advisory services	Multi-modal agri-services by startups and individual members of Farming community	FarmRise- Bayer Youtube/FB DeHaat NetMaize
6	Farm mechanization/Automa tion solutions	Addressing mechanization needs of farmers and enabling precision farming operations automation using AI and Robotics.	EM3 Mahindra (Krish-e) TAFE (Farmer to Farmer) Tartansene HarvestCroo BlueRiver SimplyFresh
7	Measurement of Soil health status	Electronic devices connected to digital platforms for assessment of soil health status and providing Input application recommendations	Easy Krishi KrishiTantra Agri Rain (IaaS)

Key examples of innovative digital technologies are presented below.

a) Farm management Apps:

- **Nurture.farm :** Nurture is a unique Application developed by the Indian Agri-input major UPL, which integrates innovation for providing quality services to farmers. Some of the innovative processes delivered through digital mode are as follows
 - Authentic inputs supplied as per requirements of farmers including comparative product/pricing analysis
 - Provision of insurance and credit services
 - Exchange seeds , products and tools with other farmers and earn rewards
 - Health insurance to farmers family
 - Soil testing
 - Spraying as a Service (SaaS)
 - Crop advisories
 - Farm monitoring
 - Access to markets and storage
 - Smart pricing information
 - Irrigation and water saving practices

The App innovatively brings together exchange of seeds and implements between farmers. Nurture has also build other apps such as Nurture.retail for retailers, Nurture.trade for traders for enabling traceability and Nurture.sustain for sustainable and regenerative agriculture practices.

- **CropIn**: CropIn is one of the first full-fledged Agri-focused software company in India. It has over the period of past 6-7 years developed applications for farm management, risk management and Machine learning which can be considered as a full scale agri stack suitable for all stakeholders. It has the following applications.
 - SmartFarm for farm management
 - Smart Risk for production monitoring
 - Smartware for supply chain management
 - Root Trace for end to end supply chain traceability
- **Fasal:** is a farm management app using farm level data collected by IoT devices to provide weather forecasts, irrigation alerts, pest and disease alerts and records overall costs of operations of the farm. It is an ideal app for developing precison agriculture based systems using AI and IoT devices.
- **DeHaat** broadly works at two levels, advisory and access. The following are services provided.
 - Personalised crop advisory based on precision farming technologies, provided to farmers at almost free of cost.
 - Access to quality inputs at the right time and right price.
 - Access to market linkage for sale of produce at higher margin.
 - Access to affordable financing and insurance solutions.

Dehaat aims to provide all the above through a single stack platform developed as DeHaat App and delivered through DeHaat Centres, which are managed by a network of micro-entrepreneurs. The Agri-advisory engine is called as AEROS (Agronomic Earth Observations) for connecting to farmers. All other apps including IoT devices connect to the AEROS platform. They are also developing Kheytibook to deliver precision agriculture based services to farmers.

• **Simplyfresh:** is among the largest precision farming based Hydroponics startup which is utilizing the power of Artifical intelligence and climate engineering for growing exotic vegetables and medicinal plants. It has also developed systems for water conservation and traceability and standardized advanced hydroponic based semi-urban farm model.

- **Bayer**: Along with Startups, it is also pertinent to understand the Digital innvoations being implemented by large established organizations. Bayer Crop Science, the largest Agri-input company in India has been in the forefront of developing ecosystem-wide interventions and innovations for smallholder farmer and its channel partner engagement. Some of the initiatives undertaken by Bayer are as follows.
 - Better Life Farming (BLF) Centres in collaboration with FPOs and retailers for providing Agri-inputs, Demonstration and advisory services and financial services
 - Digital advisory through FarmRise knowledge application available in 6 languages.
 - Facilitation for crop harvest collaboration
 - o Digital assets for channel partners including channel partner financing
 - Image based disease recongnition
 - Pest and disease alerts
 - o Nutrition advisories
 - IoT based applications for measurement of Soil moisture, pest infestation, remote field monitoring, germination monitoring, weather and soil correlations, predictive analytics, Weed emergence monitoring, etc.

Bayer has also collaborated with multiple institutional partners including State and Central Governments for piloting various technologies including AI/ML, Climate smart agricultural practices, bundled products, etc.

b) Crop and Soil Diagnostics:

- **Plantix:** Crop diagnostics by real-time image recognition based identification of pests and diseases from a repository of images is an useful way of crop advisory for suitable crop management practices. Plantix is a pioneer in this field with nearly 15 million downloads and is presently being utilized crop protection companies also for sales of Agri-inputs along with crop diagnostics.
- **Krishi tantra:** Krishi Tantra has developed an advanced digital analytical device for testing of 14 soil parameters in 1 hour and provide for a recommendation of the nutrient application. The results are sent to the farmer on his mobile.

c) E-Commerce platforms:

- **Agrostar** is the E-Commerce platform for purchase of Agri-inputs based on missed call service. It has also entered into a Phygital model wherein it is developing physical stores to aid in fulfilment.
- **Bighaat** is a pureplay e-Commerce platform coupled with advisory services. There are also other platforms as Farmkey, Ugaoo, Trustbasket, SeedsnPots,etc for floriculture and vegetable seeds.
- **Livestoc:** India's first Livestock app which enables sales of animals digitally and also provides for a one stop shop for all veterinary requirements.
- AquaConnect: is an ecommerce for aquaculture and fisheries.
- d) Farm Automation and Mechanization solutions: Labour scarcity and high costs towards farm labour are important challenges for many of the smallholder farmers in India. In certain crops, more than 50% of the cost of cultivations is spent towards labour cost. Further majority of farm size in India being less than 2ha, it is difficult for farm machinery to achieve scale unlike in developed countries. Digital solutions for scheduling farm machinery and automated operations through precision farming are innovations which can address the challenges related to farm mechanization.

- Krish-e is an initiative of Mahindra where Krish-e centres are established for providing the following services
 - Advisory services through demo plots
 - o Machinery Rental services
 - Digital services through app
 - Precision farming for spraying, inter-cultivation, harvesting, etc.
- **TAFE -JFarm services:** JFarm is a free of cost app which connects tractor owners and Custom Hiring Centres (CHCs) operated by tractors and equipment owners directly to farmers seeking farm mechanization solutions, thereby facilitating a fair and transparent rental process while focusing on quality, dependability and timely delivery.
- **EM3:** has developed Samadhan digital platform along with Samadhan kendras for providing farm mechanization services starting from land preparation, sowing and transplanting, inter-cultivation, harvesting and post-harvest management with timely market linkages and quality assurance services.
- **TartanSense** is a startup focusing on Artifical intelligence based machine weeding with a robot called as Bladerunner. The robot is equipped with cameras and recognizes weeds from the crop plant and thereby removes weeds in a precise manner.
- **HarvestCroo:** is a AI based spectral imaging robot designed for harvesting in fruits and vegetables.
- AgroPad: Al-powered technology helping farmers check soil and water health. AgroPad was developed by IBM, is a paper device about the size of a business card. The microfluidics chip inside the card performs on the spot a chemical analysis of the sample, providing results in less than 10 seconds. A drop of water or soil sample is placed on the AgroPad and the set of circles on the back of the card provide colorimetric test results; the color of each circle represents the amount of a particular chemical in the sample. Using a smartphone, the farmer can then take a single snapshot of the AgroPad by using a dedicated mobile application and immediately receive a chemical test result for a water or soil sample²⁸.
- **AgriRain:** is a startup which is providing Irrigtion as a Service (IaaS) through the Digital platform. It trains rural youth as Water entrepreneurs on irrigation scheduling as per critical stages of crop growth. Automatic notifications are sent to farmers who subscribe to the service and Water entrepreneurs provide the required amount of irrigation at the right stage of crop growth. The app collects weather, soil data and sends alerts on the quantity of irrigation , quantity of water saved and payments to the farmers.
- **FlyBird:** Precision irrigation scheduling not only saves water and electricity but also makes water available at critical growth stages of the crop. Flybird is a startup with a digital solution that automates irrigation, controls pump-sets, valves and fertigation tanks and reduces water usage by over 30 percent. FlyBird has prioritised the cost and application of its smart irrigation systems, ensuring that the solutions are cost-effective and practical for small farms. FlyBird products can be mapped with the drip irrigation and fertilisation systems.

