DETAILED PROJECT REPORT

ON

IMPLEMENTATION OF NATIONAL E-GOVERNANCE PLAN IN AGRICULTURE (NeGP-A)

Submitted to:-

Digital Agriculture Division, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India.

PUNJAB AGRO

Submitted by:-

Punjab Agri Export Corporation Limited (A State Govt. Undertaking) through Department of Agriculture and Farmers Welfare, Government of Punjab.

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1 Introduction

India, the world's second most populous nation is seeking to ensure food security not just for its population but also would want to play a pivotal role in securing food security for the world. In the overall scheme of things, Punjab is extremely important given the progress it has made in the agriculture sector over the past many years. Climate change is a reality; we have already started to see its impact of it with increasingly volatile weather conditions. In an increasingly volatile world access to information will hold the key to a proactive response to ensure effective risk mitigation and control. Climate change makes agriculture the most vulnerable sector hence a serious threat to food security.

Technology adoption is still at a nascent stage in India. “Limited availability of technology infrastructure and recurring natural phenomena like floods, and droughts have also worked against the deployment of digital solutions,” in India. However, there is one data source that is free from such natural hazards which is satellite data. If a harnessed way can potentially change the way we look at agriculture as the sector with recent advancement in satellite imagery, coupled with advancement in the field of computation has made technologies like Artificial intelligence/machine learning leveraging big data, a reality.

Punjab is one of the most fertile regions on Earth. The region is ideal for growing wheat, rice, sugarcane, fruits, and vegetables. Indian Punjab is called the “Granary of India” or India’s bread-basket. It produces 20% of India’s wheat and 9% of India’s rice. On a global scale, this represents 3% of the world’s production of these crops, so the Indian Punjab produces 2% of the world’s cotton, 2% of its wheat, and 1% of the world’s rice. The largest grown crop is wheat; however, other important crops are rice, cotton, sugarcane, pearl millet, maize, barley, and fruits. The principal crops of Punjab are barley, wheat, rice, maize, and sugarcane. Among the fodder crops are bajra and jowar. The main sources of irrigation are canals and tube wells. The economy of the state primarily depends upon the agriculture sector.The total geographical area of Punjab is 5.036 million hectares and the area under forest is 2, 93,000 hectares. The cultivable area is 4.20 million hectares (83.4%of total

geographical area) and the net area sown is 4.023 million hectares (95.7% of the cultivable area). The gross cropped area is 7.739 million hectares and the area sown more than once is 3.704 million hectares with a cropping intensity of 186 %. The net irrigated area is 4.019 million hectares (By canals- 26.2%, By Tube wells- 72.5%, and by others – 1.3%). The gross irrigated area is 7.442 million hectares and the percentage of net irrigated sown area is 96.17%. The total number of land holdings is 10.93 lakh out of which 2.04 lakh (18.7%) are marginal farmers, 1.83 lacks (16.7%) are small farmers, and 7.06 lakh (64.6%) farmers hold land above 2 hectares. As the farmer navigates through the crop cycle, they come across multiple challenges in the state across different crop phases such as **field preparation, sowing, crop monitoring & management, harvesting, post-harvest & marketing/selling of crops**. These challenges are due to climate change and uncertainty, which impacts the crop cycle; and information asymmetry, which limits farmers' ability to take timely decisions. For Punjab Agri Export Corporation Limited in association with other stake-holding departments there is a need **to create an efficient structure for collecting data and disseminating information to farmers** on various new technologies and to bring-in efficiencies by transforming the services by leveraging digital technologies, integration of best practices, and systematic management of interdependencies.

1.1 The Vision of the Project

Digital transformation technology can be a big enabler to bring transparency in the value chain of agriculture commodities. Digital technology including the internet, mobile technologies, sensors, remote-sensing, drones, data analytics, artificial intelligence, and block-chain are changing agriculture and its supply chain. It can provide better market linkage between producers and suppliers and new markets and enable new ways to monitor and ensure compliance with standards and provide a faster and more efficient procedure that is essential, especially for perishable products. This is achieved by digitizing the farmer data base giving access to technical know-how on crop planning and management, inputs, credit, post-harvest management, value addition, and better market linkages for the farmers. This

integrated block-chain platform would digitize all the farmers engaged with them across different districts in the state and makes the field-level data collection user-friendly. The centralized platform would help capture all relevant information through a simple mobile application and give dashboard-based insights on the data captured. Having field-level monitoring capability, all the farm activities are captured in the system ensuring traceability of the entire value chain.

Some of the problems made easy by Digital transformation are as under:

1. Supply chain efficiency & traceability through Block Chain platform.
2. Monitor and ensure compliance with standards operating procedures or Package of Practices to provide faster and more efficient procedures for advisory service.
3. Monitoring production, harvest & market linkage of Kinnow, Basmati Rice & Organic /Millets products.
4. Adhering to export compliance & building trust between consumers & suppliers.
5. Implementing a Package of Practices.
6. Value addition through enhancing the supply chain of an agricultural commodity through technology.

1.2 Primary Objectives:

Punjab Agri Export Corporation Limited (PAGREXCO) is a government enterprise established by the Government of Punjab in the year 1997 as the nodal agency for agricultural export from the state of Punjab, India. The company works for the export of fresh and processed agricultural produce, infrastructural development, and policy implementation in the state. It is a subsidiary of Punjab Agro Industries Corporation. The company has been awarded Sustainable Development Goals Action Award by the Punjab Planning Department for Sustainable Organic Production and Innovative Marketing System. It has also received a Leadership award in Agriculture Marketing.

The list of functions of PAGREXCO is as follows:

- Facilitating export of fresh & seasonal agricultural produce and value added products like; Chilli Paste, Rice, Wheat Flour etc.

- Exporting processed agricultural produce.
- Setting up the state-of-the-art infrastructure for facilitating organic farming.
- Introducing and developing high-tech Agri technologies.
- Promoting joint ventures for export-oriented Agro/horticulture farms.
- Dealing with all sorts of chemical and equipment-based needs for farming
- Facilitating farmers to adopt Organic cultivation in the State of Punjab.

As per the Government of Punjab, PAGREXCO is the mandated agency to implement the Organic Program by providing institutional support to the organic farmers of the state under various Government of India schemes to educate the farmers about product development and branding to market their produce. PAGREXCO has introduced an Agricultural Export Policy for medium to long-term export development, strengthening back-end and front-end infrastructure, developing production and export clusters and building capacity among farmers. The company also provides organic certification to eligible farmers.

The primary objectives of the project proposed by PAGREXCO and Agriculture Department are given below:

- To streamline services and operations across the agriculture value chain, into one single online platform.
- To create a seamless platform for efficient delivery of services by involving all stakeholders – Farmers, Businesses, State Agriculture Department, Department of Horticulture, Punjab Agriculture University and all other aligned Government Departments, etc., and to manage, monitor, control, and optimize all stakeholder actions.
- To create an efficient structure of dissemination of right and timely preventive & curative information to farmers on available crop cultivation technologies, schemes, advisory services and other needs to improve the farmers' overall development and welfare.
- To bring-in efficiencies by transforming the services by leveraging digital technologies, integration of best practices, and systematic management of interdependencies.
- To create a data-driven approach in the conceptualization, implementation, monitoring, and measurement of services delivery.

- To provide direct market access to farmers to reduce the middlemen intervention and to increase the farmers' share of agriculture revenue.
- To create a well-developed integrated service delivery reporting and monitoring system which would act as a critical tool to identify gaps and address them effectively.
- To enhance and scale up the existing Online Integrated service delivery platform to deliver need-based farm-specific services to farmers across the crop cycle.

