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Advanced Technologies Reshaping Indian Agriculture

Technology Led Resilience for Aatmanirbhar Bharat

White Paper Series:

Digital Agriculture | **Biotechnology** | **Nanotechnology** | **Robotics**

White Paper: I

Digital Agriculture

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Introduction

With the onset of the 21st century, the global agriculture sector has seen an influx of technological innovations that are transforming value chains from farm to fork. From data-analytics based precision agriculture solutions, gene editing based hybrid seeds, nano-inputs to automated robots, different technology segments are contributing to the development of the sector.

The Strategy Papers on four key technology themes – Digital Agriculture, Agri-Biotechnology, Agri-Nanotechnology, and Agri-Robotics, are an attempt to draw learnings from the rapid development that has taken place in these sub-sectors globally, cutting edge research taking place in leading global institutions, and the need for these innovations to be translated into the sector in India. The Strategy Papers on Next-Gen Agri Technology segments are being devised in consultation and deliberations with world-renowned experts from Australia, Brazil, Israel, Netherlands, USA and India. The objective of these Strategy Paper is to develop a roadmap for implementation of the respective technologies in India. The papers intend to serve as roadmaps for rapid technology uptake and capacity building of the sector.

The first of the papers is focused on digital agriculture and the need of digitization in Indian agriculture, which is well recognized and accepted. Efforts have also been made on several fronts towards digitizing the existing value chain. Technological interventions based on Remote Sensing, Soil Sensors, Unmanned Aerial Surveying, and Market Insights etc. have provided us with several data points that in combination with robust Artificial Intelligence/Machine Learning algorithms generate actionable insights. Mapping of stakeholders and examples of collaboration from across the world showcase possible scenarios which can be adapted in the Indian setting.

Biological innovations form another important aspect of precision agriculture as they can enable plants to express targeted characteristics or provide inputs that target the precise pathogen. The role these innovations play in developing sustainable agricultural value chains has been deliberated and discussed multiple times. Biological solutions hold the key to improving the resilience of the crops and increasing the productivities. Despite being intrinsically connected with the Food and Agriculture sector, despite India being a front runner with the Green revolution, the deployment of biotechnological innovations has been limited in India. There are many examples of commercialization and deployment from countries with similar policies around biological products. The disruptive innovations that are needed for strengthening the sector have seen limited adoption at a farm level. Global initiatives to develop high nutrition crops and climate resilient seeds have helped in achieving food security. Some of the tools that have been used globally are genome editing, smart breeding technologies, integrating digital AI based technologies with microbial soil mapping to increase the output quality, pest and disease resistant seeds, among others. Focusing on creating a pragmatic, data- based research translational platform is an important aspect of the paper which in combination with several other aspects charts the way forward for the sector.

Another important technological segment that is intrinsically connected to biological innovations and digital solutions is next gen nanotechnological products. Nanotechnology has given the Food and Agriculture sectors a whole host of solutions from Agri-Input products that help increase the quality of the crop, to catalytic compounds that have an integral role in increasing the efficiency of food processing. This is one of the sub-segments of AgTech where India has multiple successful examples in terms of deployment, albeit limited in terms of market reach.

The paper outlines several examples and draws parallels between the growth of nanotech solutions in India and the global pioneers. Deliberations would focus the global extent of usage of nanomaterials in agriculture such as targeted delivery of nutrients or pharmaceutical capsids for detection and treatment of diseases, delivery of bioactive compounds to targeted sites and thus boosting the growth of the crop, among other innovative applications. The paper also outlines strategies for deploying these international and Indian learnings on ground for accelerating the transformation of the food and agriculture sector.

Advances in technology have also resulted in highly productive farms managed by autonomous robots. Sowing, pruning, weeding, harvesting, and several other steps of the farming cycle are carried out by robots that run on AI based algorithms. Robotics and automation innovations have seen a significant development across the world. Products for both protected greenhouse farming and open farm cultivation have been developed, commercialized, and deployed globally. Focusing on collaboration and success stories from leading academicians and industry experts in robotics and automation from around the world the Robotics paper deliberates about the status of the sector, and strategies for accelerating its growth in India.

The roadmap developed by these papers would be deployed on ground through a multi-stakeholder effort between Indian and International public sector bodies, governments, industry partners, and research institutions. The implementation would be done in a gradual manner with multiple phases between pilot testing and mass deployment. The end goal is to benefit the smallholder farmers reap the benefits of transformational innovation in agriculture, and for the industry to develop a more robust tech-enabled value chains.

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Digital Agriculture

The agriculture and allied sectors are considered the bedrock of India's economy. With farming employing almost half of India's workforce, Agri Gross Domestic Product (GDP) can be considered the engine of growth for the economy.

The global need to produce 50% more food by 2050 cannot be accomplished with only 12% of global land area under cultivation for agricultural crops[1]. The vulnerabilities arising from climate change, coupled with the risk of increased dependency on unsustainable agriculture practices, can lead to agricultural distress.

Digital technologies such as Artificial Intelligence (AI) and Machine Learning, Remote sensing Technologies, Big Data and IoT, etc are transforming agriculture value chains and playing a key role in modernizing agricultural activities.

While several countries such as Netherlands, United States, Australia, and Israel, among others have adopted and leveraged Digital Solutions successfully towards revolutionizing agriculture, India's adoption of the same is still at a nascent stage compared to global counterparts.

Outlining the Problem Statement

An important step in the journey towards digitizing Indian agriculture is to identify and define problem statements and gaps that exist in the value chains. By looking at each step in the farming cycle, we can map different data types and source, match them digital and physical data together, and find relevant tools available for that phase.

The farming cycle begins with the farmers deciding what crop to grow on their farm. This decision is often made based on traditional practices and general know how and is seldom based on reliable data sources. The suitability of a crop for a farm depends on several factors such as the soil type and quality, market conditions (need for a specific crop), weather conditions, and several such factors. Digital AI-ML based tools are needed to analyze these factors and suggest the best crop that farmers can grow on their farm in a certain season. While there are several such solutions being developed and deployed by AgTech ventures these are limited by scale. Widescale implementation of such technological solutions can only be enabled through systemic stakeholder collaboration.

Optimizing the cost of production is another important role that digital tools can play in the farming cycle. Quality estimation of the seeds to be cropped along with highest quality of soil preparation and precise seeding advisory is needed to increase the efficiency of the input resources. Based on the soil health analytics, the amount and type or micro/macro nutrients can be decided and added to the soil. Estimation of ideal moisture percentage will also be helpful to prevent over/under irrigation of the farm.

[1] The State of the World's Land and Water Resources for Food and Agriculture, Food and Agriculture Organization of the United Nations, Accessed September 2020

Real time analysis of data is a crucial need to aid this process. The available soil health card testing is time intensive while the farmer needs real time, actionable insights on the type and amount of inputs to add to the soil. IoT enabled soil sensors combined with remotely sensed data through drones or satellites and fast processing capabilities can determine what is needed by the soil and can either send a notification to the farmer's phone or through a central server, enable automated irrigation. Companies today have developed solutions that can determine the health of the crop by analyzing the leaves of the plant. Such an analysis type that determines the nutritional needs of the crop by analyzing the pigment concentration in the leaves, along with soil sensor and other data types, can provide reliable and holistic information to the farmers.