²⁸

https://csd.columbia.edu/sites/default/files/content/docs/ICT%20India/Papers/ICT_India_Working_Pap er_35.pdf

3) Market linkage and Agri-output Supply chain effectiveness solutions:

Once the agricultural produce is harvested at the right time, the harvested produce need to be stored either for short term or long term, before it is sold in the market. The quality of the produce, the supply available in the market and sale of the product at the right place and time determine the right price for the product. Availability and access to agricultural infrastructure including rural roads, logistics, warehousing, cold-chains, electricity, transportation, fuel prices, market mechanism, Government policies on procurement, credit, etc., also determine the market effectiveness in realization of reasonable price for the farmer, all the value chain participants and the end consumer.

The achievement of market effectiveness of realizing best price by all participants in a perfect competitive market condition is an important challenge in agricultural markets of India. The following are the key business challenges addressed in this dimension through innovative digital technologies.

- 1) Lack of crop planning at a village or block level creates challenges of aggregation of produce of uniform quality in line with market requirements.
- 2) No incentive for farmers for growing plant varieties with marketable attributes required by consumer due to improper bulking in the value chain and no varietal identity in case of many crops.
- 3) High levels of information asymmetry at various levels of agri-value chain price differential between producer and consumer.
- 4) Multiple intermediaries and handling leading to higher prices to consumers
- 5) Unutilized and improperly managed inventory both in public and private sector leading to quality losses.
- 6) High post-harvest losses, especially in perishable commodities leading to high volatility in demand and supply.
- 7) Inadequate supply chain infrastructure, leading to post-harvest losses, improper handling of agri-produce and low price realization.
- 8) Sub-optimal aggregation potential due to smallholder agriculture and very fragile aggregation potential in farmer collectives such as FPOs.
- 9) Improper quality and traceability validation mechanisms, leading to lower price realization and value loss.
- 10) Weak enforcement and regulatory mechanisms both in government and private sector.
- 11) Inadequate local processing power which can help reduce transaction costs and also generate local employment
- 12) Poor market linkages bidirectionally, wherein processors lose
- 13) Absence of timely credit facilitation for various market participants
- 14) Need for reform at various stages of agri-supply chain for improving process efficiencies.

Market linkages and Post-harvest management- Innovations and interventions: Over the past-two decades, Indian agriculture is transitioning from cereal centred production system ot high-value fruits and vegetable production systems²⁹. The shift in value addition of cereals is moving towards conversion into animal feeds, given the changes in dietary patterns of the country. There is also a significant shift towards Ready To Cook (RTC) and a Ready To Eat (RTE) foods in urban areas. Within this overall context, comprehensive infrastructure for post harvest management of perishable commodities such as fruits and vegetables, dairy products, fish, meat, etc., need to be developed through value addition and providing quality products with longer shelf-life.

²⁹ <u>https://www.epw.in/journal/2020/16/commentary/post-harvest-management-and-farm-</u> outcomes.html

An assessment of crop losses conducted by the Indian Council of Agricultural Research in 2016 revealed that about 3.9% to 6% cereals, 4.3% to 6.1% pulses, 2.8% to 10.1% oilseeds, 5.8% to 18.1% fruits, and 6.9% to 13% vegetables were lost during harvesting, post-harvesting activities, handling and storage³⁰. As per the estimates of the Committee on Doubling Farmers' Income (2019), at the all-India level, farmers are unable to sell about 40% of the total fruits and vegetables produced in the market or lose around `Rs 63,000 crore (Approximately USD 10 bn) every year for not being able to sell their produce for which they have already made investments³¹.

Business process mechanisms and digital interventions for reducing post-harvest losses shall directly add value and unlock huge potential of Indian Agricultural economy. The key mechanisms for post-harvest management are as follows.

- a) Crop planning based on quality specifications through farming contracts for year-round scheduling of supplies of perishable commodities
- **b)** Vertical and precision farming systems including hydroponics based farms for scheduling the
- c) Staggered cultivation and prolonging the shelf-life of agricultural produce on the farm itself thereby scheduling harvesting as per market requirement. This entails development of plant varieties and agronomic practices which can provide for multiple pickings of fruits and vegetables and scheduling the harvest at an appropriate time and quality in line with offtake by the markets, both domestic and international.
- d) Development on on-farm storage infrastructure including low cost cooling chambers and cold chains for short term storage to develop supply regulation.
- e) Developing local processing clusters for transformation of agricultural commodity from perishable value-added form to forms with longer shelf-life including primary, secondary and tertiary processing.
- f) Access to price hedging, storage and supply mechanisms for post-harvest losses.
- **g)** Uitlization of non-renewable energy and digital innovations for prolonging the shelf life of perishable commodities

Digital interventions and innovations centred around the below models or similar models shall pave way for design of better solutions for reduction of post-harvest losses. Digital innovations at each stage of post-harvest process flow till it reaches the consumer in the form of a product are as follows.

- Digital platform for pre-harvest, harvest and post-harvest crop scheduling mechanism linked with crop revenue and profits management
- Digital inventory management systems including pre-emptive loss-saving vaults and transformation into value added products
- Cold chain management systems linked to processing and manufacturing systems
- Traceability and quality linked transaction systems enabled on blockchain.

A few initiatives which have focused on post-harvest management are depicted below³². The frameworks from the Intellecap report³³ on post-harvest losses are reproduced below to showcase various strategies for post-harvest management. The market linkages which bring together convergence between price parity, time of sales, compliance to quality specifications

³⁰ Jha, S, R Vishwakarma, T Ahmad and A Rai (2016): "Assessment of Quantitative Harvest and Post-Harvest Losses of Major Crops/Commodities in India," ICAR.

³¹ <u>https://www.downtoearth.org.in/news/agriculture/poor-post-harvest-storage-transportation-facilities-to-cost-farmers-dearly-61047</u>.

³² <u>http://intellecap.com/wp-content/themes/intellecap/pdf/Public-Facing-Report.pdf</u>

and access to market information, infrastructure, warehousing and logistics is also tightly linked to the post-harvest management.

	Post-harvest Value Chain				
Phases	Harvesting & Primary Processing	Storage & Crop Protection	Processing	Market Linkage	
Key Activities	 Harvesting Drying Grading Sorting Produce aggregation Loading Transporting 	 Pre-cooling Packaging Ripening Cold storage Warehousing Quality control assessment 	 Grading Sorting Secondary Processing 	 Packaging Branding Transporting Market information Wholesale market Retail market 	
Drivers of PHL	Improper harvesting leads to crop losses during and post-harvest. Lack of primary processing soon after harvesting adversely affects shelf-life and increases PHL.	Currently, there is a huge gap in infrastructure at the farm gate especially for cold storage and pack-houses. Poor storage and crop protection facilities contribute to significant spoilage and crop loss.	The huge gap in food processing significantly limits value addition. In India only 2% of the total F&Vs produced are processed currently. Inadequate processing capabilities, particularly near farm contributes significantly to PHL.	Lack of market information and linkages both contribute to PHL. Lack of information on prices and demand leads farmers to often make uninformed choices and distress sales. Farmers are not able to access the optimal price for their product within current markets.	

Digital interventions at various stages of post-harvest management³⁴



^{34 34} http://intellecap.com/wp-content/themes/intellecap/pdf/Public-Facing-Report.pdf

This section shall describe the innovative digital technology interventions in post-harvest and Agri-output supply chains. This dimension has the largest potential in terms of revenue, followed by Agri-finance. Given below is information on the various players in this dimension.³⁵

Sno	Business process Challenge	Innovative Solution	Players
1	Market linkages to FPOs and Farmers	Linkages established on a sustainable basis through digital platforms	Bijak Samunnati ENAM
2	Testing of quality and enabling traceability	AI and IoT based devices for assessment of Quality at the source	AgNExt SourceTrace Stellaps O4S
3	Reduction of Agri-value chain steps by improving processes	Phygital models for reducing transaction costs and number of intermediaries thereby directly connecting the producer and processor	DeHaat AryaCollateral NBHC KissanDhan-Sohanlal
4	Management of Post- harvest losses	Digital platforms for inventory tracking, quality monitoring and sales closure	Ninjakart Crofarm
5	Market pricing information and market intelligence	Market information/ intelligence and bidding platforms for enabling sales of produce	eNAM platform

1) Market Linkages:

• **eNAM trading platform:** e-NAM (e-National Agriculture Market) has been developed as a Pan India electronic trading portal to provide market access to both producers and consumers. It is a digital platform designed with an objective to create a national network of virtual agricultural market that can be accessed online with a physical market (mandi) at the back end.

It seeks to leverage physical infrastructures of mandis through online trading portal enabling buyers (even outside the State) to participate in trading at the local level³⁶. The following are objectives of eNAM³⁷.

- A national e-market platform for transparent sale transactions and price discovery initially in regulated markets.
- Liberal licensing of traders / buyers and commission agents by State authorities without any pre-condition of physical presence or possession of shop /premises in the market yard.