1.3 Purpose of Designing, Implementation & Running of Traceability mechanism for all major agriculture/ horticulture crops & Organic Farming:

- The traceability mechanism is a secure, online, data hub that provides detailed analytics for regulatory agencies and law enforcement. Detailed reports will be available for the Department of Agriculture or other agencies once the technology is implemented. This ensures compliance and adherence to industry standards and state laws.
- The purpose of implementing this technology is to create a platform for managing the entire farming and agrarian base, manage monitor & advising farmers in their local languages, farm-to-fork traceability, and remote monitoring of the crops with satellite pictures aligned with the ground data captured.
- A farmer application for individual farmers to access the advisory, video training materials, and weather information through a farmer application as per crop requirement.
- The proposed agri-based IT solution to have a reports section that will provide the operational day-to-day as well as consolidated figures in the field of farmer's management, crop management, Agri-input management, field staff management, harvest management, marketing linkage, etc for managers/officers to check the field performance and act accordingly.
- A Comprehensive Map based Dashboard to give an overall perspective of how the clusters are performing. The farmer spread can be seen over the

map with the complete status of their crops, pest, and disease incidence, harvest, activities, etc so that real-time action can be taken to help the farmers.

- The department wants to implement this technology for following major agriculture and horticulture crops with a broad scope of work envisaged:

Kinnow:

- Development of Digital Ecosystem for Kinnow Crop Mapping (yield) production estimation.
- Marketing Information System (MIS) platform to facilitate vertical & horizontal market connect.
- Traceability and mobile application platform for e-marketing and to strengthen the supply chain.
- Design & development of the mobile application.
- Crop yield estimation.
- Setting-up of State Project Management Unit.
- Monitor crop health, irrigation, pesticide management, planting, etc.
- Block Chain Technology for Integrated Nutrient Management (INM)/ Integrated Pest Management (IPM).
- Yield level estimation by using remote sensing imagery (satellite/drone-based) for the yield prediction model.
- Sensing for soil moisture, health and nutrients.
- Information on water usage & optimal plant growth.
- Determining custom fertilizer profiles based on soil health.
- Information on optimal time of harvesting.
- Satellite data procurement images processing & crop advisory generation.
- Marketing linkage platform with real-time market information.

Basmati Rice:

- Traceability mechanism for target cluster.
- Crop monitoring.
- Monitoring the phase-wise production of the targeted cluster.

- Real-time weather advisory services.
- Crop yield estimation.
- Monitor crop health, irrigation, and pesticide residue-free management.

Organic Farming/ Millets Production:

- Soil testing management (soil organic carbon).
- Market linkage and promotion the certified organic products through digital marketing platforms.
- Crop monitoring through drone technology and yield estimation.
- Vermi compost & Organic manure management and its supply to strengthen the requirement of raw material for organic production.
- Development of a digital eco-system to promote the production of millets in the State.
- Awareness camps to promote the production of millet in the State.
- Identification of potential clusters for millets production as per millets.
- Strengthening the marketing of millet and its value-added products.
- Digital marketing & information platform for millets usage and to strengthen the supply chain of millets.
- Application of drone technology to monitor the production and processing of millets in a targeted cluster on a pilot basis.

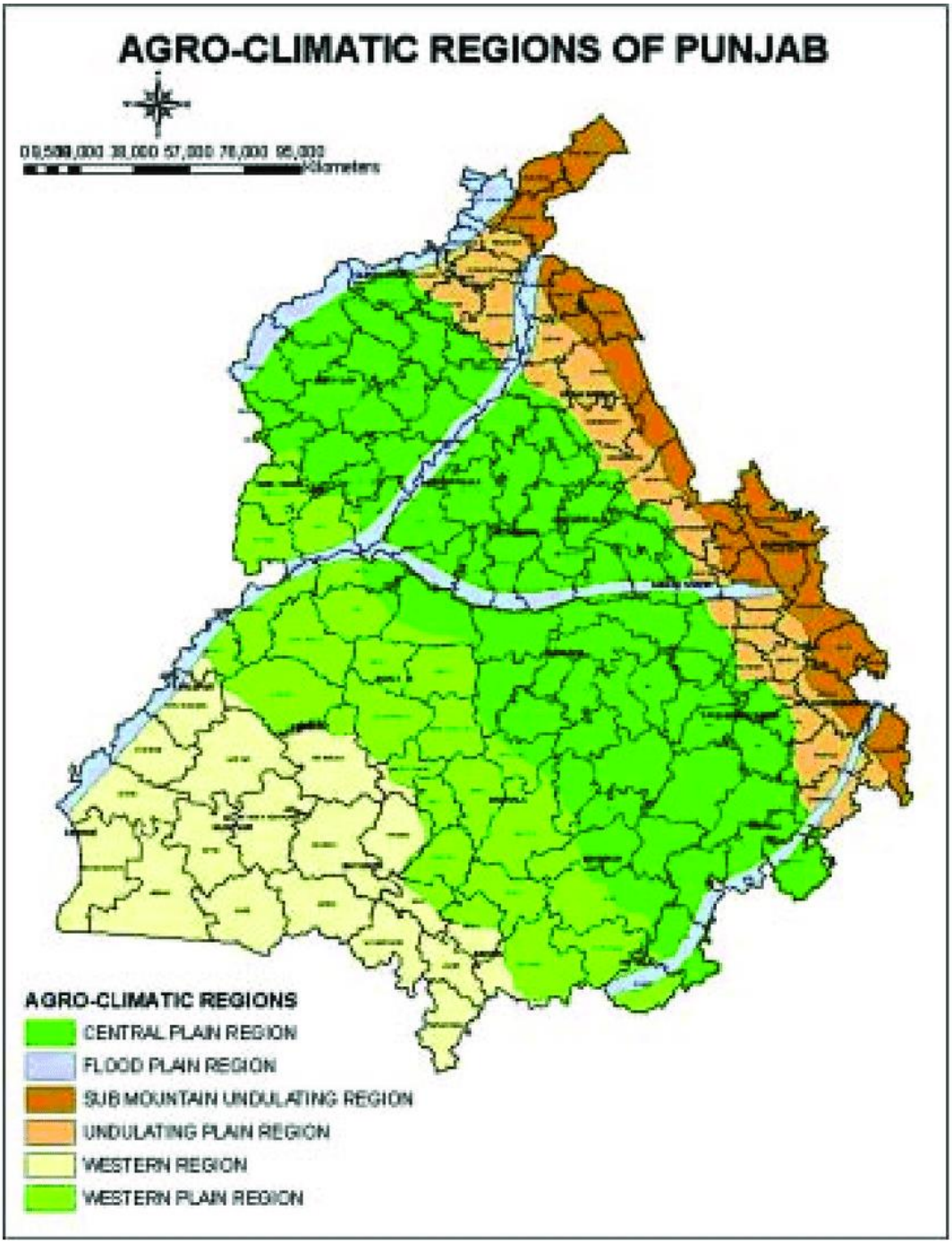
2 About DPR

2.1 Agro-Climatic Zones of Punjab

According to Punjab Agriculture University (PAU), Ludhiana, there are 6 agro-climatic zones in Punjab which include:

1. Sub-Mountain Undulating Region
2. Undulating Plain Region (UPR)
3. Central Plain Region (CPR)
4. Western Plain Region (WPR)
5. Western Region (WR)
6. Flood Plain Region (FPR)

These regions have rainfall variations from 165 mm to 2000 mm annually and climate from humid to cold-arid to arid and extreme arid. The variations in soil range from hill soils, tarai, brown hill, alluvial to desert.



Following are few major crops grown in this state based on the majorAgro-Climatic Zones:

Sr	Agro-climatic Zones	Districts Covered	Major Crops Grown	Average Rainfall (mm)	Cropping Intensity (%)
1	Sub-mountain undulating zone	Gurdaspur and Hoshiarpur	Wheat, paddy, sugarcane	1,000	177
2	Undulating plain zone	Rupnagar (Ropar) & SBS Nagar (Nawanshahr)	Wheat, paddy, sugarcane	1,000	187
3	Central plain zone	Amritsar, Tarn Taran, Kapurthala, Jalandhar, Ludhiana, Fatehgarh Sahib, Sangrur and Patiala	Wheat, paddy	630-700	189
4	Western plain zone	Firozpur and Faridkot	Wheat, paddy, cotton	630-700	190
5	Western zone	Moga, Bathinda, Mansa, Muktsar, Sangrur & Barnala	Wheat, paddy, cotton	630-700	193

SOURCE: Compiled from http://punjabrevenue.nic.in/for%20website/agro-climatic%20zone.htm and Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India.