Data based harvesting decisions are the next important step that can increase the efficiency of the farming decision. IoT and analytical tools are integral in this phase as well as they can identify the parameters for harvesting in real time and allow the farmer to decide whether the crop is ready to be harvested. Presently this is done based on physical attributes of the crop (such as colour, size, shape). Through digital tools the farmer can estimate when the nutritional content is highest in the crop and determine the correct time of harvesting. For example, harvesting of sugarcane crop can be done based on sugar content in the plant and not by its size. This would ensure that the crop has been harvested at the optimum time.

Post the harvesting stage, enabling farmers with price, storage, transportation and logistics information is of utmost importance to the farmer. Decisions such as selling to the local buyer or another buyer in a different state who is offering better price, storing the produce and selling at a later stage among others can be made based on market insights. The algorithms can also connect farmers to nearest FPOs for better produce aggregation and ensure optimum value creation. Tracking of produce from the farm gate to the end customer level is also important for bringing accountability to the quality of produce and to optimize the supply chain.

All these solutions are oriented towards maximizing value and optimizing resource use to create value for farmers and ensuring efficient and sustainable use of resources. There is undeniably a compelling case to create a strong data driven strategy, and regulatory framework that facilitates standardization and interoperability to deploy these solutions at scale.

Digital Agriculture in India

The need for digitization in Indian Agriculture is well recognized and accepted, and efforts have also been made on several fronts towards digitizing the existing value chain. Technological interventions based on Remote Sensing, Soil Sensors, Unmanned Aerial Surveying, and Market Insights etc. have provided several data points, which in combination with robust Artificial Intelligence/Machine Learning algorithms can generate actionable insights. However, despite such developments, the update of Digital Solutions remains at a nascent level across the sector.

The primary factor behind this slow uptake is the prominence of segregated small holder farms in the country, which makes data gathering a complicated activity. Limited percolation of mechanization tools and recurring natural phenomenon like floods, droughts, etc. have also worked against the deployment of digital solutions in the sector.

Additionally, data of different geographical locations, markets, weather, soil types, crop types, and many other is needed to make a viable advanced technology-based model. An effective artificial intelligence or machine learning algorithm needs to churn an extremely large amount of data to become precise and efficient, developing a platform that can offer different resources to the stakeholders also utilizes large amounts of data about the market conditions and patterns. At present there isn't a centralized repository of different varieties of data stacks to be used in agriculture.

There are instances where companies and several start- ups are working in silos or on project to project basis, where they resort to generating data themselves which consumes crucial time and depletes the resources that can instead be deployed toward scaling up of operations.

An efficient analytical model requires high quality weather, soil, cadastral, and several other data types. In India, while satellite data is available to a certain extent, finding matching levels of other data sets is an issue. Cadastral data with administrative boundaries and geo-coded soil data availability is needed through public sources to improve the analytics and insight generation capabilities. At present only 6 states in India have GIS maps of cadastral boundaries, which limits the potential of widescale implementations of digital solutions. Geo-coded data with latitude and longitude of field is needed for developing sound outputs.

Major source for weather data for the centre is the Indian Meteorological Department that has close to 1000 operational automatic weather stations. Private sector leads in terms of active AWSs in field with close to 30,000 stations across the country. Standardizing these AWSs would lead to interoperability between different stakeholders. Uniformity in terms of site selection for the station and adherence to World Meteorological Standards is essential.

There are several disparate sets of rich data that exist across various parameters. For instance, Soil Land and Use Survey of India captures data

on soil and land characteristics, that is made available for watershed-based soil and water conservation and soil health management. The soil health card database is another rich source of data on micronutrient status of soil. The challenge however lies in that these data sets are disparate and not interoperable, limiting analytics and value creation.

The solution towards scaling up of digital agriculture in India therefore is partnerships. Learnings can be drawn from several successful examples of partnerships between stakeholders within India and internationally to bring digitization to the farm and impact the sector.

Different modes of partnerships can be observed for deploying technological solutions on ground. Multiple techno-commercial models have shown high rates of success globally.

In the US, the partnership between Microsoft (technology developer) and PepsiCo (on-ground implementer) helped benefit potato farmers improve efficiencies and overall profitability. Meanwhile, in Netherlands, multiple stakeholders including Wageningen University and Research, Farmer Cooperatives, and Public Sector Bodies came together to develop and deploy Akkerweb. The platform can be termed as a prime example of technological crowd-sourcing success, which uses multiple data streams such as digitized public domain information including land and farm records, combined with soil, weather and market related data from each of its 4000+ subscribers.

From an Indian perspective, the Public-Private Partnership (PPP) mode is of prominence as government is the largest and most important stakeholder in Agriculture sector. The government is also the largest custodian of farm data. Additionally, farmers/growers are much more amenable with the government utilizing their data to develop useful outputs.

For the government, the Mahalanobis National Crop Forecast Centre (MNCFC) utilizes vast amount of data and analytics to give data backed forecasting for produce quantity, weather patterns for drought related conditions, insights for insurance dispersal etc. The center sources different data sets such as remote sensing data, hyperlocal weather data, soil moisture related among others and analyses them through its advanced analytical modules based on artificial intelligence and machine learning.

Meanwhile, there are several examples of PPP models in India, such as MoA-IBM where the Ministry of Agriculture and Farmer's Welfare partnered with IBM towards a pilot study for farm level weather forecast and village level soil moisture data.

State Governments' are also moving towards digital agriculture through partnerships. A prime example of the same is the Bhoomi Project by the Government of Karnataka, under which farmland records were digitized involving active youth participation for physically collecting data for over 200 lakh farms across the state.

Spokes of Digital Agriculture

A key reason behind partnerships being the key towards leveraging the full potential of digital agriculture, is that digital agriculture involves layering and juxtaposing several data sources to solve a particular agricultural problem with precision. In India, several stakeholders are involved in agriculture data, each with their own expertise at maintaining and utilizing them. This section looks at the various stakeholders and their expertise.

An efficient digital agriculture model will require the enmeshing of dependable data backed by strong analytical tools along with constant finetuning through research and innovation. While Government remains the most reliable source of data for agriculture, industry needs to be leveraged for practical and analytical on-ground solutions. This needs to be further backed by research and innovations through premiere research organizations, both government and private.

Data Sets

The single most important entity in building a robust digital infrastructure in the country is the presence of reliable and in-depth data. The data sets can constitute of satellite imaging, soil health information, land record, cropping pattern and frequency, market data, amongst a plethora of other types depending upon the desired results.

In India, the most important custodian of these data sets is the government (both central and state). Government has the means to collect and procure data from different sources and by different modes and make it available to be used for developing solutions for application in agriculture.

The data thus provided would be accepted by all parties and be considered authentic as it is coming from the government and not from a private player. Also, government is empowered to monitor the usage of this data and make suitable policies to ensure that it is being used as prescribed. Regulatory bodies can also track the usage and prevent any breach of privacy or misuse of privileged information.

The largest and most extensive source of agriculture data is remote sensing data (RST) sourced from multiple sources such as remote satellites (through ISRO), and airborne instruments (drones, weather balloons).