³⁵ <u>https://www.dai.com/uploads/Rapid%20Analysis_External%20FRMT2.pdf</u>

³⁶ <u>https://nceg.gov.in/sites/default/files/eNam.pdf</u>

³⁷ https://darpg.gov.in/sites/default/files/eNAM%20Best%20Practices.pdf

- One license for a trader valid across all markets in the State. 4. Harmonisation of quality standards of agricultural produce and provision for assaying (quality testing) infrastructure in every market to enable informed bidding by buyers.
- Common tradable parameters have so far been developed for 125 commodities.
- Single point levy of market fees, i.e. on the first wholesale purchase from the farmer.
- Provision of Soil Testing Laboratories in/ or near the selected mandi to facilitate visiting farmers to access this facility in the mandi itself.
- States which are willing to bring about marketing reforms for implementation of eNAM can accordingly enact suitable provisions in their APMC Act for promotion of e trading by their State Agricultural Marketing Board/APMC. The eNAM process flow is depicted below.

Over 1000+ APMC mandis, which is 14% of total Mandi's in India have joined the eNAM trading platform. The state of Rajasthan has highest number of 144 mandis onboarded on eNAM, followed by Uttar Pradesh, which has 125 mandis within the eNAM system. The state of Odisha has 41 mandi's onboarded on eNAM platform. Out of 1000 onboarded mandis,296 mandis are actively trading on eNAM. ³⁸ The basic features of eNAM platform which have improved operational efficiencies in marketing process are as follows.



³⁸ <u>https://www.enam.gov.in/web/</u>

- Notifying and trading commodities on e-NAM
- Increasing the participation of traders on e-NAM and thereby increasing the quantity and value of commodities being traded on e-NAM
- Increasing the numbers of bids quoted by traders
- Promoting cashless transactions, e.g. online payments, to Farmers
- Promoting inter-market trade between Mandis
- Providing access of Soil Testing Laboratories to farmers
- Conducting awareness and farmer orientation programmes
- Providing basic amenities and facilities for cleaning, sorting and
- packing to farmers in the Mandi
- Making logistics and infrastructure available to promote intermarket trade on e-NAM platform
- Display of rates quoted on screens as a measure of transparency
- Generation of sale agreement signed by all stakeholders i.e. namely the seller (farmer), commission agent and the trader with the highest bid after completion of sales process.
- Registration of transport companies on the portal along with rates for ensuring transparency.
- Unified bidding in notified mandis
- Linkages with other Government schemes for farmers including Soil Health card scheme, Solar photovoltaic pumps scheme, Seed village schemes, National food security mission, etc.
- **ReMSL:** Similar to eNAM platform, the Government of Karnataka state has as part of market reforms in collaboration with NCDEX (National Commodities and Derivatives Exchange) has established a joint venture company called Rashtriya e Market Services Private Limited (ReMS) in 2014 as a PPP initiative³⁹.



³⁹ <u>http://www.remsl.in/about-us/milestone</u>

REMSL platform has been designed based on the principle of One State, One market and through a Unified Market Platform (UMP) system which provides for Trading platform, Material accounting, trade fulfilment, fund management and document management systems. It also provides for unified license for traders, electronic auction platform, online payments, quality assaying, e-permits provision at any time and a separate facility for Farmer Producer Organizations (FPOs) for sales of aggregated produce on the platform. The REMSL process flow is depicted below.

The ReMs system is also part of the overall eNAM market, however independently developed by the State of Karnataka. It is a best practice for other states to emulate within the eNAM system as a unified marketing platform, which brings together digital tender/bidding system for agricultural produce across different mandis in combination with quality assaying, physical inspection and payment and accounting systems for trade fulfilment⁴⁰.

Currently REMSL provides a platform for 162 markets in the State, 44000 traders and access to 66 FPOs through its UMP. In future is it planning to develop integrated logistics and warehouse-based sales mechanisms along with quality assay systems and analytics for further streamlining the system.

- **Bijak:** is a agri-commodity trading platform enabled in 27 states for 110 commoditites aimed at bringing transparency to agri-value chain through buyer-seller rating system. Bijak has developed a large network of Buyers and Sellers and provides book keeping and working capital facilitation. It also enables smooth payment settlements, alerts and reminders along with Buyer/Seller rating system.
- **Farmart:** is India's first Saas platform for food distribution wherein it connects 20000 retailers with 1 million farmers in 15 states thereby enabling supply chain disintermediation. Farmart's focus is on retailers and merchants who are in B2C or B2B and aims to develop direct linkages or compress the agri-value chain by connecting them with the producers.
- **Samunnati:** Samunnati Financial intermediation services is a non-banking finance company focused on lending to FPOs and collectives. It generates market linkages between FPOs and various market operators, in addition to providing working capital loans to FPOs and Agri-enterprises. Samunnati also works as a commodity trading company and provides Structured distributor finance and receivable finance. The FPO database and digital platform developed by Samunnati enables ranking of FPOs and agri-enterprises for providing working capital and financial support.

2) Quality assessment devices:

 AgNext: AgNext has developed the Qualix platform for digitizing food quality assessment across value chains. Agnext works on principles of Artifical intelligence and optical sensors, thereby providing instant on-field quality assessment in food grains, pulses, oilseeds, spices,tea, milk and animal feed, which enables immediate decision making and traceability. Other Apps in this area are SourceTrace, which is a SaaS based quality assessment and supply chain management application and TracX,

⁴⁰ <u>http://www.remsl.in/images/LatestUpdate/capam-report.pdf</u>

3) F&V supply chain:

- **NinjaKart:** primarily works with Fruits and Vegetable supply chain and manages heavy volumes through a digital platform, which is based on the harvesting calendar of nearly 7000 registered growers. The demand is forecasted based on well-defined algorithms and historical trends. The supply and demand are matched based and the deliveries are scheduled in line with the market requirements. The crates are RFID tagged and are sealed which can be broken after the OTP is confirmed at the retailer end. Ninjakart also has a farmer App for farmer engagement, a logistics routing algorithm and RFID based traceability system.
- **WayCool** works both in F&V and non-perishable commodity space and has developed a Soil to Sale Phygital supply chain model. The model has three tech suites, MyFarm for farm management, Rapid for Phygital supply chain for traceability and Garuda for demand forecasing, order and distribution management. It is also developing Pragati, direct cash and carry retail service⁴¹.
- 4) The interventions made by large private sector companies through use of digital innovations is presented below as reproduced from the Government of India publication⁴².

Organisation	Context	Solution	Impact
Hindustan Unilever	 Hindustan Unilever uses real-time point-of-sale data to improve sales and operations planning processes 	 Captures data using hand-held-terminal platform called Unify along with bar codes on products Uses advanced statistical tools and models to get a robust baseline number Cloud-based data collaboration tool to make data easily available to planners Shorten planning cycle significantly, replenish inventory based on real-time market signals Already being implemented in Mumbai, Dalhi Basediaco and Chappai 	 14% reduction in inventory Service improvement by 200 basis points during the pilot
	 Adopts a micro- segmentation approach at the customer level to manage demand and supply 	 Enables market-based customised offerings at optimal supply chain cost Sustains higher service levels with higher complexity Accelerates speed to market with faster response times Leaner tail means less waste and non- value-adding complexity 	 Improved service by 300 basis points over two years Reduced inventory by 16% across supply chain Reduced volume of slow and obsolete inventory by 20%
Amazon	 Amazon has established 62 fulfilment centres across 13 states, serving micro, small, and medium-sized retailers, wholesalers, and manufacturers 	 Amazon Seller Services platform offers participating sellers the option to manage inventory online Platform uses big data analytics to forecast demand 	 Over 300,000 sellers manage their inventory online directly, making it cost effective Higher customer satisfaction through faster delivery and reliable transit times

Big data is helping corporations to better manage complex supply chains

⁴¹ <u>https://medium.com/waycool-foods/the-phy-gital-supply-chain-with-waycool-labs-1d06c3a32cf</u>

⁴² <u>https://www.meity.gov.in/writereaddata/files/india_trillion-dollar_digital_opportunity.pdf</u>