The State has a Flood Plain region which is locally known as Bet area. Patiala, Ropar, Sangrur, Bathinda, Ferozepur districts fall under Bet area. This region has four components, Satluj, Beas, Ravi & Gagghar with an area of 3500 sq. km which is 7 percent area of the state. The flood plains transversally cut across the state in the east-west cross section, so the region is not homogenous in climatic conditions. The climate of different segments of Flood Plain region corresponds to the surrounding agro-climatic zone.

At present, 82 percent of the geographical area of the state is under cultivation. The cropping intensity is 191 percent with over 95 percent of the cultivable area being under assured irrigation. The gross area sown in the state was 7823 thousand hectares & Net area sown was 4119 thousand hectares during 2019-20. As per Agriculture Statistics At Glance of 2021, Issued by Government of India,, The State has highest yield of Rice (4366 kg per hectare) and Wheat (4862 kgs per hectare).

The food grain production in the state has increased from 3.16 million tons in 1960-61 to 31.53 million tons in 2018-19 with a minor decrease of 29.77 million tons in 2020-21. as a result of introduction of High Yielding Varieties & new technologies to the hard working and highly receptive farmers with the support of the government policies. The

Punjab state known as "**Granary of India**" has played key role in transforming India from a famine affected & grain importing nation to self-reliant& export surplus nation by contributing to the central pool over the years. Punjab contributed the production of wheat with 17.14 million hectare and 12.8 million hectares of rice to central pool during the year 2020-21.

The gains resulting from the success of ever-increasing food grain production during the past five decades, have not been without their consequent environmental & socio-economic costs. The major environmental issues assailing the agriculture in the state includes alarming decline in water table, deterioration soil health, non-judicious use of farm chemicals, reduced genetic diversity, crop residue management & over all degradation of fragile agro-ecosystem. Thus, it has resulted in greater impacts on environment & climate and health of people in the state. The stagnated yields and high cost of inputs are also leading to diminishing economic returns to farming community in the state.

Imperative initiatives are required to keep the agricultural economy of the state in stable condition like increase in Research and Development, crop diversification and to restore rural non-farm activities to put the agriculture sector of the state on fast track.

2.2 AI Powered Geo Spatial Block Chain Platform:

AI-powered Geo-spatial block chain platform is envisaged to create a geo – spatial intelligence web for agriculture to ensure a data-driven approach to policy making and interventions. It is expected to revolutionize the sector with information and bring symmetry in such information across all stakeholders to bridge the information asymmetry which exit today. It will have both direct and indirect effects on agriculture as a sector and the rural economy as a whole. It's going to cut across the value chain of agriculture and make all transactions more efficient. The state of Punjab has been at the forefront of adopting digital technologies to bring positive change in the agriculture sector. This is another step in making the sector truly digital with data lakes which will be benefited all stakeholders with backward or forward linkages to the sector. Information asymmetry across stake holders is the most fundamental challenge for the

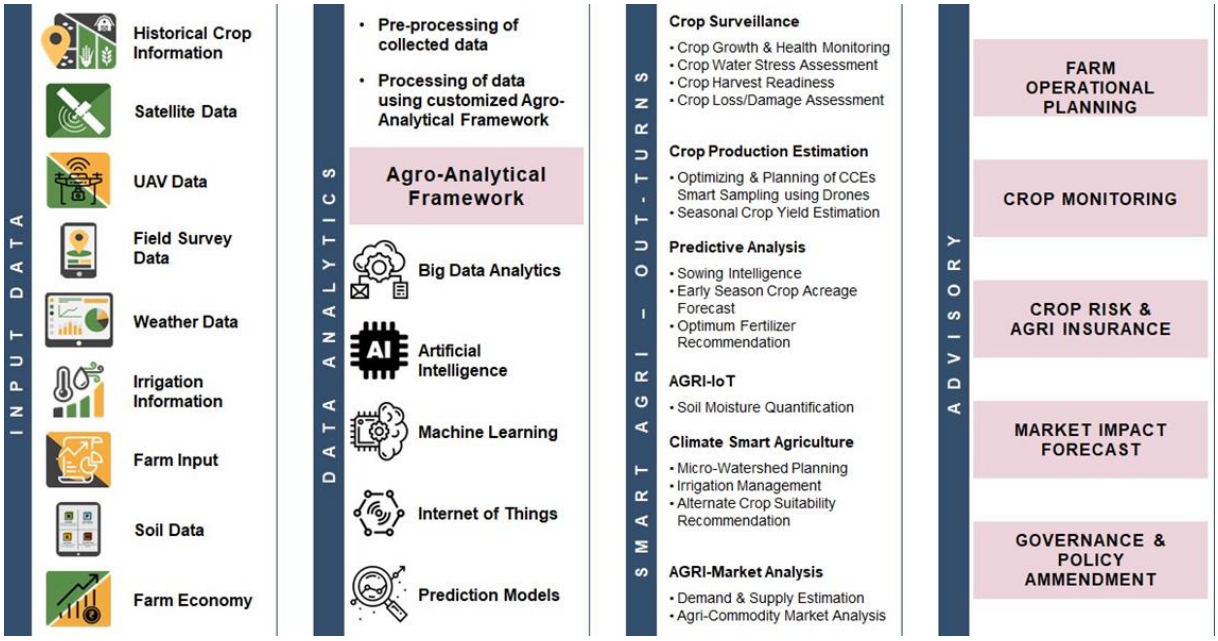
sector. Such information asymmetry makes every transaction costly and hence inefficient. To address the huge information asymmetry, we need to have a fully integrated decision support system with a 360-degree view of the sectors where all stakeholders with the backward or forward linkages to the sector including govt are fully connected in a true sense.

Access to real-time information powered by state-of-the-art intelligence shall make every transaction with the sector more efficient and cost-effective. The proposed dynamic decision support system aims at bridging information asymmetry across all stake holders including farmers to ensure that all can make more informed decisions. This project has three components:

The first component, Promoting Climate- resilient Agricultural Systems, aims to strengthen the adaptive capacity of smallholder farmers to adjust and modify their production systems to moderate potential future impacts from climate events.

The second component, Post- harvest Management, and Value Chain Promotion aim to support the participation of smallholder farmers in Farmer Producer Organizations (FPOs) and the integration of these FPOs in value chains for crops relevant to the climate agenda and to strengthen the supply chain for climate-resilient crop varieties in the project area.

The third component, Institutional Development, Knowledge and Policies for a Climate Resilient Agriculture, aims to enhance the transformative capacity of institutions and stakeholders to promote and pursue a more climate resilient agriculture, with sector strategies and policies based on strong analytical underpinnings and cutting- edge climate, water, and crop modelling.



2.3 Challenges and Problems to be Addressed: Agriculture Site

- Presently, agriculture has become a relatively unrewarding profession mainly due to low productivity, unfavourable prices, and practically little value addition.
- Scanty rainfall, scarcity of irrigation water, and inefficient water management practices constitute some of the major challenges in the State.
- Besides increasing the overall system productivity, the challenge also is appropriately reducing the cost of cultivation.
- The integrated farming approach is another area that needs preferential attention.
- Huge yield gaps exist between the experimental yield and those obtained at the farm level. Up-scaling of farm-validated modern technologies and agriculture innovation is often lacking.
- Farm mechanization, which is important for increasing production and quality of produce, is presently lacking in the State, especially in tribal areas.

2.4 Challenges and Problems to be Addressed: Technology Site

- The land size, cost, and benefits of technology are some of the economic factors that determine the rate of agricultural technology adoption.

- Farmers' education level, age, social groupings, and gender are some of the social factors that influence the probability of a farmer adopting modern agricultural technologies.
- Small-scale farmers face both internal and external challenges as far as the adoption of modern agricultural technologies is concerned. This aspect accounts for the slow rate at which such technologies are adopted.

The challenge also is to provide proper institutional mechanisms and coordination between various agencies for development activities and investment for overcoming the felt constraints coming in the way of farm prosperity in the State.

Regardless of the challenges, what matters is whether modern technology has any value in the agricultural sector especially Karnataka state-specific requirements in the current scenario and futuristic changes. One of the challenges that farmers face nowadays is the need to satisfy labour. There is an increasing cost of labour, which calls for better approaches to ensure less cost of labour. The use of modern technology in agriculture ensures that farmers grow vast food within the shortest time possible. It is therefore important, to plant; early harvest, in time, as well as ensure that the yield is stored within the right time.