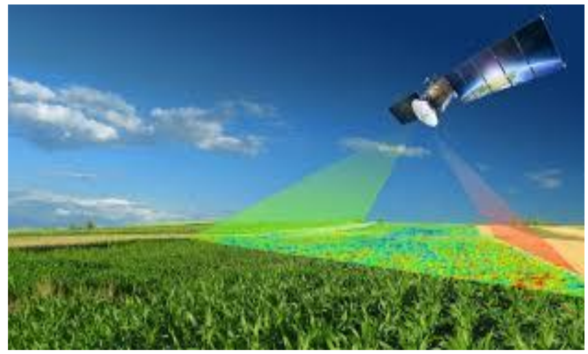
- Data from satellites has demonstrated usage in land use and land cover classification, parcel delineation and crop characterization.
- Data from airborne instruments is a cost-effective alternative for high-resolution satellite imagery and can be used for Geographical Information Systems, topographic mapping, terrain modelling, and other specialized surveying applications.

The usefulness of satellite data is determined by its spatial resolution. Key factors such as nominal size of production units, mappable landscape features etc. play an important role in determining the quality of data.

Satellite data sources: Majority of the data used by MNCFC is acquired from ISRO and through both free and fee-based agreements with bodies such as the European Space Agency (ESA).[2]

ESA has classified the following two satellite sensor categories based on the nomenclature used in its Copernicus Programme:

- Microwave Spectrum (SAR) – Sentinel-1, Radarsat-2, TerraSAR-X, CosmoSkyMed
- Visible & Infrared Spectral Domain (Multispectral) – LandSat, Sentinel-2, WorldView-3, PlanetLabs, Sentinel-3, MODIS, Proba-V



The use of fee based commercial satellite imagery is limited because of the associated costs. The data is licensed for most remotely sensed satellite modules and the user needs to pay to get the relevant imagery from it. Types of licenses are single use and multiple use. Single use license is cheaper in comparison to multiple use, but as the name suggests is limited by scope of data sharing (to a single institution). In certain cases, the insights generated by analyzing this data also fall under the purview of the license and thus increase the associated costs.

Open Access (free) data sets are available from MODIS, LandSat, Sentinel-1, Sentinel-2, and a few others. The free access of these data sets is provided by European Union (Sentinel data sets) and by the US government (MODIS, LandSat).

The data sets also vary in their readiness status for analytics. Depending upon sensor type and processing levels, the satellite data may need pre-processing before analytics can generate

[2] Handbook on remote sensing for agricultural statistics, Food and Agriculture Organization of the United Nations. Accessed July 2020.

insights by ingesting it. alternatively, data that doesn't need any pre-processing and can be readily analyzed is termed as "Analysis Ready Data".

The necessary support for pre-processing acquired data is extended by the source agency (Sentinel Applications Platform – SNAP).

A combination of multiple tools (JAVA programming, Artificial Intelligence, Statistical Analysis etc.) is used to process the data and generate useful and applicable information.

Data Efficiency: To generate meaningful insights from satellite imagery, several additional data layers are required which are combined to produce holistic results. Some of these are:

- Digital Elevation Model (DEM)
- Digital Topography
- Land Use & Land Cover
- Soil Map
- Land Registry
- Administrative Boundaries

Information from these layers is highly varied in terms of quality, quantity, and availability. For certain regional levels, these are completely non-existent, which require additional efforts such as the use of airborne instruments, thus making the analytical process highly resource intensive.

Satellite data in India is also overlapped with data collected on ground. Different states have their own ways and means of collecting agricultural data. A strong on-ground presence for collecting of real time data related to crop growing intensity and patterns, soil quality and health, market demand and supply etc. is critical.

Certain states such as Karnataka have shown progressiveness in creating this robust presence and using digital tools for several purposes such as yield estimation and crop insurance. Some states have even integrated GIS systems and have a dashboard view of activities taking place for any cropping season. They rely on data collected physically by on-ground representatives at the Block or Village level, which is then aggregated to the Taluka and District level, and ultimately combined to form State Level Data.

The key drawback with such a system is that very little of this data is digitized. Also, since different states follow different formats and parameters for data recording, the inter-operability between States for using this data becomes difficult.

Market and Demand Side management systems. Similarly on the market side, there exists significant data on mandi arrivals, pricing and with the advent of systems like e-NAM, there is real time information and signaling on price maximization opportunities basis, product parameters that with predictive analytics can help the farmer make informed choices on what to plant and when . The new logistics enablers such as **Kisan Rath** initiated by the Ministry of Agriculture also offer significant opportunity for optimization of travel routes, cost and aggregation efficiencies that can reduce significant costs for farmers. These different platforms, however, operate in silos limiting opportunities for timely decision making and profit maximization for farmers.

Recommendations for Data Utilization

While efforts are being made by both central and state governments towards creating robust data sets for agriculture, the absence of a mechanism for data sharing limits the avenues of usage of this information.

This data has tremendous untapped potential and can be used for drafting regulations, ordinances, and schemes such as the Pradhan Mantri Yojanas. At present the scope of utilization of data-based insights or solutions is limited to monitoring and execution of these schemes and settlement of insurance related queries.

Another important use of data could be to determine the Minimum Support Price. It could help the government with the decision-making process to determine which regions and crops to support during a certain season and where the intervention is needed the most.

Thus, creating a mechanism for data sharing between different states, government institutions, and other public stakeholders is recommended to access the complete potential of utilizing data. Through the development of a centralized data repository, and by defining the norms for data usage, government can play a pivotal role in the digitization of the agricultural value chain across the country.

Analytical Abilities & On-Ground Implementation

The second most crucial spoke in creating a robust digital agriculture framework is the processing and analytics of the extensive data. The key stakeholder for this is the technology segment of the industry, including Tech MNCs, Agri-Input Companies, Supply Chain Companies, AgTech Startups, etc.

Companies such as Microsoft, IBM, Cisco, Infosys and other IT pioneers have highly advanced and sophisticated tools to analyze multiple data streams, find patterns and produce helpful outputs. These outputs can be further processed to develop simple and useful results that can be implemented on ground.

The companies have deployed crop specific solutions in certain parts of the country, albeit at a limited scale. Owing to a vibrant innovation ecosystem in the country, several startups have also created algorithms and platforms that help in optimizing the value chain and deliver higher efficiency to the sector.

Despite high technological prowess, the application of technology remains at a nascent stage due to limited data sharing collaborations between different stakeholders. The major impediment is lack of standardization or harmonization of available data across all levels, which makes application difficult

While the IT sector has built capacity in data analytics and result generation, the implementation of these solutions will be most fruitful when done by either the government or by companies working on ground, such as Agri-Input Companies, Tractor Companies, Food Processing Companies, Banks & NBFCs, and other private players that are actively engaging with farmers and Farmer Producer Organizations.

It is thus recommended that different partnership models be explored between Government and Private sector for the deployment of these solutions. There are several successful examples both within India and internationally where an enterprise partnered with the government (PPP Model) and helped increase the efficacy and efficiency of the Agri Value Chain. These are further illustrated in Annexures.

Research, Development, and Innovation

With the face of technology fast changing, it is imperative for innovation to keep pace through constant research and development.