- 5) Dairy supply chains: India is the largest producer of milk in the world and yet faces numerous problems across the Dairy supply chains right from productivity of cattle to availability of quality feed, monitoring of collection and cold chain infrastructure to individual animal health management. Stellaps, an ICT startup which specializes in Dairy sector has developed holistic digital solutions for digitizing the Dairy value chain.Key components of Stellaps Digital platform are as follows.
 - a. Automatic milk collection unit management for monitoring productivity of individual cattle and also for the entire Dairy farms
 - b. IoT based real-time management of cold chains
 - c. IoT based animal health management and herd management devices for constant monitoring of micro-level operations and building supply chain visibility and traceability for precision interventions.
 - d. Linkages to financial solutions, credit, insurance for Cattle farmers
- 6) Micro-Cold stores: Access to cold chains in India and the requirement of scale economies to operate them at fullest capacity utilization has been a challenge faced for a long time. Both large scale cold storages and reefer trucks/refrigerated transport need threshold volumes to operate and are also costly to maintain. Tango Thermals is a startup which has developed 50 litre capacity micro cold storage boxes for storage and transportation of perishables. The boxes are cooled using thermal batteries, which require shorter charging time to provide the same level of cooling and performance that an ice pack provides after 12-15 hours of charging. Shorter charging time implies faster turn-around and lower operational costs. Such micro devices align with smallholder farm contexts and can be further standardized to meet the needs of Indian market⁴³.
- 7) Solar power and AI based farm solutions: Ecozen is a startup which is developing a AI based digital platform for connecting farmers and markets especially to tackle the issue of perishable agricultural product value chains. The solution provides for a solar powered cold storage room called as Ecofrost along with an App which provides for real-time produce quality information generated through IoT devices. The solutions provides for product quality assurance for perishable products like fruits and vegetables.Ecozen also has a solution for irrigation scheduling for conservation of water and electricity.
- 8) **TraceX:** Indian agriculture has a long way to go in terms of standardization of demand driven crop planning and agricultural production aligned to market demand and requirements. In a supply driven agricultural economy there are huge post harvest losses and challenges related to quality and traceability.

TraceX is an agri-startup which offers a BLOCKCHAIN based technology which enables multiple participants across the supply chain to securely exchange data via a digital ledger. The technology ensures the data is secure, verified and protected from unauthorized modification.

Supply chain participants in the pre-harvest lifecycle use multi-lingual mobile application to track the produce from sowing until harvesting and participants in the post-harvest lifecycle use web-based application to further track and trace journey of the produce/product.

Eventually the entire journey of the agri commodity can be traced and verified by the supply chain network via a permissioned BLOCKCHAIN using a simple QR code. FOODPRINT is offered as a SaaS solution for agri and agri allied business. he platform

⁴³ <u>https://fedev.org/wp-content/uploads/2020/03/AI-TIA%20Report%20V7.pdf</u>

captures information from farmer, field, crop, activities, use of seeds, fertilisers and other agricultural inputs to link it all the way to customers.

Leveraging a permissioned blockchain, participants in the supply chain can share information that enables trusted transactions (inputs, insurance, finance etc). FOODPRINTTM organizes the supply chain and enables a better Customer demand forecasting with the FPOs in advance, thus resulting in reduced wastage and income visibility for partner FPOs. It empowers agri and products also have a QR code on the packaging, thus empowering customers to trace the entire journey of the products from farm to the logistics centre⁴⁴.



- 9) E-Choupal: ITC's e-Choupal model is among the first digital inventions in the country for disintermediation and re-intermediation of agri-value chains. The unique e-Choupal model creates a significant two-way multi-dimensional channel which can efficiently carry products and services into and out of rural India, while recovering the associated costs through agri-sourcing led efficiencies. This initiative now comprises about 6100 installations covering over 35000 villages and serving over 4 million farmers. Currently, the 'e-Choupal' website provides information to farmers across the 10 States of Madhya Pradesh, Haryana, Uttarakhand, Uttar Pradesh, Rajasthan, Karnataka, Kerala, Maharashtra, Andhra Pradesh and Tamil Nadu. Starting with internet kiosks at village level providing farm advisory and market information, e-Choupal has today evolved further into a phygital model including demonstration farms, farm management software and building traceability across the supply chain.
- 10) **Apple Value chain:** Fruit master Agro private limited is engaged in apple production, processing and trading. SourceTrace has implemented a digital platform with blockchain capabilities for Fruitmaster to establish traceability and digitization of transactions which has led to significant increase in income and improvement in quality

⁴⁴ https://fedev.org/wp-content/uploads/2020/03/AI-TIA%20Report%20V7.pdf

and optimizing supply chian and inventory management. The software helps in Complete visibility of produce from farm to consumer for various value chains such as fresh produce, apple, organic cotton, aquaculture, cocoa and coffee. It also standardizes Digital procurement transactions with lot numbers to help trace the origin of produce to farm level. It enables maintenance of Batch / lot numbers and keeps track of origin information such as farmer location, date of harvest, packing and transport info into scannable bar codes and QR labels. Supports GS1 and other standards. The digital innovations not only reduce post harvest losses, but also manage inventory scheduling for placement in the market for obtaining remunerative prices.

11) **Organic Cotton value chain:** Chetna Organic Agricultural producer company formed with tribal farmers is a leading organic cotton supplier in the country. For traceability management of manual paper-based systems were not sufficient to track the field level information. Non-availability of real-time information was a problem for the management to take decisions and provide the support required to the farmers.

By deploying SourceTrace's digital solution, Chetna organics was able to achieve transparency in their production as well as show traceability of the source of cotton to its buyers. Individual farmer data is linked by ID number to cooperative sales data collected on SourceTrace's platform and attached to raw cotton truckload deliveries to the Chetna's gins. Ginning is completed in small batches, resulting in sequential bale numbers that can be traced to approximately seven concurrent truckloads of raw cotton. Bales are given lot numbers and loaded into trucks for delivery to spinners, each containing approximately 100 bales. Each bale is linked to a lot number and the lots are linked directly to 100 percent real farmer data growing the organic cotton. SourceTrace application enhances Chetna's transparency in production, procurement, and flow of goods throughout the value chain.

12) Farmer producer organizations (FPOs): Farmer and rural collectives have been existing in the agri-landscape for many decades. The Cooperative movement started in 1930s firmly established itself in 1960s and 1970s through the success in Dairy, Credit and other commodity cooperatives. Similarly Self-Help Groups (SHG), Community Managed Resource Centres (CMRCs) and Cluster Level Federations (CLFs), have all been established with specific objectives including promoting rural enterprises, livelihood generation, promoting thrift and investment and other social and economic objectives.

The Government of India promoted Farmer producer organizations (FPOs) for collectivization of farmers to successfully realize the power of aggregation as an independent enterprise. The FPO can be a legal entity of any form such as a company or society or cooperative. FPOs are being promoted by NABARD, SFAC, State Governments or other Civil society organizations. The Resource Institutions (RIs), Producer Organization Promoting Institutions (POPIs) and Cluster based business organizations (CBBOs) help in formation of FPOs and handhold them towards commercial transformation with respect to successful aggregation and business function of FPOs leading to regular sale of agri-commodities, collective procurement of agri-inputs and undertaking investment activities in processing, marketing, etc. Nearly 10000+ FPOs exist in India today along with several cooperative societies which are also being considered to function in the FPO model⁴⁵.

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https://ncdex.com/downloads/fpo/casestudy/Success%20Stories%20of%20FPOs_Aug%202020_com pressed.pdf

Many of the FPOs have successfully implemented innovations including use of digital technologies in collaboration with market players. Some of the success stories are presented below.

- Sahyadri Farms is India's largest FPO started in 2010. Today it has a revenue of Rs 535 Crores⁴⁶ and actively deals with fruits, vegetables, and flowers It is the largest exporter of grapes to Europe and has developed its own fresh fruit juice brand called "Juice Farm". Sahyadri farms also deals with processed foods such as IQF vegetables, purees and pulp, packaged foods and agri-inputs. It provides advisory services to its 800+farmers through Kisan hub application, which provides monitoring of production operations, quality monitoring, analytics dashboards and Rol calculators. Sahyadri has also conducted a blockchain pilot to establish traceability function across all its transactions.
- eFresh Global is an Agri-input supplier which is exclusively functioning for servicing FPOs and farmer collectives. As a part of its digital initiatives it has developed e-Merchant platform for FPOs and an integrated digital platform which functions as content and document management system for FPOs including FPO compliances. eFresh global is also developing capacities of FPOs to function as Agri-input retailers and has digitally connected FPOs in its network for inventory management of Agri-inputs⁴⁷.
- Kanchi is a web & mobile based platform used to manage agri-business operations
 of farmer collectives such as selling inputs to farmers, leasing farm equipment,
 produce aggregation and selling it in wholesale or retail. It also captures financial
 transactions of FPOs and farmers generating a financial profile of farmers. It is
 developed by the Centre for Digital Financial Inclusion (CDFI) and is actively
 piloting Kanchi as an exclusive digital platform for FPOs. It has seven modules
 which enable optimization of operational costs for FPO run shops, maintain
 transaction history, develop Agri-input centres along with micro-retail/kirana stores
 and also function as banking correspondent for providing financial services.
 The different modules of Kanchi FPO digital platform are provided below.