2.5 National e-Governance Plan in Agriculture (NeGP-A)

National e-Governance Plan in Agriculture (NeGP-A), is a central government sponsored scheme where in use of Information & Communication Technology (ICT) is used in agriculture information distribution to the Indian farmer. All the relevant information pertaining to agriculture is provided to farming community, government agencies, private sectors, and any stakeholder involved in agriculture. This scheme will improve access of farmers to on-time and relevant information & services throughout crop-cycle. This can be achieved through a uniform platform and hence the time between the generation and dissemination of information is reduced. It is important to notice that this plan is farmer centric and all relevant information is provided in a real-time manned, with utmost transparencies and with advisory services.

With recent significant advancement in smart agriculture, more focus is given to remote sensing &GIS system, data analytics, cloud computing, Artificial Intelligence and Machine Learning (AIML) tool, Drone implementation and Blockchain in the supply chain for traceability. To infuse these advancements in agriculture to make it more accurate in assessing and determining more developed solutions to make better implementations; the government has made amendments to NeGP-A.

3 Benefits of Blockchain enabled Platform for Traceability

The department has already implemented a Blockchain-based traceability mechanism for seed potato &Organic cultivation2 since 2019 and currently, the department is envisaged to develop an advanced version of the blockchain platform which includes state of art remote sensing, drone, Artificial Intelligence, and Machine learning algorithm. It will be designed to bring all stakeholders on board on a common platform to help regulation with data and compliance processes. It will be built on more advance digital technologies such as IoT and Deep Learning which enables much more possibilities and superior data security.

It allows all participants in the seed & crop supply chain and its respective organic traceability including Seed Regulators, Farmers, Seed Companies, Processors, Distributors, and Retailers to be on board a private permissioned Blockchain based platform and record all transactions between them digitized and stored on Blockchain so it cannot be manipulated or changed.

The kea features are:

- The authenticity of all information is proved by Blockchain technology.
- All Seed companies, final crop output stakeholders, Certifiers, Processors Distributors, and farmers use the platform for registering the transactions and they are recorded in an immutable and transparent manner.
- The transparency will be well connected to both vertical market and horizontal market.
- Seed-specific information such as geographical indications, weather conditions, soil moisture, humidity, etc. can be recorded using IoT devices

- Role-based access is provided to all stakeholders with convenient Web and Mobile UI
- All functions are strategically built to have all the information all along the process coming from each stakeholder stored on Blockchain and available to view on a need basis.
- Geo-tagged photos can be taken from the farm and processing

Using state of art remote sensing, drone, artificial intelligence, and machine learning all critical information associated with the crop life cycle. The fundamental benefits are:

3.1 Crop Area Estimate, Yield Estimate, and Performance Monitoring to Manage Supply-Side Risk:

While for the government the real benefit lies in ability to assess acreage under different crops in quick time and the ability to assess the crop growth more frequently to be able to assess the situation in advance as it has impact on various critical decision that the government undertakes. Traditional approach which is predominantly based on surveys / crop cutting experiments are time consuming and costly. Moreover, the coverage is always a challenge given the geographical area to be covered. Given the scale, the sample size for these surveys / crop cutting exercise is always a challenge. More importantly by the time the yield is assessed it is already a reality. There is literally no response time. This leaves all stakeholders including government and famers exposed to supply side risk on either side (deficits / surplus).

One of the main objective is to leverages such a technology to able to monitor crop across the life cycle of the crop growth to be able to forecast likely yield with acceptable confidence to ensure lead time to respond to ground realities instead, of treating it as supply side shock which has been the reality so far.

3.2 Run the Business of Agriculture More Business-Like

Until advancement in remote sensing, there was no primary source of high frequency data available to be able to monitor crops growth. The alternate technologies were prohibitively expensive. With advancement in remote sensing, coupled with

advancement in the area of computation, machine learning and AI has made it possible monitor every single land parcel with high frequency in near real time. These advances create a significant opportunity to make all interventions and interaction with the sector data driven and run the whole sector more like business to make it viable and sustainable. At the same time make the business of farming more lucrative.

3.3 Acreage Allocation to Crop (Profitable &Sustainable Farming)

Any yield improvement measures must also be linked with crop diversity as it would otherwise lead to oversupply situation which will not help price realization of end produce. We must ensure that the areas under cultivation across all Agriculture commodities are linked with market. Unless collective intelligence is made available to farmers to ensure they can take more informed decision on how much areas they should allocate to which crop given the likely yield. Unless the collective intelligence is made available and consumable, we cannot protect farmers from falling on the wrong side of the price curve. Area allocation is critical for price realization. One of the medium-term objectives is hence to drive crop diversity leveraging a digital platform to not only monitor the farm land but also aggregate farmers on such platform to ensure that the desired end objective is achieved. The ultimate success parameter will be impact it creates own farmer's income. Monitoring alone won't suffice unless some of the key objectives are met. The ultimate objective remains making farming sustainable and profitable as a result of which farmers income shall improve.

3.4 Climate Change

Climate change is another concern which is already reality. Weather risk management becomes extremely critical to manage otherwise it potentially wipe out all the gains of past we have made. Agriculture is one of the most vulnerable sectors as it depends heavily on weather conditions. Such platform which also aggregate farmers in due course would also help in weathering the weather risk.

3.5 Fundamental Benefits

Timely precise & reliable information of crop area acreage, crop condition & growth estimate at regular interval with frequent revisit to ensure that the yield estimates are always updated based on latest on the ground condition instead of waiting till the time of harvest. The fundamental advantages can be summarized as below:

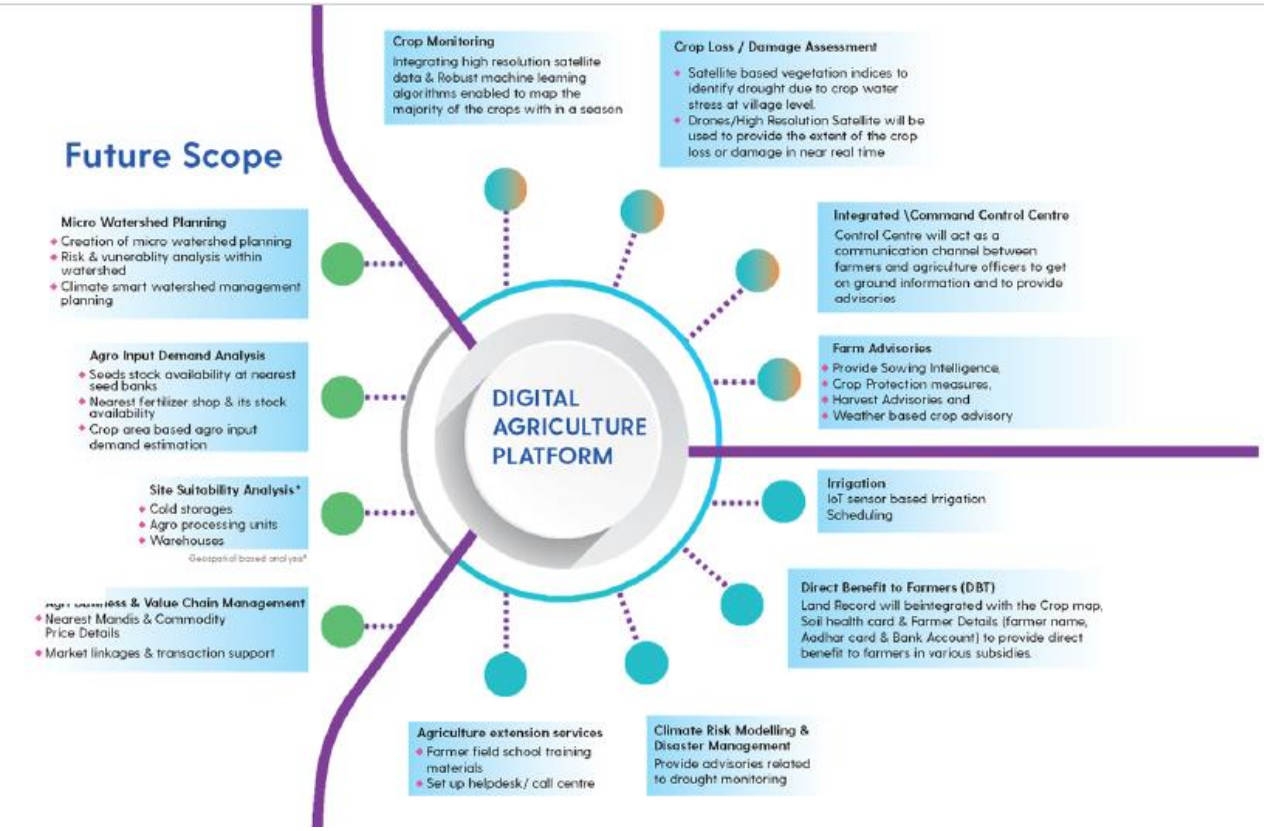
- Season wise crop monitoring at village level with information on crop and performance for individual land parcels within village.
- Pre- and post-harvest risk assessment for all clusters / administrative boundaries: real time dashboard on performance and risks.
- Accurate incidents assessment like drought, pest attacks or other stress leveraging satellite data which can be further augmented with UAV data.
- Unified dashboard with single version of truth across all stake holders within and outside government in the form of web GIS.
- Reduction in cost by moving away from manual crop cutting exercise in due course “Leverage satellite data for crop yield estimates which is further augmented with ground trothing leverage UAV (drone data). Leveraging UAV for ground truthing will not only help improve the efficiency but also allows for creating significantly larger sample size for ground truthing.”
- Generate skills in the field of remote sensing, machine learning and AI.
- Generation of employment and skills in the sector of Remote sensing and GIS not only as office apprentices but also at field level by setting up a geo spatial capacity Centre in Punjab state.