While the industry has invested heavily in developing innovative solutions and turned them into commercial products, from an agricultural standpoint, contribution of academic and research institutes is paramount. Institutions such as the IITs, NITs, ICAR among others dedicatedly carry out research and development with specific problem statements in focus.

Agricultural & Technology Universities, Research Institutions such as MNCFC, Krishi Vigyan Kendras (KVKs) across the country are thus major stakeholders for digital agriculture.

These organizations collect data from several primary and secondary sources such as weather-based information, remote sensing, on-ground farmer data repositories and provide insights at different levels. While MNCFC advises the government on real time actionable insights based on satellite data analytics, KVKs warn farmers about oncoming pest attacks and undertake capacity building initiatives such as mechanization training camps.

The research output generated by IITs, NITs, ICAR and Agri Universities in combination with the practical understanding of the industry and scope of applicability of the government, needs to be translated from the laboratories and deployed on the ground. Accelerating the validation and commercialization mechanism of these innovations is important to keep up with the pace of evolvement of the sector.

The data under the custody of these institutions is of extreme importance and in combination with information from other sources, can be a crucial input element for developing a robust and efficient digitization infrastructure in Indian Agriculture.

Recommendations

Efforts are already underway by the Ministry of Agriculture that is putting in place a National Database of farmers, based on their Aadhar numbers, creating the foundation for a data stack. There are however certain necessary conditions, that will need to be in place as well, if we are to unleash the full potential. **Digital literacy in youth, revamping our extension mechanism and re-wiring our Krishi Vigyan Kendra's (KVK's)** will be critical to create the networks needed to support an ecosystem that digitalizes Indian agriculture, in addition to the following key actions

Need for a Central digital data repository

Data has become the life source of many advanced technologies such as Artificial Intelligence, Blockchain, and Satellite Image Processing. Accessing a pan-India data set that covers a whole host of information on attributes such as weather type, soil type, market conditions, crop production and variety etc. is crucial for tech ventures to develop their technologies and make them useful at a macroscopic level. Thus, creation of a unified single data authority is recommended.

Need for data sharing mechanisms

Creating a mechanism for data sharing between different states, government institutions, and other public stakeholders is recommended to access the complete potential of utilizing data. The example of Akkerweb, an online digital agriculture portal developed by collaborative efforts of Dutch Industry and Academia, can be learned from in this context. It provides the users access to reliable data such as global weather conditions, satellite imagery, farm boundaries, and farm management.

Akkerweb sources data primarily from the government's PDOK (High Quality Geo-Data Platform) as well as from several other sources such as IBM's Weather Company. The portal also allows users to upload their own data, which is in the form of drone images, tractor mounted sensor information etc. An important highlight of the platform is that the uploaded data remains the sole property of the uploader and is restricted for use by any third party without due permission. This ensures the privacy of data and allows diligent application by multiple parties. Annexure 3 gives more details about the Akkerweb platform.

Need for Accelerated Data Validation and Interoperable Data

Accelerating the validation and commercialization mechanism of digital innovations is important to keep up with the pace of evolvement of the sector. A centralized, governmental, Data Standardization body on the same lines as ISO Certification is recommended. This will help remove the ambiguity around data sharing and usage.

Further, interoperable data is crucial. To build an efficient analytical model, the centre needs high quality weather, soil, cadastral, and several other data types. While the satellite data is available to a certain extent, finding matching levels of other data sets is an issue. Cadastral data with administrative boundaries and geo-codded soil data availability is needed through public sources to improve the analytics and insight generation capabilities.

Interoperability is a salient feature of satellite data as inputs from different sources can be merged and processed to develop output. Similar standards are desired for other data sets such as weather-related data as well, soil data, cadastral data among others. A third-party accreditation would be a first step into creating a single platform where different agencies can input data and quality based filters based on accuracy levels can be applied.

Collaborative initiatives through a Public-Private Partnership (PPP) mode can advance the inter-operability of data by defining the standard operating protocols and guidelines. A partnership between government and industry would analyze the most effective procedures and guidelines for maintaining a standard of the recorded and digitized data, thus allowing it to be used across the spectrum for various purposes. This would also help in defining the governing principles in order to create robust and practical data standards.

Need for Data Privacy

Apart from the challenge of fragmented land holdings to scaling up digital agriculture in India, the other key challenge which needs addressal before accelerating the digitization of agriculture is privacy of data.

To develop sound advice for the farmer, a technical entity needs several layers of data. These include macroscopic inputs such satellite data, weather conditions, historic yields etc. and microscopic data such as when the sowing was done, what inputs were applied, expected time of harvest, and more such fine grain information. This level of detailed information can only be accessed through contacting individual farmers or through accessing village level records available with the governments.

The question arises about the ownership of this data and the privacy of farmer's information. This issue needs addressal by creating a mechanism where only farm related data can be made available to the private sector and other personal information can be kept confidential. Pace of digitization would increase exponentially once this underlying issue is resolved.

The need of the hour is to create robust data security norms and to nurture and support partnerships between stakeholders.

Annexure 1: Domestic Case Studies- Government

Mahalanobis National Crop Forecast Centre (MNCFC)[3]

Established by the Ministry of Agriculture, Government of India, NCFC utilizes spatial and geospatial technological solutions for implementation in several segments of the agriculture sector. Its primary role is to provide in-season crop forecasts and assessment of drought situations using innovative tools developed by the Indian Space Research Organization (ISRO).

Initially the centre was involved with government's programs around crop prediction and drought assessment using satellite and weather data. It used data from both Indian and International sources such as the satellites Sentinel, Landsat, Radarsat, among others.

In the recent past, the centre has been working with the Pradhan Mantri Fasal Bima Yojana for accurate crop insurance amount estimation. Earlier the emphasis was on district level crop or drought estimation assessment whereas now the centre also focusses on on-farm level applications. It has partnered with multiple private enterprises, startups, international bodies, regional government agencies to carry out several pilot studies with the goal to improve yield estimation using technologies such as Drones, Sensors, IoT, and AI-ML. These farm level applications are at a research phase at present and limited deployment has happened in the field of smart sampling while crop-cutting experimentation is being carried out to devise a strategy for application considering the large diversity on field where for every hectare a different crop type is being grown.

To build an efficient analytical model, the centre needs high quality weather, soil, cadastral, and several other data types. While the satellite data is available to a certain extent, finding matching levels of other data sets is an issue. Cadastral data with administrative boundaries and geo-codded soil data availability is needed through public sources to improve the analytics and insight generation capabilities. At present only 6 states in India have GIS maps of cadastral boundaries, which limits the potential of widescale implementations of digital solutions. Geo-coded data with latitude and longitude of field is needed for developing sound outputs.

Major source for weather data for the centre is the Indian Meteorological Department that has close to 1000 operational automatic weather stations. Private sector leads in terms of active AWSs in field with close to 30,000 stations across the country. Standardizing these AWSs would lead to interoperability between different stakeholders. Uniformity in terms of site selection for the station and adherence to World Meteorological Standards is essential.