⁴⁶ <u>https://www.sahyadrifarms.com/docs/Annual%20Report%202020-21.pdf</u>

⁴⁷ <u>https://www.efreshglobal.com/digital-transformation/</u>

- The Unversity of Hyderabad in collaboration with SEEDS FPO Tamilnadu, implemented a blockchain pilot for The blockchain project aimed to bring the entire agri ecosystem, from farmers to financing on to a single platform, thereby simplifying the exchange of information by reducing the level of information asymmetry and easing the manner of transaction. This platform will increase the transparency for all the stakeholders involved and facilitate the collection of reliable data by recording every step in a product's value chain⁴⁸.
- Cropin, the leading digital startup in India is developing centralised platform for FPOs to create and maintain a complete digital database of farmers along with land and crop profile digitisation, and accounting of financial transactions within the FPOs. It is facilitating FPOs to configure expert-recommended advisory services including agronomy services, post harvest management, market linkages and financial services for practice of climate-smart and sustainable agriculture.



- 13) **Blockchain models:** Application of Blockchain technologies in Agriculture is an attractive proposition especially for supply chain optimization and developing transparent transactions on a foundation of traceability across the value chain. The Government of India is working on projects to establish block chain based traceability models in food and seeds. Further startups like Whrll, SourceTrace, TracX,etc., are working on various models to develop block chain based transactions which are relevant in agribusiness. Globally blockchain startups in agriculture are increasing by a rapid pace in the areas of traceability, crop insurance, supply chain optimization and transactions. The key applications are provided below.
 - a. Optimization of the Food Supply Chain Reducing the time of food origin tracing to a matter of seconds ensuring safety and improving efficiency.
 - b. Crop Insurance Communicates loads, geo way-points and basic compliance information with carriers and registers the quality of the product, its price, location, and parties involved.

⁴⁸ <u>https://herald.uohyd.ac.in/university-of-hyderabad-samunnati-seeds-and-synchrony-support-integrated-agri-blockchain/</u>

- c. Transaction Helps farmers to sell commodities at fair prices and lowering transaction fees thereby supporting smaller farmers to enter the market.
- d. Traceability Smart contracts insure a farmer's crops and claim damages thus replacing old and burdensome insurance processes, which could take up to months⁴⁹.

An illustration of key areas of blockchain applications is provided below as per the infographic reproduced from the cited reference.



⁴⁹ https://www.startus-insights.com/innovators-guide/8-blockchain-startups-disrupting-the-agricultural-industry/

5. Baseline assessment in Technology innovations in Agri value chains

a) Rajasthan:

Rajasthan is India's largest state covering 10.5% of the area. Bajra,Cotton, Soybean, Garlic, minor millets, Maize, Pulses and vegetables are important Kharif crops, whereas Wheat,Mustard,Gram,Coriander, Guar, and Vegetables are important Rabi crops. Rajasthan is considered among the leading states with respect to digital readiness. Rajasthan has the i 40 million of internet users which is among the top 10 States of India.⁵⁰ The state has embarked on the following ICT initiatives for service deliver to its citizens and farmers ⁵¹,

- i) The State is a leader in trading on the eNAM digital national platform with around 38000 licensed traders. Rajasthan is the first state to convert single trading license into unified license to promote digital transactions of farm produce⁵².All the Mandis in the State have also been equipped with digital infrastructure such as touchscreen kiosks, digital dashboards, IT infrastructure and connectivity.
- j) The State Government's flagship schemes, the Bhamashah Yojana which provides over 250 G2C and B2C services which created a foundation for Digital infrastructure. The state has developed an integrated digital platform connecting various Departments and has also initiated an incubator for Startups⁵³.
- k) The State also has the largest number of eMitra Kiosks or Common Service Centres (45000+), which account to 17% of the total CSCs in the country⁵⁴.
- I) The State has also pioneered in land record registration through e-Dharti portal and Apna Khata land property record systems.
- m) The Raj-KisanSaathi portal provides both services and information to farmers and Agribusinesses. Services related to development of farm infrastructure, irrigation equipment subsidies,Farm machinery ,Shadenets, Polyhouses, Plastic mulches and registration for seed production are provided in the portal⁵⁵.
- Agri-input company has established Bayer Better Life Farming (BLF) Centres in States of UP,Rajasthan,Odisha,etc., and is providing Agri-inputs, product demonstrations and financial solutions to the farmers. Bayer has also tied up with Axis Bank to provide credit to FPOs and smallholder farmers through the BLF centres.
- o) The Rajasthan Agricultural Competitiveness project, a World bank funded project has also enabled in development of physical infrastructure in market

⁵⁰ <u>https://regions.regionalstudies.org/ezine/article/digitisation-in-india/?doi=10.1080/13673882.2021.00001100</u>

⁵¹ https://ficci.in/spdocument/23117/Digital-Rajasthan-Embracing-Change.pdf

⁵² <u>https://government.economictimes.indiatimes.com/news/digital-india/rajasthan-emerges-leader-in-trading-at-enam-state-govt/85448724</u>

⁵³ <u>https://icea.org.in/wp-content/uploads/2020/07/Contribution-of-Smartphones-to-Digital-Governance-in-India-09072020.pdf</u>

⁵⁴ <u>https://www.meity.gov.in/writereaddata/files/india_trillion-dollar_digital_opportunity.pdf</u>

⁵⁵ <u>https://rajkisan.rajasthan.gov.in/</u>

development in the State which has given a fillip for laying foundation for digital infrastructure.

- p) In line with the digital readiness of the State, several Agritech startups with innovative digital technology models are operating in the State. Some of the startups originating from the state of Rajasthan are given below.
 - a) ApnaGodam- Online warehousing platform connecting traders, farmers and warehouses along with quality infrastructure.
 - b) FarmKey- Online agri-input platform for farmers
 - c) Geomatics lab- GIS and Geo-spatial solutions based climate advisory and risk management system
 - d) Meri Dairy- Dairy management software for milk collection centres
 - e) Seeds N Pots- A portal for seeds, floriculture and gardening tools
 - f) Balwan- A portal for farm advisory services
 - g) Freshokartz:Online distributor of fruits and vegetables
 - h) Nebulaas Matt: Crop produce quality assessment system
 - i) Veggies Greenhouse: B2B platform for fruits and vegetables
 - j) Agrisale: Agri trading and bidding platform
 - k) EM3 services has established 1200 Samadhan centres for enabling farm mechanization.

b) Odisha :

Odisha is one of the fastest growing states in India, even though it is considered backward in terms of developmental indicators. Rice, Vegetables, Jute, Oilseeds, Coconut and pulses are important agricultural crops. Odisha is also on the southern side of digital divide with only 5.9% of the population having access to computing power and only 85% of people with access to mobile phones which is less than national average of 91%. As per a sample study on the use of ICTs in Odisha⁵⁶ majority of the respondents identified their source of information as TV and Radio, followed by Mobile phones.

The Government of Odisha is working on several initiatives to promote use of ICTs in agriculture for improvement of productivity and profitability of farmers. The Government has launched MoSarkar platform as public service delivery system for its citizens. Among initiatives in Agriculture⁵⁷,

a) The Government of Odisha has implemented the KALIA scheme, which is a Direct Income Support (DIS) scheme to 5 million farmers. This scheme is considered as a best practice in the country along with RYTHUBANDHU scheme of Telangana State. Extensive use of digital platform by innovative use of ICTs for hree-step framework, called "Unification-Verification-Exclusion", to identify beneficiaries, has been enabled through this scheme. The first step involved unifying state databases to eliminate lists of farmers who planed to opt out of the scheme. The second step involved verification of 12 million applicants through integrated database search system including various Departmental databases such as the Socio-Economic Caste Census, National Food Security Act and other databases; de-duplication through Aadhaar; and bank account verification through bank databases. The third step involved excluding ineligible applicants like government employees, taxpayers, large farmers, and those that voluntarily opted out⁵⁸. The use of technology and non-farm databases also meant that

⁵⁶ https://www.journalajaees.com/index.php/AJAEES/article/view/30349/56945

⁵⁷ <u>http://www.businessworld.in/article/Odisha-Bridging-Digital-Divide-with-Tech-Enablement/13-08-</u> 2020-308142/

⁵⁸ <u>https://opendigitalecosystems.net/blogs/lessons-in-direct-income-support-from-odisha/</u>

KALIA could include sharecroppers, tenant and landless farmers as beneficiaries, which is a significant step towards inclusive agricultural policymaking.