4 Strategy- Block Chain Platform Components &Features: Overview of Proposed Project:

4.1 Technology based Agriculture.

Technological reformation has prospective of transforming agriculture and dairy technology. The technological requirements are also changing as per the global changing situations where farmers also want to unlock innovation using modern technology for competitive productivity. Technology has potential to address challenges

such as inadequate demand prediction, lack of assured irrigation, and overuse / misuse of pesticides and fertilizers, improvement in crop yield through real time advisory, advanced detection of pest attacks, and prediction of crop prices to inform sowing practices. We need to develop deep learning and big data analysis tool that facilitate real-time decision making and make use of appropriate framework/platform for collecting contextual data in an efficient manner.



The technology solutions need to become more affordable to ensure that the technology reaches the farmers in cost effective manner. This should also use an open source platform which would make the solutions more affordable using available resources with the farmers in the remotest location of the state (like mobile and internet connectivity), with resulting in rapid adoption and higher penetration among the farmers. The technology should be useful in helping farmers in high yielding and having a better seasonal crop at regular interval. “Proposed Plan will be designed for State Wide Artificial Intelligence and Hi-tech Interventions in Agriculture for the State of Punjab”

4.2 Intangible benefits of Block chain platform along with Target Stakeholders of the Agriculture ecosystem

4.2.1 Policy Makers and Government

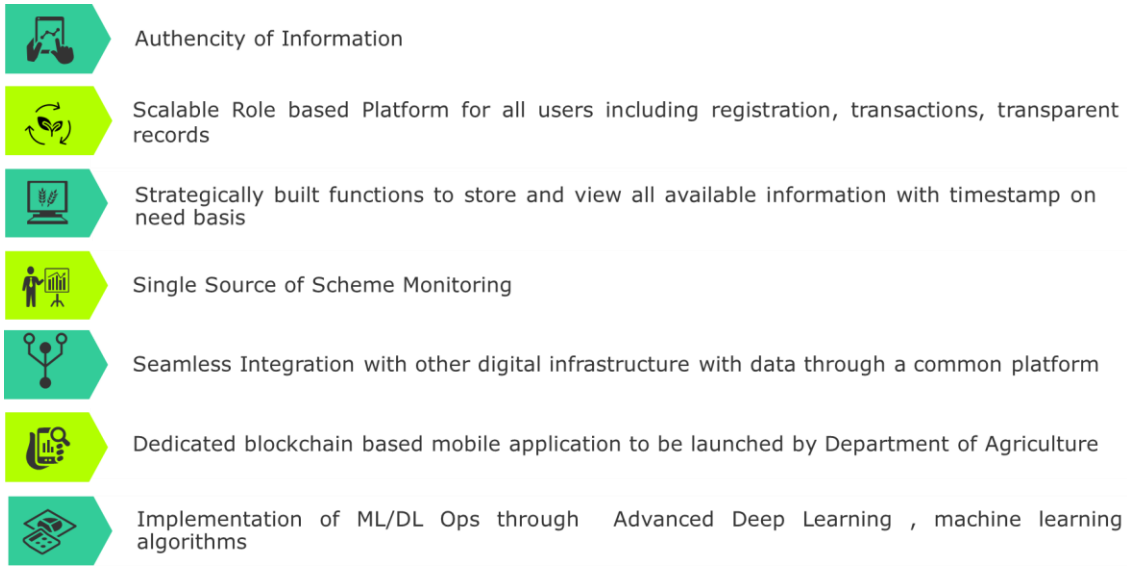
Data-Driven measures on Policy & Scheme Effectiveness	Measure effectiveness of Policies and Schemes: Data-driven effectiveness and off take measure across the cluster in real-time A. Real-time access to off take on various Policies and schemes B. Real-time access to off-take on incentives understand various schemes C. Areas-wise estimate on off take D. Identify areas with high off take vs those with low off takes E. Understand the bottle necks in off take Impact Assessment: A. Detect changes: Pre-and post-roll-out of schemes/Policies B. Area/Cluster dynamics: Identity areas with significant changes vs clusters with no impact. Area/Cluster wise mapping of Schemes and Policies A. Ability to map schemes and policies based on ground reality. B. Monitor cluster-wise performance of various schemes C. Monitor progress on the roll out of schemes and policies across clusters in real-time Cluster/geography Wise performance Benchmarking
Real-time dashboard	Stress Watch: Real-time stress watch for the sector at various levels of granularity with the ability to drill down to individual farmers in stress A. Performance / Stress Monitoring at various levels of granularity a) State b) District c) Taluka d) Panchayat e) Village f) User Defined Cluster B. Predict monetary losses and provides compensation

	benefits proactively C. Create contingency and emergency plans based on possible crops failures <u>Vulnerability Index:</u> Real-time stress watch for the sector at various levels of granularity with the ability to drill down to individual farmers in stress A. Create contingency and emergency plans based on possible crops failures B. Monitoring change in vulnerability index a) Identify clusters with improvement on vulnerability index vs those with no or negative change C. Fund utilization under various schemes specifically meant to address the vulnerability Progress on various initiatives linked to specific vulnerabilities across the cluster
Seed, the harvest, Fertilizer & Pesticides Distribution	<u>Estimate demand for various seeds and fertilizers across the cluster</u> • Geo-tagged land parcels and soil quality map: Results in a more targeted approach to the right fertilizer for any given land parcel to ensure an optimal mix of fertilizer for every land parcel. • Monitor performance of various seeds across the cluster: With geo-tagged land parcels, it becomes feasible to monitor the performance of various seeds across the cluster as it makes the pre-post analysis of performance feasible. • Monitor the performance of various fertilizers across land parcels which makes recommendations more targeted and precise for every land parcel depending on soil quality weather conditions and crops. • Link input to farming calendar: as the farming calendar gets linked for every land parcel, the right input at the right time is feasible. • Ensure the availability of seeds ideal for the crop for all clusters • Ensure the availability of fertilizer across clusters covering the complete life cycle of harvesting. • Real-time access to performance in real-time to ensure that any stress is detected early for proactive interventions. Ensure timely delivery of pesticides to all plots which are

	likely to be under stress due to pest attacks.
Insurance Claim Settlement	Stress Watch: • Claim processing is one of the most tedious and time-consuming processes today which does not benefit any of the stakeholders. The moment claims hit the system fund is to be allocated but it sits idle until the complete cycle of the claim processing including verification is complete • Invariably this results in delay in processing genuine claims at the same time there is a time value of money which is a dead weight loss. Ideally, if this can be saved, the same will help in reducing the cost of insurance which currently is indeed expensive • Decision Support System –Unified Farmer-Centric Platform • Real-time stress watch for the sector at various levels of granularity with the ability to drill down to individual land parcels under stress • Real-time assessment of claims • Real-time processing of claims • Proactive intervention to minimize loss at the time of stress to reduce likely claims
BFSI: Access to credit	Real-time loan processing at a reduced cost: • Information asymmetry in sectors results in a cost of transaction which ultimately affects the cost at which a product or service can be delivered to the end beneficiary. • A 360-degree view of the sector with information available at individual survey numbers will go a long way in easing out the access to credit to the large set of farmers. • Currently given the cost of operation which involved physical verification of assets makes it non–scalable and costly for lending institutions. More often this results in a secondary market where mostly the local credit lending institutions tend to be more active and the larger banks (barring PSUs). Meet their priority sector lending targets through portfolio buyouts from such regional players.