Interoperability is a salient feature of satellite data as inputs from different sources can be merged and processed to develop output. Similar standards are desired for other data sets such as weather-related

[3] Inputs from Dr. Shibendu Ray, Director, Mahalanobis National Crop Forecast Centre

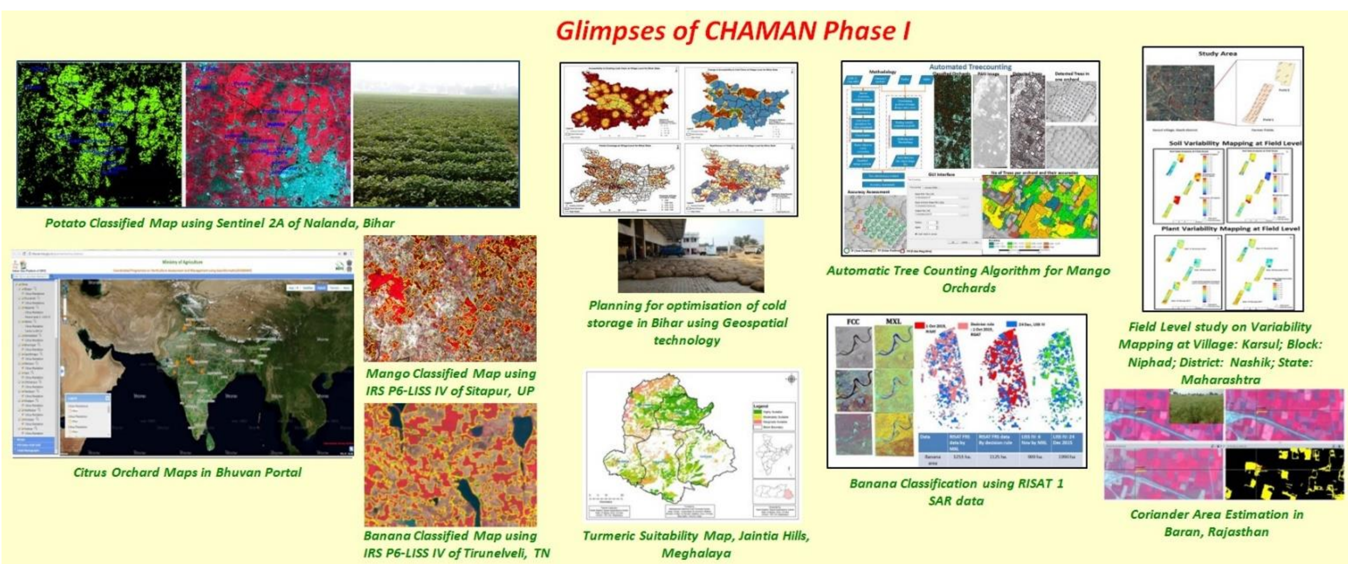
data as well, soil data, cadastral data among others. A third-party accreditation would be a first step into creating a single platform where different agencies can input data and quality based filters based on accuracy levels can be applied.

MNCFC works with State Agricultural Departments across the country, ICAR, ISRO, National and State Agricultural Universities, and several other institutions on several varied projects:

- FASAL – Pre-Harvest multiple crop production forecasting for eight major Indian crops at a national-state-district level.
- KISAN – Satellite data usage for crop insurance purposes under the Pradhan Mantri Fasal Bima Yojana. Data outputs include – crop loss assessment, area discrepancy, yield dispute resolution etc.
- NADAMS – Satellite data-based drought indicator assessment at district and sub-district level.
- CHAMAN – Crop production estimation through remote sensing and geo-spatial analytics for seven major horticultural crops at National-State-District level.
- Many other projects including crop intensification, yield assessment etc.

The center uses several different data types from multiple sources to develop meaningful insights.

Through its intensive collaboration and highly specialized technical capabilities, the Centre is a champion of implementing data driven innovations in the agricultural sectors.



Bhoomi Project– Government of Karnataka[4]

Bhoomi project was developed by the Government of the State of Karnataka with an aim to digitize the entirety of land records in the state. Several aspects of farming such as types of soils, land-holding sizes, types and quantity of crops grown etc. were converted to digital format and were made accessible to authorities through a dedicated software. The software also enabled biometric login of users, both authorities and farmers, for updation of records or to print reports.

Inception of the Project

During the Kharif season, the state of Karnataka had over 100 lakh hectares of farmland under cultivation. This summation of land constituted of over 200 lakh plots run by over 70 lakh farmers.

Despite such high numbers, there was absence of a mechanism to get reliable farm information about crops or other factors. The manual land record system that was ideally supposed to capture crop details lacked updated details.

Also, while disbursement of crop insurance, the government lacked a reliable methodology to verify the legitimacy of the claim. Even for MSP operations, manual certificate was being issued by the village accountant about the type and quantity of crop grown, which lacked authenticity. Similar difficulty was being faced for drought related funds and compensation for other calamities. The satellite data available alone wasn't enough due to limitation of granularity (resolution of the images). Also, the multi-cropping pattern of the farms made reliance on satellite data alone a challenge.

To address these challenges, the government enrolled local youth for conducting on ground survey of the farms. The youth were paid Rs. 10 per plot visited. Over 27000 individuals surveyed and collected data for 206 lakh plots across state between 5 Sep 2018 and 15 Nov 2018.

This data in combination with existing data sources was henceforth used for calculating and disbursing crop insurance, MSP, crop loss payment, and was applied for multiple other purposes by the government in partnership with the industry.

This initiative resulted in a multitude of benefits for stakeholders across the sector. For the farmers, it eased the access of obtaining relevant documentation without the having to visit central offices. It eased the due diligence process for financial institutions and enabled farmers to obtain loans and credits much easier. The project helped the industry to draw insights from this highly detailed information and draw sound advisory for farmers guiding them on the type and quantity of the crop to be grown and best practices to be followed to maximize the yields.

Bhoomi Project is a landmark in the journey towards digitizing Indian agriculture and can serve as a blueprint for other states and the central government for launching such an initiative.

[4] Electronic Integration of BHOOMI with Stakeholders, Karnataka, National Informatics Centre & Revenue Department, Government of Karnataka, Accessed July 2020

Annexure 2: Domestic Case Studies-Industry

IBM[5]

Another major example of deploying data based digital solutions on field is observed from IBM.

IBM's The Weather Company is a leading global forecaster of information related to wind, precipitation, atmospheric pressure etc. These elements are used for short term and long-term prediction of weather-related information.

There are three distinct parts to IBM's solution. Data, Analytics, and Deployment.

The company uses data from several sources such as the weather-related insights generated by its own commercial division. It also sources data from external sources such as several space research institutions, and market insight enterprises. The data types being analyzed are collected are land data, soil data, atmospheric forcing functions, satellite imagery using both multispectral or radar based satellites (400+ orbiting the earth constantly).

The second layer in IBM's processing schematics is the Analytics layer. The decision platforms Watson, PAIRS and others are used for high throughput analytics to drive insights out of extremely large amounts of data. The platforms generate field level insights directly for the use of farmer/ground level operator, for crop health, crop monitoring, crop stress, fertilizer application, irrigation decision supports etc. They also generate super-field level, district level, and state level insights as well which are used by their clients, both government and industry. These are used for monitoring farm health in a wider geography in both crop specific or crop agnostic manner, wide analytics for determining prices in a mandi, trading related data for commodity price prediction and multiple other applications. These also constitute the deployment layer of IBM's solution.