- b) Precison Agriculture for Development (PxD) in collaboration with Agrcultural Department Government of Odisha is advising on the design and roll out of a service for Rice farmers across the state of Odisha with ambitions of reaching 1 million farmers.
- c) The Government is aiming at use of Blockchain for paddy procurement to develop tamperproof transaction records between farmers and millers.
- d) Several pilots are in progress in various districts on innovative digital technologies in Agriculture. In Sundergarh district, ICRISAT is working with District Mineral foundation for implementation of agri monitored re-engineering transformation (AMRT) system, which integrates remote sensing, artificial intelligence and machine learning, the internet of things, big data and drone technologies as a technology convergence platform to be implemented through FPOs.
- e) The Digital Green project in Odisha supported by international funding agencies involves: (a) participatory identification and co-development of local content for improvement of agricultural practices; (b) group discussion that uses videos as a basis for mediated instruction, where a mediator encourages the audience to discuss the video content; and c) follow-up home visits to support and monitor the adoption of the practices or behaviors being promoted through the videos. The Digital green initiative has been very useful for not only improvement of efficiencies in Agriculture, but also for social and public health issues.
- f) Under The Bill and Melinda Gates Foundation funded project, a web and mobile based platform KANCHIhas been provided to Access Development Services (ADS) to collectivize 16,000 maize farmers into FPOs, digitize their operations using KANCHI and sell their produce.



Two FPOs formed across Raigarh & Umerkote blocks in Nabarangpur district. Details of 9,386 farmers has been captured. The produce aggregation module of the app

allows for collection of procurement information from the farmer.Each bag of maize has a barcode that is scanned and stored in the database.

- g) Agri Startups like DeHaat, AquaConnect, Samunnati, etc., are expanding in Odisha working with FPOs for working capital loans and market linkages.
- h) A few startups like FarmEx-eKutir are working on precision agriculture-based pilots in Odisha with an objective to improve farmer productivity and profitability. Similarly Villamart is working on F&V and commodity supply chain to build operational efficiencies.
- i) The state government has announced provision of free smartphones to 6 lakh selfhelp groups under Mission Shakti programme.

c) Uttar Pradesh

Uttar Pradesh is most populated state in India and is the largest producer of food grains in the country. It is the largest producer of Wheat, Sugarcane and Milk and second largest producer of Rice. The state has 40 millions of rural internet users which is the highest and among the fastest growing in India⁵⁹. The following are the digital initiatives undertaken by Uttar Pradesh as a part of improvement of productivity and profitability in agriculture.

- Direct Benefit Transfer (DBT) scheme is the most successful scheme with respect directly transferring subsidy benefit to farmers with respect to agri-inputs and other agriculture related schemes. The integrated use of databases for identification and deduplication of beneficiaries for enabling transactions has been standardized and Uttar Pradesh presently disburses the largest amount of subsidies to farmers in the country.
- The Government of UP, is developing farmer databases for building a digital ecosystem in the next few years for improvement in service delivery to farmers in terms of welfare schemes of the government, personalized services to farmers such as soil and plant health advisories, real-time weather advisories, irrigation facilities, seeds, fertilisers and pesticide related information, logistic facilities and market access information and also to provide technical information for overall improvement of farm productivity.
- Uttar Pradesh Government launched the UP FPO Shakti Portal as part of the Kisan Kalyan Mission. The portal, the first of its kind in the country, has been developed by the department of agriculture with the support of the Bill and Melinda Gates Foundation (BMGF) and is aimed at benefitting the farmers at the grassroots level. It will bring farmers, producer groups, traders and the department of agriculture and other allied departments of the state government on one platform. The portal connects 733 FPOs and 2.16 lakh farmers for providing information on market access, schemes, agri-input supply, advisory services and pricing. The UP government initiative of creating a portal www.upfposhakti.com is first of its kind in the country.
- The MANDI (Market Access enabled through Digital Innovation) project being implemented in the Purvanchal region of Uttar Pradesh aims to strengthen capacity of the farmer producer organization (FPO) to connect smallholder farmers, especially women, to markets and finance and to improve farmers' incomes and resilience. Around 12,000 people would benefit from at least one service being offered under the program, with 10,000 of these being members of FPOs and 2000 members of selfhelp groups (SHGs) and their spouses who are not FPO members. The FPO members, of whom 40 percent are women, are likely to benefit directly under the capacity building program directed at the FPOs, while all 12,000 people would benefit from the improved household gender dynamics that would enable participation of more women in the

⁵⁹ https://www.thenewleam.com/2021/05/rural-internet-connectivity-in-india-gaps-and-challenges/

agriculture sector. The program is being implemented in 10 districts of eastern Uttar Pradesh⁶⁰ with a focus on digital financial inclusion and skill development.

- The Centre for Digital financial inclusion through its Kanchi App⁶¹, has digitized 5 FPOs with 2,700 + farmers onboarded for capturing farmer info rmation through a mobile app Mobile app enables FPO users capture information such as basic profile, land details, bank details, Sowing information etc.
- EM3 startup operates sugarcane operations in 5 lakh acres for farm mechanization using its Samadhan digital platform near Shahjahanpur district of Uttar Pradesh
- Jagriti foundation and Zoho have collaborated for development of Digital Centre for Excellence at Deoria in Uttar Pradesh for digital inclusion of 3500 Small and medium enterprises and 20000 companies in 15 districts of Purvanchal region of Uttar Pradesh for particularly building digital transformation in Agri enterprises, women led enterprises, healthcare and handicrafts.
- Many of the Agri-input companies such as Bayer, Corteva, Syngenta, Yara, Rasi, etc., have developed farmer engagement apps and also agri-input retailer apps which are functional across Uttar Pradesh. These apps not only provide product information, but also enable farmer and channel engagement.
- Almost all the Agritech startups such as DeHaat, WayCool, Unnati,Fasal, Bijak, etc., are functioning in Uttar Pradesh.

⁶⁰ <u>https://grameenfoundation.in/?page_id=1284</u>

⁶¹ <u>https://www.meity.gov.in/writereaddata/files/75-DI-Success-Stories.pdf</u>

6. Policy & Digital Architecture framework for Agri-value chains in India

Digital systems being implemented, either as small incremental innovations or disruptive system-wide changes need to be viewed through a holistic perspective. Overall, the common thread across any of the digital systems is conformity to standards and falling into an overall public service delivery framework. For all digital public services delivered, conformity to e-Governance standards set by the national Government is essential to enable inter-operability across systems, uniformity in coding standards and to enable disparate IT systems communicate with each other. Such standardization towards an overarching solution architecture at business process level, systems level and infrastructure level creates a target operating model and an operational framework for both technical and business professionals⁶².



An example for the above is widely practiced digital standards in healthcare such as consolidated clinical documented architecture, Health Level 7 messaging standards, Integrating Healthcare enterprise standards, Quality Reporting Document architecture, Electronic Health Records, Healthcare Information and Management Systems, etc., Similar standards are in place for other sectors such as Banking & Finance, Government processes, Chemical process industry, etc. These standards are developed by standard setting industry associations comprising of technical experts or by Government organizations to harmonize the digital/ICT standards across the world and enable free information flow or exchange in a globally networked and integrated environment.⁶³

⁶² https://www.fao.org/e-agriculture/news/e-agriculture-action-blockchain-agriculture

⁶³ <u>https://pib.gov.in/PressReleaselframePage.aspx?PRID=1741995</u>

Digital architecture design and development have been standardized in developed countiries for new innovations such as Internet of Things (IoT) and precision agriculture⁶⁴. As per a study by Waganingen University, the following is the solution architecture for the IoT based digital architecture.



The various applications hosted through the IoT based digital architecture system developed by Waganingen University are given below. MQTT, XMPP, AMQP, DDS, CoAP, CAN and



⁶⁴ <u>https://link.springer.com/content/pdf/10.1007/s11119-018-09624-8.pdf</u>

ISOBUS are standard data exchange protocols used for IoT devices, systems and other associated devices such as farm machinery. For example, ISOBUS is a exchange protocol for farm machinery and IoT devices.

As per USAID study on the emerging digital ecosystem, the following illustration describes the transition from a system-centric view to an ecosystem view linking Big Data and IoT⁶⁵.



⁶⁵<u>https://www.usaid.gov/sites/default/files/documents/15396/Data_Driven_Agriculture_Farmer_Profile.</u> pdf

As per Indian Cellular and Electronics association study, the best practice framework for digital innovations are depicted below⁶⁶.