	• Moreover, the distinction between real cultivator's vs those with land holding but non-active farming activities tend to benefit at the cost of proactive smaller and marginal farmers. • The proposed platform can change that for good with real-time reliable information with performance scores for every land parcel, this will give the edge to those who are active as opposed to those with simply large land holdings. More importantly, it will bring down the cost of interest for the community as a whole as the cost of processing such a loan goes to zero given no physical verification.

4.3 Addressing Capabilities and Issues



Blockchain enabled Platform for traceability

A Geospatial AI-based application is to be developed to provide agriculture advisory services for various stakeholders involved in agriculture-related decision-making processes. It will offer a holistic view of the agricultural ecosystem. The Machine learning-driven insights offer greater visibility to decision-makers in government to formulate optimal strategies for planning, distribution, marketing, procurement,

transportation, and storage of essential agricultural products. It will be focused on 5 core thematic areas:

- Crop Estimations
- Disasters
- Crop Insurance
- Soil Nutrients
- Agro-forestry

More thematic areas could be added in as the application matures, and its usage improves. It can also enable private players to test out the products and solutions through an API.API will be such that, only the central infrastructure that would allow individuals and organizations to test their technologies, solutions, and digital services in a safe, contained, and controlled environment to safely fail, get quick feedback, learn, re-iterate, and succeed.

It can also be enabling the Integrated Command & Control Centre in the department to monitor the Agriculture schemes in India, support pro-active and timely response to exigency events, and generate useful insights to support data-driven policy development along with following recompenses:

- Give useful insights into the agriculture sector in India
- Help in proactive and timely responses to droughts, disasters, and pest attacks in India
- Support in monitoring and implementation of schemes of the Ministry at state and national level
- Support decision-making in the Ministry through data-driven insights as and when required.

4.4 Key Features

- **Modern Architecture**: this platform will leverage machine learning to create insights from satellite imagery, weather data, soil data, agriculture input datasets, and consumer demand proxies. A solution should be built using microservices

and open-source technologies so that it can be deployed on the cloud or premise as per customers' requirements.

- **Holistic View**: A design is to be developed to capture, aggregate, and archive satellite imageries, weather data, and farm details of agriculture such as crop type, crop health, yield, and production. It should also generate alerts and notifications in case of exceptional scenarios so that timely and data-driven decisions can be made by policymakers and agriculture extension service providers.
- **Operational Efficiency**: Designed to help improve the efficiency and productivity of government entities by providing real-time insights about crops and their performance in a single dashboard, also helps authorities to manage workforce and tasks, and allocate resources based on field-level data.
- **Scalable**: The platform would be highly scalable, and can be deployed at national, regional, and sub-regional levels based on customer's requirements. Insights are produced at different administrative levels which can benefit from small co-operatives, farmer-producer companies large agribusiness corporations, and government agencies.
- **Data Storage**: The platform would have a scalable and secure storage system to store the data from various sources. The data storage system would include relational databases, NoSQL databases, or a combination of both.
- **Data Processing**: The platform would be able to process data from different sources to generate useful information. This can involve data cleaning, data transformation, feature extraction, and data aggregation.
- **Analytics Engine**: The platform would have an analytics engine that supports geospatial analysis and provides various data visualization and analysis tools. This engine would be able to generate insights and help users make informed decisions.
- **APIs and SDKs**: The platform would provide APIs and SDKs to enable developers to build custom applications and integrations with other systems.
- **Security and Access Control**: The platform would have a security framework to ensure the confidentiality, integrity, and availability of the data. The security

framework would also enable access control to the data based on user roles and permissions.

5 Block-Chain Platform Feature

The functional architecture will have the stratified components in each layer of the digital platform. It consists of external integration services, enterprise utility services, platform service, agriculture extension services

5.1 External integration service

The digital platform will have the capability to integrate external data sources through API and online based platform. External integration services in the platform will include:

- Satellite data
- Weather data
- Soil Health card data
- Land records

5.2 Enterprise utility services

- Centralized logging audit & monitoring: The logging and audit module stores the audit logs for critical transactions performed on the application. Further, monitoring services for API-level interfaces are also encapsulated in this block.
- Issues management: The issues management module is a generic module used for managing service tickets – it provides a workflow to resolve tickets using a set of standard operating procedures. The department operators will have the flexibility to create SOPs and then use predefined workflows to address the service tickets.
- Identity and access management: The identity and access management module manage the identity of the users, along with the roles and tasks allocated to the user. This module also manages the authentication and authorization of various other modules while they access other functionalities of the product.
- Alerts and notifications: The alerts and notifications module delivers the advisories or notifications to the end users – such end users can be farmers or

extension workers. The module accepts advisories from insights input services and sends advisories to the end users using notifications on the app, emails, and messages.

- Content management: This module manages media in terms of PDF documents, and videos for extension services. This module also will serve as an image store for all images that are uploaded by the farmers from the mobile application. This module is used by visualization service and extension service.

5.3 Platform services

- Government and business services: Disaster management will be integrating satellite and weather data to provide various insights such as crop damage area, Inundated area, spatial view of the damaged areas, etc. to the government officials to mitigate the situation. Service request module will farmers to directly connect with department officials and request their services. Real-time Market Price module will get crop-wise market price details from each mandi and provide personalized advisories to the registered officers and farmers based on their geo-location.
- Forms, Maps, Reports, Advisories, and dashboards services: Krishi DSS creates Various reports at regular intervals and results which will be displayed in the map as well as table format in an interactive dashboard. Aggregated view of results in a single screen enables authorities in quick decision-making.
- Crop Acreage: Crop acreage maps and statistics will be created at different stages of the crop season for example in the early season to show the sowing progress, mid-season, and at the end to get the final acreage of the season.
- Crop Condition: Satellite data derived vegetation indices-based crop health condition assessment at peak vegetation stage.
- Crop Loss assessment: Satellite and ground information integrated crop loss assessment in case of any natural calamities' occurrence.
- Mid-season adversities: Satellite and ground information integrated, mid-season adversities assessment in case of drought condition impact on crops.

- Crop Yield estimation: Satellite data and crop model integrated, crop yield estimation of all major crops before harvesting of crops
- CCE Smart sampling: Satellite data-based CCE smart sampling plan at the crop condition assessment.
- Field Data Management: Effective management of field data collected by village agriculture officers. Multiple information collected related to crops is integrated with location-registered geo tagged photographs and stored in a cloud platform which enables department authorities to download and analyze collected field data in real-time.
- Demand and Supply Management: Taking the advantage of satellite data, weather data, and agriculture input data to estimate demand for agriculture inputs such as fertilizer, pesticides, and seeds and further enables government departments to make data-driven decisions to ensure the right inputs are available in the right quantities at the required regions.
- Schemes Implementation: Effective dispersal of government schemes and their benefits to farmers. It also facilitates authorities to monitor the impact of the schemes implemented and helps in the verification of the authenticity of the applied beneficiary.
- Disaster Management: Use of satellite, UAV, and weather datasets combined with advanced crop models to assess crop loss due to mid-season adversities or natural disasters. It also helps the agriculture department in effective resource planning, deployment, and compensation to farmers immediately after a disaster occurrence.