The company is working with clients such as Government of Karnataka for Acreage Estimation, Supply Estimation, Price Prediction, and Crop Health Monitoring of Corn and Tomato for five districts. It is also working with several private clients for blockchain based traceability solutions, insurance advisory etc.

Partnership Example:

IBM – Ministry of Agriculture and Farmer's Welfare, Government of India[6]

Central Government (MOAFW) has partnered with IBM for conducting a pilot study under which IBM's Watson Decision Platform was used to obtain farm level weather forecast and village level soil moisture in three districts in Central & Western India.

[5] Interview with Dr. Shantanu Godbole, Senior Manager – Industries Research, IBM Research India
[6] Government Signs MoU with IBM for weather forecast, Economic Times, Accessed June 2020 https://economictimes.indiatimes.com/news/economy/agriculture/govt-signs-mou-with-ibm-for-weather-forecast/articleshow/70061187.cms?from=mdr

The pilot uses artificial intelligence and weather analytics to generate insights that will be used by farmers to make informed decisions regarding water and crop management and result in improved productivity.

Annexure 3: International Case Studies

Microsoft[7]

Microsoft is working to digitize several aspects of the agricultural value chain globally. It has developed various data-based solutions for on-farm production, market linkages, price discovery, market connections etc.

Another major aspect of Microsoft's digitization solution is sustainability. It aims to make farming more sustainable overall by deploying digital tools and practices by quantifying the impact and providing incentives to farmers/growers to ensure that they undertake data-based decisions.

One of the key projects on Digitization of the Production Phase of Agri-Value Chain is FarmBeats which uses TV White Space Frequencies to carry data from different nodes in the farm to the Base Station (farmer's home/office). This data is stored in the cloud and is processed to develop meaningful insights.

FarmBeats offers**:**

- Connected Farmers – Data collection using sensors, drones, connected farm equipments
- AI Based Advisory – Real-time actionable insights based on ground conditions combined with remote sensing and weather patterns
- Precision Farming – Irrigation, Fertilizing, Weeding, Spraying etc.
- Traceability – Blockchain for tracking of usage and compliance

The above are combined to achieve:

- Improved Yields
- Reduced Costs
- Sustainable Farming

FarmBeats is a product that Microsoft has deployed with several public and private partner organizations and institutions across the world. Some of the key partners are:

- CSIRO - Australia
- USDA, Land O'Lakes, PepsiCo - USA

The partnership model helps Microsoft reach end users (farmers) and provide them with digital solutions. FarmBeats uses Cloud, Edge, different data types and Artificial Intelligence to merge different data

[7] Inputs received from Dr. Ranveer Chandra, Chief Scientist, Azure Global, Microsoft

streams to develop concrete insights. The on-ground implementation is done by the partner organizations that are actively working with the farmers.

Issues around Data Sovereignty also need addressal before any widespread application of data tools can be made possible in any country across the world.

FarmBeats addresses the issue of data privacy by following a subscription model in which the analytics are run at the client end and Microsoft doesn't have access to the farmer data, its role is to develop the platform. However, if the client company needs to share data with other private players or the government, FarmBeats can be customized to include data sharing capabilities as well.

- **Partnership Example 1: Microsoft – Land O'Lakes -** Microsoft's partnership with Landolakes is structured around digitization of Land O'Lakes' existing tools. Land O'Lakes is a large farming cooperative based in Minneapolis, United States and works with crop growers as well as dairy farmers. Microsoft developed the digital tools for Land O'Lakes based on FarmBeats platform. One of the resulting tools is a Digital Dairy Platform where several data points, insights, and other tools can be accessed. These tools help the Cooperative's member become sustainable and adopt best practices for their businesses.
- **Partnership Example 2: Microsoft – PepsiCo -** Microsoft has partnered with PepsiCo in the US to increasing the productivity and profitability of Potato farmers associated with PepsiCo. FarmBeats is able to ingest several varied data streams from PepsiCo and run AI tasks that churn out insights to make the process highly sustainable and reduce the costs.
- **Partnership Example 3: Microsoft – USDA –** Under this partnership, Microsoft is helping the Agriculture Research Service under USDA to develop sound models for growing cover crops in the field. Microsoft is providing the technology for data recording and analyzing and the agri experts at USDA are turning this data into recommendations for the growers. They are advising the farmers about the right type and variety of cover crop to be grown alongside their main crop in the field. Cover crop usage while limited in india can impact the sector in multiple aspects. They can provide farmers with an additional financial source in addition to their main crop and their nutrient dense structure can boost soil quality gradually. Cover cropping was considered as one of the earliest regenerative agricultural practices and holds significant potential for India if done with the help of data backed advisory.

Similar partnership models can be explored in India between a large industry player and/or other private players, governments, development bodies, financial institutions etc.

Deployment can be done easily for large and medium scale farms in India. FarmBeats has sourced satellite data that it can combine with other data stream from the farm (sensor deployment, crop-soil related data) to develop insights. Robust cellular connectivity in rural India would also aid the deployment.

Challenge for deployment is around small and segregated farms. Multi-cropping patterns in these farm limit the usability of satellite data. The Sentinel Satellite data resolution is in the scale of 10 meters which limits its viability. In such cases, sub-meter resolution data is needed. Such high-resolution data is available from private players such as Planet Labs and Airbus but acquiring it would compromise with the affordability of the deployment. Unavailability of accurate weather-related data is also a challenge in the Indian context. For weather modelling purposes, digitized historical data is needed to make hyperlocal predictions.

Satellites launched with SAR capability can provide this much needed India specific data in sub-meter resolution. Leading government space research organizations (ISRO) can collaborate with Agricultural bodies for enabling this data.

Government's involvement in any such partnership is integral in an Indian scenario as not only it is the largest stakeholder in the agricultural sector, but also the largest custodian of farm data. Also, the farmers/growers would be much more amenable with the government is utilizing their data to develop useful outputs. Another important role can be played by the financial institutions (Banks/NBFCs) for accelerating the uptake of digital solutions. They can incentivize the farmers to adopt certain technologies in return for better loans and other financial support. This would result in reduced risk for the banks as digital tools would provide them with relevant data about the farms. Banks can also subsidize farmers for installing broadband connectivity in their farms and adopting other digitally means such as sensors, drones, and several applications.

Learnings from Netherlands

Agri-centric industrialized countries have also faced and overcome the challenges faced by Indian stakeholders today. The Netherlands through rigorous research and technology commercialization mechanisms has become a leading producer of agri-produce, despite its limited land mass. The example below demonstrates a collaborative initiative between a university-research institution and a private company for creating and utilizing a digital solution in Agriculture.

Kingdom of the Netherlands

Akkerweb[8]

Akkerweb is an online digital agriculture portal developed by collaborative efforts of Dutch Industry and Academia. It provides the users access to reliable data such as global weather conditions, satellite imagery, farm boundaries, and farm management.

akkerweb.

The team behind Akkerweb was building a Geographical Information System to analyze a wide range of soil samples and designing decision support systems to control plant-parasitic nematodes. The team decided to expand the scope of the platform to include several other data types such as satellite maps, sensor data, field data recorded through tractor mounted devices, weather data, among others.