Ideal elements for Digital Governance portals and applications



thereby enabling incorporation of these elements to ensure effective governance services.

⁶⁶ https://icea.org.in/wp-content/uploads/2020/07/Contribution-of-Smartphones-to-Digital-Governance-in-India-09072020.pdf

Considering the above the need for an integrated view for a standard based Agri stack of applications for Indian context also arises, given the rapidly evolving digital ecosystem in this space. Agriculture sector is vast and heterogenous with innovation ecosystem rapidly evolving at various stages of the agri-value chain. The digital innovations at the upstream, midstream and downstream of the ecosystem in complex interaction with the mainstream digital systems in finance and banking, logistics, warehousing, markets and infrastructure management all at various points of time need to converge for delivering various services and different service levels.

The Science, Technology and Innovation policy of Government of India, aims at strengthen national water, agriculture, food, and nutrition security as well as ensuring employment generation through a robust STI enabling the environment to ensure better lives for citizens, enhancing incomes for farmers, labourers and artisans, and to create resilient and liveable human settlements, while sustaining natural resources and safeguarding public health⁶⁷. The Ministry of Electronics and Information Technology (MEiTY) of Government of India has identified the following seven priority sectors to promote digital innovation.

- 1. Healthcare
- 2. Education
- 3. Agriculture
- 4. Financial inclusion including digital payments
- 5. Infrastructure and transportation
- 6. Environment and clean tech
- 7. Clean Energy Solutions

The policy framework for digital agricultural innovations has been summarized as part of IDEA (Indian Digital Ecosystem Architecture) framework paper by Government of India⁶⁸. The objectives of the national digital ecosystem are as follows.

- To enable the farmer to realize higher income and better profitability through access to right information at the right time, and from innovative services.
- To enable better planning and execution of policies, programs, and schemes of the Central and State governments, and, also of the private sector and Farmers Producer Organizations (FPOs)
- To enhance efficiencies in the usage of resources including land, water, seeds, fertilizers, pesticides, and farm mechanization by providing easier access to information
- To provide location-specific and personalized extension services across agriculture lifecycle, with simultaneous protection of privacy of personal data.
- To build capacities across the gamut of digital agriculture and precision agriculture 6.
- To promote adoption of standards for interoperability and seamless exchange of information across ecosystem, while ensuring that he digital rights are properly managed.
- To give a fillip to R&D and Innovations in agriculture through access to high-quality data
- To adopt the best principles of cooperative federalism while working with the states and union territories for the realization of the vision of IDEA.
- To formulate and leverage PPP frameworks for realizing the 'power of the digit

With the above background, Government of India, constituted a taskforce with various domain experts in digital agriculture to develop a common architecture for Digital agriculture solution

⁶⁷ <u>https://dst.gov.in/sites/default/files/STIP_Doc_1.4_Dec2020.pdf</u>

⁶⁸ <u>https://agricoop.nic.in/sites/default/files/IDEA%20Concept%20Paper_mod31052021_2.pdf</u>

stack for various applications in the sector. Accordingly, the Ministry of Agriculture and Farmers welfare, Government of India has initiated a consultation paper for development of India Digital Ecosystem Architecture for Agriculture. (InDea)⁶⁹. This framework is developed for various departments and is called as IDEA (India Digital ecosystem Architecture). The objective of InDEA is to "To build a National Digital Agriculture Ecosystem, to elevate Indian Agriculture Sector to higher levels of efficiency and productivity, and to improve the welfare and income of farmers."

The digitization of Indian post office network across more than 1.5 lakh post offices incuding rural post offices is going to open up not only logistical services for agriculture, but also provide financial inclusion services for farmers and labour.

While the IDEA is the overall solution architecture for various Departments, InDEA is specific to Agriculture and allied sectors and is based on the following principles. These principles follow a digital ecosystem approach to develop an integrated view of the digital innovations and can be considered as best practices for design and development of solutions.

- a) Ecosystem principles
 - 1) Ecosystem thinking instead of Systems thinking approach: In contrast to indivifudal systems, Ecosystems span across Centre and States, public and private, and are composed of several autonomous, interoperable, and federated systems, which is considered as a best practice while developing digital platforms in agriculture.
 - 2) Building block approach: The elements of digital ecosystem are considered more as independent and re-usable building blocks. All the building blocks shall be able to evolve orthogonally, thereby meaning that any building block can be modified without requiring the other building blocks to make any consequential changes.
 - Open API based : By default all the Application Program Interfaces (APIs) shall be based on open standards to provide for sharing of services with other applications seamlessly.
 - 4) Built on open source, published on open source and conform to open standards
 - 5) National level portability considers the language localization and special requirements so that such digital platforms can be utilized all over India.
 - 6) Participatory design to drive end-user engagement at all stages to establish robust and transparent rules of engagement for all players.
 - Innovation through promotion for establishment of a open testing environment (Innovation sandbox) for responsible and responsive deployment of emerging technologies⁷⁰.
- b) Architectural principles: The Information Technology architecture principles to be considered for development of an digital agri-solution stack are as follows.
 - 1) Federated architecture with Single-Source-of-Truth, System-of-Records, and unbundled applications.
 - 2) Agile Architecture signifies not being prescriptive and templated solutions, but specific solution designed in as per Agile architecture principles.

⁶⁹ <u>https://agricoop.nic.in/sites/default/files/IDEA%20Concept%20Paper_mod31052021_2.pdf</u>

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https://reader.elsevier.com/reader/sd/pii/S0308521X16303754?token=E1A60748A5214EFA0830292 C4B4637BC0D2A57B83BE184D892DE446F76661C76946A07F331FA44EEDBF43CAC013E0D31& originRegion=eu-west-1&originCreation=20220119172129

- Technology independence and agnostic to a particular class to promote multiple options for developers including innovations in combined use of technologies for delivering results.
- c) Technology principles which need to be followed as per InDEA architecture are as follows. These principles provide an indicative direction at both the business process technology and infrastructure level.
 - 1) Cloud first approach to leverage full range of benefits and advantages from Cloud based technologies
 - 2) Mobile first approach to deliver services through mobile devices to reduce any dependence on any other devices.
 - 3) Data is an asset approach to underline the fact that data will be the new wealth of the future and promote regulated data exchanges.
 - 4) Data sharing with clear policies in conformation to data protection regulatons.
 - 5) Standards compliance as per InDEA architecture.
 - 6) Privacy and security by design
- d) The following are the salient applications which emanate through the development of InDEA architecture
 - 1) Unique Farmer ID
 - 2) IDEA Core registries
 - 3) IDEA Core Directories
 - 4) Unified Farmer Service interface
 - 5) IDEA architecture repository
 - 6) IDEA App store
 - 7) SMS messaging
 - 8) Weather data
 - 9) Call Centre
 - 10) IDEA Service portal
 - 11) Lab-to-Field
 - 12) Real Time prices
 - 13) Direct Benefit Transfer (DBT) to farmers
 - 14) Gol Schemes
 - 15) Regulations
 - 16) State Cores
 - 17) Agri-Data exchange
 - 18) IDEA SandBox for innovators

The above are few elements of the overarching digital architecture being developed by the Government of India for all Central and all the State Governments for getting ready for the future digital ecosystem emerging in India.

The open standards proposed shall enable the third-party applications to easily interface and exchange data with the Government applications through Application User Interfaces (API) and also using shared infrastructure through cloud based services.



For more details on InDEA architecture and ICT best practices, the reader may go through the consultation paper at

https://agricoop.nic.in/sites/default/files/IDEA%20Concept%20Paper_mod31052021_2.pdf

7. Summary of Findings and Recommendations:

The study on assessment of digital innovations in agricultural allied sectors of India was conducted as secondary research along with interviews with sector experts. Overall digital innovations are inevitable in an emerging ecosystem where internet penetration and smartphone-based applications have been rapidly adopted by majority of Indian population either directly or indirectly.

Furthermore, with 70% of millennials in rural India, high digital literacy and adoption of innovations has accelerated in the past one decade due to increased access to formal and non-formal knowledge-based communications which are part of everyday life. The disruptive innovations in terms of fintech tools such as e-wallet based payment gateways for commercial transactions, PoS devices, QR code-based payment mechanisms, AADHAAR (Unique Citizen ID of India) linked payments and overall increase in digital economy has laid foundation for a new era, which is an ideal start for innovations in Indian Agrarian economy. In line with various insights generated during the assessment the key findings of the assignment are as follows.