5.4 Agriculture Extension Services

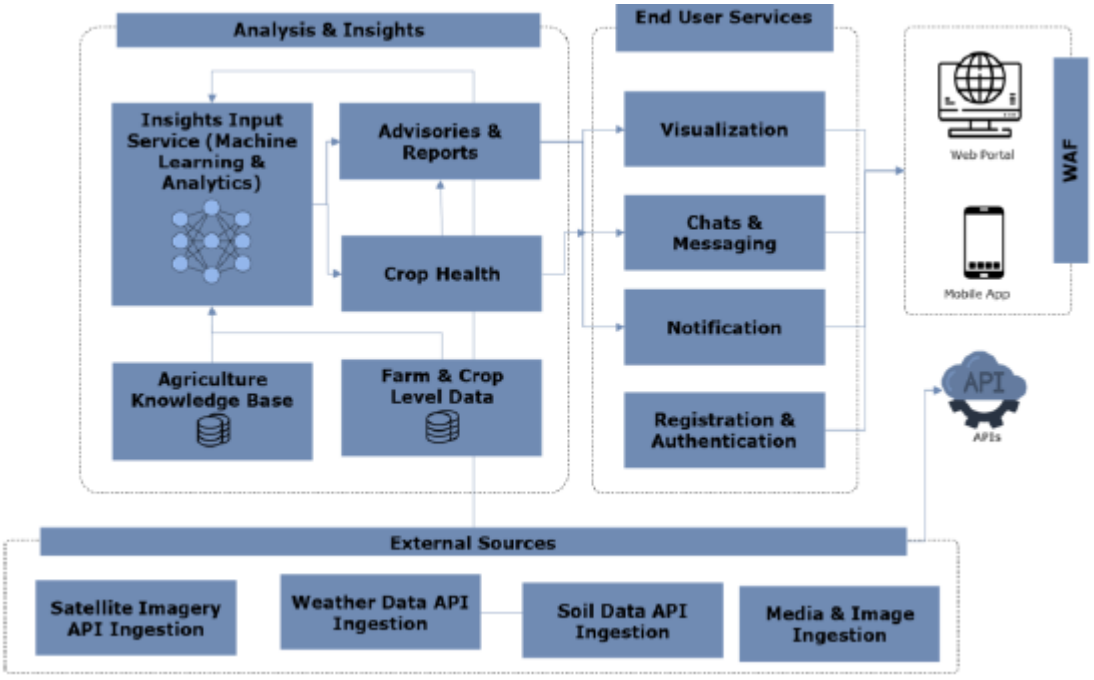
The development of an extensive knowledge database of the agro-ecosystem and the insights created from ML analytics help the agriculture department to select and disperse the right advice to extension services at the right time.

- Agro Meteorology Data Integration: Connectivity with automatic weather stations and satellite-based weather data sources to collect agro-meteorology data which

are the basis of decision-making for crop production. Predictive weather insights help department authorities in season planning and agro inputs distribution and help to get prepared for adverse weather situations.

- Harvest Progress: Leveraging multi-dated satellite data combined with advanced crop models helps to track crop-wise harvest progress in a region. This can help the department to plan their crop-cutting experiment activities such as resource deployment and selecting survey farms in advance.
- Cloud architecture & deployment: Cloud hosting is a robust, stable, and integrated platform on which complex high-volume applications can be built. Cloud hosting will reduce the time devoted to “cobbling together” infrastructure components required to support IT requirements. The upgrade scalability is easier with modular, secured, and scalable components of cloud hosting. The successful applicant will be deployed on a cloud environment. Cloud computing enables access to resources such as storage and server without incurring upfront capex infrastructure on the resources. Cloud computing eliminates the need to buy infrastructure on an outright basis, further reduces the requirement for employing qualified personnel to man the data centre, and reduces the need to have the elaborate civil, electrical, and cooling infrastructure to sustain the computing and storage infrastructure. The cloud will allow clients to access storage and servers on a run-time basis based on the demand from the stakeholders of the client as well as based on the computing requirement of software generating the insights.
- The system architecture’s four components: Every component in the platform will be designed and developed keeping the requirements of critical workloads of the production environment. It will include scalable compute resources, enterprise-class storage, multi-layer integrated security options and services, access network, monitoring, and management support. Cloud platforms will help in taking advantage of virtualization, massive scalability, integrated scalable components with enterprise security, and intelligent management with granular control.

1. Ingestion from external sources: The data from sources such as satellite imagery, weather data, and soil data will be ingested through the computing and storage provided by the cloud service provider.
2. Analytics and Insights: The objective of the client is to generate context-specific advisories and reports which will benefit the farmers and government stakeholders alike. This will be accomplished through machine learning algorithms to generate specific advisories and reports. This will consume the data generated from farm and crop level information provided by farmers, internal agriculture knowledgebase, satellite images, weather information, and soil data.
3. End-user modules: The end-user modules will gather processed data from the analysis and insights block, and provide visualization in form of maps-based reports, MIS reports, and contextual advisories. This module will also provide notifications, and messaging services to the end users.
4. Portal, mobile applications, and affiliated infrastructure: WAF and load balancing for external users will be performed within this block.



6 Functional components

6.1 Data Integration & Data Mapping

a) Macro data mapping
   1) Macro Soil Quality map
   2) Water Table / irrigation map: Already Available just that its static what is required is dynamic irrigation map which takes into account current condition: A system which dynamically updates the state of water resource
   3) Moisture transition overtime to understand the likely impact on current crops and potential transition
   4) Current land use and potential impact of transition
      i. Weather
      ii. Water table
      iii. Historical crop cover
      iv. Potential impact on popular crops

b) Micro Data collation and geospatial mapping with context
   1) Know your asset:
      i. Integration with Cadastral mapping with geo referencing: (Some of the states have already completed the exercise just that the progress has been wanting can be done in real time leveraging modern technology
      ii. Quality tagging: Overlay macro and micro soil quality if available, crowd source otherwise from leveraging help groups
      iii. Irrigation Score based on true ground condition leveraging SAR satellite in combination with earth observatory satellite
   2) Performance benchmarking and rating based on historical data: Classify individual and parcels into
      1. Super Prime
      2. Prime
      3. Average
      4. Sub-prime
      5. poor

6. Fallow land
7. Wasteland

3) Monitor Asset:
   i. Identify current crop across season
   ii. Monitor growth(near Real time)
   iii. Monitor weather condition (Real time)
   iv. Monitor stress (Real time)
   v. Estimate Yield (Near Real time)
4) Derive Intelligence:
   i. Identify best crop given soil quality/terrain/weather transition/soil moisture transition (Structural in nature to be updated in medium term)
   ii. Identify potential crop transition (Structural in nature to be updated in medium term)
   iii. Identify potential for high value crop transition
5) AggregateMicroleveldataandintelligencetogeneratemacrolevelaggregatedfore castwithprecisionlikeneverbefore
   i. Precise estimate on area under cultivation across all crop: The very basic fundamental requirement in order to have any reliable forecast on supply side (currently based on surveys: Now based on satellite data augmented with UAV data)
   ii. Generate Supply side forecast leveraging
      a) Precise estimate on area under cultivation across all major crops
      b) Weather condition exposure to individual land parcels hence crop
      c) Micro level stress maps and growth estimate (today one can even Perform daily monitoring leveraging multiple satellites: such data is already available)
6) Weather Data: Hyper Local weather Data (historical & Forecast)
7) Weather Transition map
8) Soil Moisture Transition Map
9) Market Data Integration:

10) Domestic Demand Across all Agro – Commodities
11) International Demand Across all Agro – Commodities
12) Agronomy Data / Dictionary

6.2 High resolution Satellite Image Procurement

The department will be facilitating to procure the satellite image by issuing a letter to NRSC if required. The spatial resolution of the image should be 5x5 meter pixel wise or better and temporal resolution should not be more than 10 days for the optical data. Multispectral satellite data should have minimum of 4 (four) spectral bands namely Blue, Green, Red and Near Infrared. In the absence of optical data, microwave SAR data can be used. Additionally, if required, some other low spatial resolution of satellite image may be used for the data processing subject to prior approval from the authority or the representative of the authority. In the absence of non-availability of cloud free data, low resolution data can be used by taking approval from the authority.