Akkerweb was developed in partnership between Wageningen University & Research (WUR) and AgriFirm, a private agri enterprise that supplies input products to 50-60% of Dutch farmers. Development of the platform started in 20010 and it was officially launched for operations in spring 2016. It operates as a not for profit organization.

While WUR develops and maintains the platform, AgriFirm takes it to the farmers and enables last mile technology percolation. Apart from farmers, private companies also use certain applications from Akkerweb through a licensing-based model. Thus the platform has both B2C as well as a B2B2C models for its usage. The revenue sharing post deduction of expenses occurs between WUR and AgriFirm.

The team surveyed the ecosystem of tools and applications already existing and different data sources that were available. These were brought together under Akkerweb making it easier for the user (farmer or a private company) to access multiple different tools through the same gateway.

Akkerweb sources data from the government's PDOK (High Quality Geo-Data Platform), from the university (satellite imagery, soil maps, etc) as well as from several other sources such as IBM's Weather Company, commercial drone imagery. PDOK Platform has digital data sets about farm bounderies, elevation maps, no fly zones , and a whole host of other essential data sets. These data sets are available anonymously without sharing the personal details of the farmers and follow the European Privacy Guidelines.

[8] Inputs received from Dr. Thomas Been, Wageningen University & Research

Akkerweb also serves as a platform to demonstrate the innovations developed by WUR. Thus, it is also a knowledge dissemination platform for the university.

The portal also allows users to upload their own data, which is in the form of drone images, tractor mounted sensor information, among others. It supports all data formats containing geographical information. An important highlight of the platform is that the uploaded data remains the sole property of the uploader and is restricted for use by any third party without due permission. This ensures the privacy of data and allows diligent application by multiple parties. Farmers can 'be-friend' each other on the platform and allow sharing of whichever data they deem fit. Akkerweb doesn't share user data even with its stakeholders WUR and AgriFirm, without prior permission of the user.

Akkerweb also enables combining multiple data sources and their processing through one of its multiple modules or apps. The apps on the platform are provided by several providers. Both free to use and paid applications exist on the platform and can be accessed based on the need of the end user (farmer, input company, trader, government etc.). Despite having commercial aspect with the usage of applications, the charge for the same must be pre-approved by the consortium responsible for running Akkerweb.

Apart from accessing the existing applications on Akkerweb, users can develop their own applications using the API framework available on the platform. They can leverage digital databanks and task map generators to turn their ideas into implementable innovations.

Through its 5800+ users, Akkerweb has data of over 40,000+ farmed crop years saved.

Some of the most widely used applications available on Akkerweb are for farmers:

- **N-Sidedress App –** Nitrogen Estimation using a multistep analytical process.
- **Late Blight App –** Mapping and intimating the farmer about Potato Late Blight disease.
- **Potato Haulm Killing App –** Determining variable rate herbicide application based on drone or satellite imagery.

For Agrifirm

- **Agrifirm GBM** – calculate the need the crop protection for all parcels based on area, soil type and crop grown.
- **Agrifirm Mineraal** – calculate the fertilizer need for all parcels based on area, soil type and crop grown.

The platform uses a subscription model where farmers can subscribe to the platform without any cost and avail the services of both the free applications, and paid applications. Farmers and commercial entities both use the platform for different agricultural purposes. While a farmer uses it to estimate the amount of inputs to be used for a particular crop type in a given soil, a private company uses to forecast the demand of input products and the regional requirement types.

Akkerweb is an important example of using data analytics for developing meaningful and actionable insights that can be used across the sector. It is also an excellent example of the results that can be achieved when stakeholders combine resources: knowledge, manpower, and financial, and develop a tool to benefit the entire agricultural sector.

From an Indian perspective, platforms such as PDOK and Akkerweb can play an important role in accelerating the uptake of digital agricultural solutions. While PDOK is a governmental database with high quality, programming ready, georeferenced data, Akkerweb is a digital gateway for accessing several digital tools and applications.

Learnings can also be drawn from projects such as the **Dutch TopSector AgriFood Public Privat Project PA4.0**.[9] The project analyzed the uptake of data-driven agriculture in open farm cultivation from different techno-commercial and ethical-legal aspects, to generate recommendations for the stakeholders.

The different data sources that are prominent in Dutch farms are monitoring of soil, climate, crops through sensor systems, benchmarking the performance or crop and farm, brining accountability to the digital information of a farm submitted to government, institutions, or partners, operational decision optimization for harvesting and store, and optimization of tactical and strategic data driven decision making. Analysis of different bottlenecks reported the need for an improved de-centralized concept where each farm can have its own data space but with efficient model for interoperability between different partners.

The recommendations outlined different phases to define the architecture principles for smart data usage in open field farming, and the value chains associated with it. The initial phases outlined defining and bringing together different elements of the ecosystem, capacity building of the farmer to apply data driven tools, establishing a data silo (repository) on each farm, defining and extending the 'Code for Data Use' to ensure robust governing mechanisms, among several others. The following phase encompassed the technical application of the tools and implementation for improved irrigation, fuel management, input optimizations, and several such aspects.

The project is presently active and the detailed results of phase 1 would be available by the end of 2020. This initiative is of importance to India due to the similarity of issues regarding commercial feasibility, data sovereignty and other legal aspects. The TopSector framework encompasses collaboration between several public and private framework and a similar platform in India can be identified and developed to create holistic analysis and implementation plans.

[9] Precision Agriculture 4.0, Kempenaar Corne, Wageningen University & Research, Accessed 10th September 2020

Learnings from Australia

Australia is one the largest countries in the world but despite its large landmass it has faced several agricultural challenges primarily due to limited availability of arable land and freshwater reserves. The country has been a champion in the field of agricultural technology and has addressed the above issues by developing a rich ecosystem of research and on-field deployment. It is a global leader in Agri-Robotics and Precision Agriculture solutions with several successful examples existing to learn from.

CSIRO – PAT (Precision Agriculture Tools)[10]

The Commonwealth Scientific and Industrial Research Organization (CSIRO) is Australia's national science agency responsible for innovative scientific research. It has been active in Precision/Digital Agriculture research for over 20 years and, over a much longer period, has developed several solutions for addressing the challenges of the food and agricultural sector. Precision Agriculture Tools (PAT) is one such platform that provide a whole host of precision agriculture data analysis tools to users. The users include farmers, private companies, and agronomic consultants. PAT is available as a free plugin to QGIS (a free and open source Geographical Information System (GIS) software package. PAT was created to overcome one of the barriers to adoption of Precision Agriculture (PA) in terms of a shortage of technical expertise in spatial data analytics, and the cost and time required for this, and provides farmers and consultants access to GIS software and tools. These tools are used for generating yield maps, and integrating these with other data layers to enable identification of management zones, and many such precision agricultural purposes.

PAT was developed to address the issue of limited adoption of PA solutions by farmers. In Australia, most of the harvesters and other farm machinery used on grains farms come equipped with an attached yield monitor. Studies showed that while 87% of total farmers had access to these yield monitors, only 50% of them were actively using them to assess variability in crop performance on their farms.