- b) Agriculture and allied sectors are unique in terms of their exposure to high risks and uncertainties and need to be considered separately in terms of the innovation potential and adoption efficacy. This is in view of the dynamic complexities of variables which interplay as part of agriculture in relation with the natural environment. This necessitates consideration of various interdependencies and interactions between various factors while analyzing business outcomes.
- c) Digital solutions do not stand alone in isolation and must be developed over a strong foundation of physical business processes and infrastructure. Therefore, pureplay digital innovations without underlying physical processes or infrastructure or not bound to succeed and most of the innovations in Agriculture are "Phygital" in nature.
- d) Network externalities either positive or negative play an important part in the successful adoption of digital innovations in view of their strong linkage to multiple ecosystem factors. A network externality is an economic term which describes how the demand for a product is dependent on the demand of others buying that product. This is in view of the fact, that more people adopt digital innovations, leads to further improvement and efficiency of the innovation.
- e) Given Indian agriculture is predominantly smallholder agriculture with nearly 85% of the farmers being small and marginal farmers, the digital innovations and their underlying business process innovations need to be tailored to smallholder agriculture. Further, the digital solutions developed for developed economies cannot be replicated in Indian context without localization and customization.
- f) A value chain perspective and an ecosystems approach is essential for conceptualization and design of solutions leading to digital innovations in agriculture.
- g) In a value chain, several other intermediary participants exist in addition to farmerproducers, processors and consumers. Every value chain participant has a role to play including the intermediaries. Digital innovations should consider all intermediaries and identify both value adding (VA) and non-value adding (NVA) intermediaries. Business process reengineering at NVA intermediaries or steps of business process flow would enable capture of value in the value chain and redistribution of the same in line with the contribution of the participant.
- Agriculture and allied sectors being priority sectors for lending, viable business projects need to be developed which are based on sustainable business models to generate gainful employment, livelihoods and solve the challenges related to agriculture.
- Despite seven decades of Government support, subsidies and favorable policies, Agriculture in India still faces various challenges with respect to access to credit, technology, and capital. This situation is in view of the systemic challenges entrenched within the socio-economic fabric of India.
- j) Although India is a leading producer of cereals, milk, vegetables and commercial crops like Cotton, spices, tea, etc., the productivity in India is very low compared to global

standards. As less than 45% of arable land in India is irrigated and nearly 55% of Indian arable land is under dryland or rainfed agriculture. In such a situation, any interventions for agricultural development should be based on multi-pronged approaches including development of high yielding plant varieties, improved agronomic practices, farm mechanization, irrigation facilities, soil health management, etc., in addition to market and technological interventions.

- k) Innovations can be small and incremental for solving a specific business problem or can be disruptive, solving a large set of business constraints and opening up entirely new vistas of business processes. Disruptive innovations not only affect a particular industry, but also have ramifications across various other sectors as best practices. For example, digital payments through unified payment interfaces not only enable ease of payments in a particular sector, but also have an impact across other associated businesses.
- As per Digital innovations assessments, the innovations can be broadly classified into three areas, viz., (i) Agri-fintech innovations, (ii) Innovations in Agri-production systems and (iii) Innovations in Agri-supply chains. Some innovative solutions may cross over across three dimensions.
- m) The key technologies underlying the innovations are as follows,
 - a. Farm management systems focused on management of farm operations,
 - b. E-commerce platforms for selling agri-inputs and food products,
 - c. e-Business systems for enabling B2B transactions,
 - d. Electronic content and document management systems for automation of transactions,
 - e. Mobile based applications for dissemination of technical and agri-advisory information,
 - f. Social media channels for exchange of market pricing and product information,
 - g. Remote sensing and climate sensor-based information on climate,
 - h. Sensor based information directly from farms connected to internet as part of Internet of Things (IoT) devices,
 - i. Deciphering data patterns from multiple sources including IoT devices, sensors, spectral imaging for enabling Artificial intelligence/machine learning (AI/ML)
 - j. Developing traceability and transaction systems using AI/ML and blockchain technologies
 - k. Farm mechanization and automation solutions using AI/ML technologies.
 - I. Data analytics, predictive analytics and decision support systems
 - m. Digital platforms for procurement and bidding
 - n. Digital technology linked spectral imaging-based devices and databases for traceability, crop diagnostics and quality assessment
 - o. Digital platforms linked to fintech apps, devices, gateways, APIs, wallets and payment interfaces for facilitation of digital payments
 - p. Infrastructure management solutions for warehousing, cold chains and logistics
 - q. Robotics using IoT and farm automations for enabling precision farming and site-specific application of agri-inputs.
 - r. Standards based data exchanges for escrow based real-time transactions and quality conformations.
 - s. Vertical farming and hydroponics-based technologies integrated with IoT and AI for improved operational efficiencies.
 - t. Smart farming and smart operations for Dairy, poultry and fisheries.
 - u. 4G and 5G wireless technologies coupled with Virtual reality and Augmented reality system for developing crop simulation models.
- n) The above technologies are indicative and present a glimpse on induction of new age technologies in agriculture and allied sectors. However the innovation and implementation of a business solutions is a function of how innovatively the above

technologies and business processes have been customized as unique use cases to solve particular business problem.

o) The digital innovations and solutions are all part of a larger ecosystem and therefore need to be looked at as an "Agri Stack" of solutions to solve various business process challenges in Agriculture. The solution architecture for different components of an Agristack has been defined by Government of India as InDEA architecture, as mentioned in the report.

The key recommendations in line with the assessment of digital innovations implemented and required for unlocking the value from Indian Agri and allied sectors are as follows.

- I) Implementation of Agricultural reforms for of access to markets, technology and credit is a complex process due to conflicts of interests between various stakeholders including Government. Digital innovations solving business challenges can provide an opportunity to circumvent the long drawn legislative and reform process if value is realized in an optimal way by majority of stakeholders.
- m) Government of India and State Governments along need to develop a mission-mode project on Blockchain to develop an end-to-end convergence project across agri-value chain.
- n) The agility and flexibility of startup ecosystem should be leveraged through public private partnerships to accelerate new business models in agriculture focused on solving key process constraints related to access of farmers to markets, technology and credit.
- o) Although agriculture is a priority lending sector as designated by Government, the rural population and farmers out of formal credit system. Despite having relatively high account ownership, India claims the second largest share of the global unbanked population, with over 190 million adults still having no bank accounts⁷¹. The fintech interventions can play a pivotal role in accelerating the progress of growth in agriculture and allied sectors. A Centre for excellence for fintech in a public private partnership mode for development of data exchange standards and audit trail need to be developed.
- p) Crop and variety planning and moving from a supply driven agri-value chain especially in cereal cropping systems towards a demand driven value chain in line with market requirements is the major transition which needs to take place in all the states of India.
- q) Crop/commodity specific Processing clusters in each taluka/district of India linked to local/regional and international markets is the need of the hour. Local processing coupled with strengthening rural road and irrigation infrastructure, warehousing, cold chain, and digital assets is the key to the overall development through Digital innovations.
- r) There is a need to develop a 'Go-To" place for FPOs and farmer collectives at the village and Taluka level which provide integrated services to the FPOs/Farmer collectives and enable them to realize their aggregation potential. Such place may be a Rural Business Hub or a Krishi Value Hub or Village Business Hub, which enables comprehensive FPO engagement.
- s) Standards based IT architecture and business architecture model need to be developed for Agritech/Digital innovations in line with the InDEA framework.
- t) There is a need for upgradation for enabling a transaction centric eNAM platform to ensure that all mandi transactions happen in a digital mode.
- u) The private sector involved in agriculture and allied sectors should focus on digitalizing transactions to set the standard and pace of the digital transformation in the sector.
- v) Government should develop cloud based digital platform with provision for sharing APIs for private sector players for sharing information and data.

⁷¹ <u>https://www.nabard.org/auth/writereaddata/tender/1608180417NABARD-Repo-16_Web_P.pdf</u>

- w) Government of India should implement traceability systems as part of their regulatory responsibilities for Agri-inputs such as seeds, pesticides and fertilizers.
- x) Government should provide free resources for startups and FPOs including shared IT infrastructure, cloud services and information repositories.
- y) Government should promote partnerships between startups and universities/academia and fund for internships/apprenticeships for encouraging young companies.
- z) As part of Rural Agricultural Work Experience programs in State Agricultural Universities, Government should mandate internship credits to students to work on digital innovations.
- aa) (i) Curtailing post-harvest losses, while promotion of quality consciousness in production, (ii) providing market linkages with processing industry and (iii) enabling smooth access to credit and technology are the three engines of agricultural growth which need a strong digital foundation. Startups should focus on these three areas to deliver innovative solutions for progress of Indian agrarian economy.