The adoption was limited because either the data analysis solutions available were too difficult to deploy or too expensive to adopt. Thus, PAT was created as a free, open source, python-based library of analytical tools which tech-savvy farmers, or their advisors, could easily utilize. It is also beneficial for Consultants employed by farmers for data based agronomic advisory (in Australia, a consultant typically serves 15-20 farmers).

The tools and software that run with QGIS allow the user to clean, prepare, and analyse several data streams such as data from the farmer's yield monitor, high resolution/electromagnetic soil data, remotely sensed imagery among others. The data can be integrated and processed to generate different management zones within a farm. Different zones can be managed for different factors such as soil salinity, disease or pest, and declining crop health to name a few.

CSIRO had multiple existing precision agriculture tools that were being used for research purposes. These tools were converted to a digital library and a front-end plugin was created to access this library. The

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[10] Based on inputs received from Dr. Rob Bramley, Senior Principal Research Scientist, CSIRO, Australia

platform can be accessed by researchers as well to build solutions based on the existing tools. Thus, PAT is both an end user tool as well as a research tool.

A key learning from the research which led to the development of PAT – conducted across a range of cropping industries – is that the adoption of precision agriculture needs to be problem focussed. Thus, the first step is to recognize variability in the production system, with opportunities subsequently identified as to how these might be addressed. The development of PAT followed to facilitate this. This is in marked contrast to much of the development of AgTech which, in many cases, can present as a 'solution looking for a problem'.

Society for Precision Agriculture Australia (SPAA)

Another important example of inter-stakeholder collaboration from Australia is of th e Society for Precision Agriculture Australia (SPAA).

SPAA is a non-profit and independent membership-based organization that works towards accelerating the development and adoption of Precision Agriculture based innovation in Australia. The organization aims to increase the uptake of PA solutions and help improve the profitability and sustainability of agricultural production systems. The membership base includes farmers, consultants, machine manufacturers, researchers, and contractors.[11]

The SPAA collaborates with several other Australian bodies such as the universities, CSIRO, state departments of agriculture, equipment manufacturers, agribusiness and others.

Some of the key projects undertaken by SPAA include:

Application of Controlled Traffic Farming in the Low Rainfall Zone[12] - Controlled Traffic Farming (CTF) involves using permanent wheel tracks on which agricultural machinery can pass. It is practiced on large scale farms in Australia to reduce the negative impacts of soil compaction due to vehicular movement. The damage caused by heavy farm machinery to the soil can impact rainfall infiltration, rooting depth of the crops, and thus the crop yield. By practicing CTF, farmers can mitigate the disadvantageous effects of heavy machinery movement, simplify their operations, reduce water erosion by improving infiltration, and thus improve soil health with follow-on benefits for yield. These factors contribute to visible commercial benefits.

CTF adoption in the Low Rainfall Zone (LRZ) of the Southern Australian Regions was significantly lower (4%) in comparison to other zones in the region (26%). The primary cause for this was believed to be doubt regarding the benefits of CTF adoption in comparison to the cost of adoption.

The project evaluated the merits of this skepticism by using empirical research-based findings to answer the farmer queries and provide them with insights to make informed decisions regarding CTF adoption. The research was conducted by a consortium of nine organizations led by the Australian Controlled Traffic

[11] Society for Precision Agriculture Australia (SPAA) https://spaa.com.au/
[12] https://spaa.com.au/portfolio-item/controlled-traffic-farming/

Farming Association (ACTFA). SPAA played the role of conducting surveys, communications, and extension activities for the project.

The project was initiated in 2014 and concluded in 2019. The results were published in the form of case studies and indicated that the barriers to adoption such as lack of information towards CTF adoption and uncertainty about return on investment were answered by data-based interventions. The farmers witnessed increased yield, decreased input requirement, decreased fuel requirement for machines, among others.[13]

SPAA coordinated another project for the adoption of site-specific weed management (SSWM) strategies by demonstrating the commercial viability of a weed ID and mapping system. Adoption of SSWM strategies results in increased herbicide usage efficiency thus reducing the quantity of inputs used. The strategies help provide economic benefits to the growers by reducing the expense on input products while improving the quality of produce by reducing the phytotoxic effects on the crop. The benefits are also environmental and social in nature as they reduce the herbicide content in cropping systems and reduce the impact on biodiversity of flora and fauna.[14]

Under the project, H-Sensor from AgriCon, a German Enterprise, was assessed for commercial viability and was deployed in the field during the winters in 2015. During the initial phase, the device used German weed classification database. As the study progressed, the classification database was modified to include Australian weed types. Also, the images captured by the device were used for improving the algorithms and software to detect a range of weeds in Australian crop varieties. The initial goal was to differentiate between different broadleaf weeds to ensure correct classification of weed groups, differentiate all grass weeds from broadleaf crops that included canola, grain legumes such as lentils, peas, beans, chickpeas and lupins, and other similar weed classifications.

The results indicated that H Sensor had the ability to identify different weed types in a range of crop types. The performance of the device was highly sensitive to the crop and weed scenario. It could successfully identify grass weeds in broad leaf crops such as ryegrass, and broadleaf weeds such as the rosette forming weeds in pre-tillering cereal crops. The outcomes proved the device to be commercially viable and helped increase its rate of adoption amongst the growers.[15]

More broadly, SPAA produces a quarterly magazine 'PA News' which is made available to members and which is believed to be the only such PA-specific magazine in existence. It contains articles describing current research, farmer case studies and provides other useful information aimed at facilitating the adoption of PA technologies across a range of cropping and livestock farming systems.

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[13] 'On the right track – controlled traffic farming in the low rainfall zone of south-eastern Australia' Grains Research & Development Corporation, Accessed September 2020.

[14] THE H SENSOR: A WEED ID AND MAPPING SYSTEM, SPAA, Accessed August 2020 https://spaa.com.au/portfolio-item/3811/

[15] The H-Sensor: a weed ID and mapping system, The South Australian Grain Industry Trust Fund (SAGIT), Accessed August 2020 http://sagit.com.au/projects/h-sensor-weed-id-mapping-system/

Confederation of Indian Industry

125 Years: 1895-2020

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

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CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

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With 68 offices, including 9 Centres of Excellence, in India, and 11 overseas offices in Australia, China, Egypt, France, Germany, Indonesia, Singapore, South Africa, UAE, UK, and USA, as well as institutional partnerships with 394 counterpart organizations in 133 countries, CII serves as a reference point for Indian industry and the international business community.

FACE

CII-Jubilant Bhartia

Food and Agriculture Centre of Excellence

FACE is CII's Centre of Excellence dedicated to building efficiencies across the agricultural value chain from farm to fork. FACE is charged with the mission of improving competitiveness of India' agriculture and food sector by catalysing innovation, building capacity and enhancing productivity across the value chain. FACE works with farmers, companies, development institutions and the government to

- Improve on and off-farm productivity through the dissemination of best practices & technological innovation
- Invest in capacity building initiatives & skill development for supply chain participants across the value chain
- Strengthen linkages across the value chain through market access initiatives, thereby reducing losses and increasing farmer incomes

FACE's service portfolio comprises commodity specific value chain assessments and supply chain advisory services for food and agri businesses, training and consulting services in the area of food safety, and sectoral research across different market segments.

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