6.3 Cadastral data integration

Cadastral map is the key to fully integrated dynamic decision support. It helps connect the entire dot seamlessly. Please note cadastral map is used more for referencing crop and performance to individual crop. It's by no means the exact ownership mappings the on the ground the plot ownership and the plot boundary may vary from cadastral map. There are differences in area estimate based on geo referenced map but such differences are not a major concern as there are significant overlaps which do allow us to reference crop to individual land parcels and so the crop performance map referencing. We are still able to assign crop and performance to cadastral boundaries. The purpose of revenue map integration is more for referencing crop and performance score to geo-referenced revenue map to be able to create the linkages between the two. This allows user to register their kharjas in the application to as part of their portfolio for which they need to get all the monitoring reports on regular interval, this is more for the farmer's application where the individual farmers are able to register their khasras as portfolio. Cadastral mapping with geo referencing is one of the key requirements for

effective monitoring alerts to individual farmers who register for such services on the platform.

6.4 Field Survey

Field survey is one of the essential components of crop classification using remote sensing data. The field surveys shall be conducted on regular basis. FRUITS platform is integrating here. Other fields surveys required for Crop Health Monitoring, Farmer Awareness etc will be done throughout different agriculture season. Field surveys are conducted in different parts of the study area to gather primary as well as secondary information about the crop from the field. The signature of various crop is very significant, so signature of crop should be collected from the field and should be used during AI & ML based classification and visual interpretation of data. Field staffs will record the latitude and longitude of the location along with associated attribute information related to crop type, transplantation date, crop growth stage etc. This ground-truth data should be updated in the crop map. The field survey should be well distributed according to the crop area and it should cover all the mentioned crops. The selected agency should submit the field survey plan to authority before initiating the process.

6.5 Resource Mapping-Land use land cover mapping:

Land use land cover describes the natural features present over an area and purpose of the land has been utilized. Studying the dynamics of land use land cover is vital in natural resource management. Use of advanced technologies such as satellite remote sensing, Drones, artificial intelligence and machine learning algorithms to map the land use categories such as crop coverage, fallow land, waste land, forest, plantation, built-up / urban, water bodies, salty marshland, degraded soil / problematic soil and other categories based on land utilization is part of project scope. These are minimum categories and they should not be restricted to. And to support department in area specific scheme formulation, resource inventory and land use by analysing changing patterns in the landscape. The pixel resolution of output should be same as satellite image resolution and the unit of LULC map should be at a Taluka level. The authority will facilitate the soil data from the concerned authority.

6.6 Crop Acreage & Production Monitoring System

a. Crop Identification:

To assess the crop specific management in a spatial temporal context accurately parcel level crop present in a season is essential. The machine learning algorithms which learn from the ground truth data and identify the crop sown in the field including horticulture plantations, parcel wise and aggregate in to village, block, district and state as per the requirement of the department. The authority will facilitate for the revenue data from the concerned authority. In the absence of cadastral data, the authority needs to define the farm boundary. The unit for the report will be Village in case parcel data is not available. A model is developed for accuracy assessment on produced outputs in which ground truthing should be utilized. It is mandatory to cover maximum sowing area so apart from mentioned below crops, other crops should be classified.

b. Crop acreage estimation:

Real time crop area statistics plays an important role in planning and allocation of resources. It is necessary map the crops and make collective crop wise, area wise crop acreage estimation report. It should be continuing throughout the period as sowing date is not fixed and some crops are being cultivated throughout the year irrespective of season. All the districts of Karnataka state would be the area of the project. The average approximate areas under cultivation are 76 lakh ha in Kharif, 21 lakh ha in Rabi and 4 lakh ha in summer season. Gross area under horticulture crop is around 18 lakh ha. The authority may provide historical crop data. Data provided by the authority will be for the reference only.

Identification of the crops with highest precision for every land parcel is major objective. Based on land parcels, Agro climatic zone should be identified and for each crop the Agro climatic zone should be identified. With the weather data integration, farmer should know what kind of weather a particular land parcel is exposed to and the likely weather risk associated with the land parcels. The authority also finds information related to plots into rainfed / irrigated. If the parcel is irrigated then generate the irrigation score based on the latest conditions.

c. Cropping pattern & crop intensity:

The potential for further agricultural expansion is limited in reality. Hence, increase of agricultural production is to intensify land-use on already cultivated lands is essential. In order to understand the potential for crop intensity, information on spatial and temporal patterns of agricultural land-use change, land-use intensity at multiple geographic scales is needed. Crop intensity should be mapped that includes cropping patterns by using advanced data analytics. The authority also gets reports which displays the area of fallow land in the report and the authority gets the analysis report of intercropping, mixed cropping and plant row spacing ratios by using geospatial and data collected through mobile app.

d. Crop yield modelling and production:

Crop production estimation typically calculated based on yield data and crop acreage estimation. Forecasting crop production estimation in time is vital for department to plan their activities related Agri marketing. Hence the integrate crop yield prediction results obtained through data analytics and crop models at earliest and with crop acreage estimation created from satellite remote sensing in order to forecast the expected crop yield and production over a given area and determine how much of the crop will be produced. This report should be submitted twice in a season where during a season, a preliminary report should be submitted and once actual CCE data are available then the final report should be submitted.

e. Performance scope integration with cadastral maps

Post geo-referencing, one is able to integrate the intelligence drawn from multispectral satellite images with individual plot/geometry. If a plot has not performed over the years its less likely to start showing performance unless, some serious interventions are made. All performance scores are normalized for crop cover i.e. kind of crop historically grown and basic fertility index for the plot.

Such normalized scores allow for attributing performance of the plot across various factors including the quality of asset, cultivator behaviour, weather condition etc.

- It helps explain performance difference across plots and decompose factors affecting the behaviour of the asset.
- This allows us to explain the performance variance across plot, hence facilitate more informed proactive interventions and well-targeted advisory to farmers. For

example, if its observed that the part of the plot is always stressed over the years, this could simply mean surface need to be levelled properly to ensure all parts of plot gets uniform moisture.

- Classify performance based on most reliable primary source of data:
- Benchmark performance / identify anomalies
- Attribute performance to factors: Understand the factors affecting performance of the plot
- Knowledge Discovery and knowledge Transfer: Well targeted study of super prime performance post normalizing t for direct factors like soil quality, weather conditions in order to understand the true impact of methods deployed vs performance. It takes series of trial to get to the optimal method once we find it the same must be disseminated across millions of farmers to benefit from it.

6.7 Weather Pattern

a. **Monitoring of droughts:**

Monitoring of weather parameters & drought patterns are essential for State Agriculture Department to plan their activities draft the policies. It is necessary to analyse multiyear weather and remote sensing to analyse the drought pattern using geo statistical and data analytics algorithms. The weather data of Punjab will be provided by State Government. Data provided by the authority will be for the reference only. The platform has capability to predict the rainfall patterns of an area with time difference between the current rainfall and the next rainfall.

b. **Flood mapping and monitoring**

The agriculture sector is vulnerable to floods. Floods can inundate farmlands and cause major damage to crops, especially if they strike during planting or harvesting time. In case of a flooding event the platform provides map of submerged area/ flooded area in case of any natural or local calamities using real-time remote sensing data. Information of crop acreage of the area with crop situation is a part of platform capabilities. The platform provides

information of map out the areas that are probable flood zone and lacking proper drainage.

6.8 Crop Loss Assessment

a. Crop loss assessment

Accurate Estimation of crop loss assessment at parcel level is very crucial in crop insurance or different compensation schemes. In the event of crop damage due to any natural or local calamities or disease/ pest infestation, generates overall scenario as well as parcel wise data with determine extend of damage in a particular crop. Crop loss assessment should cover loss happening during different stages of cropping period such as sowing time, mid-season and harvesting time. Crop loss assessment should be done by satellite data and it should be supported by the field survey.

b. Crop growth & stress

Subsequently will move to weekly and as the application matures on adoption would need to update scores on daily basis for in time stress detection. The user should be able to compare current season growth with prior season in order to benchmark current season yield to historically observed yield. If any stress it identified, alert is broadcasted in real time for proactive interventions. Given that the weather conditions are layered on top, the identified stress is normalized for prevailing weather conditions.

Key to addressing stress is detecting it early enough to avoid stress to become irreversible. Early detection of stress goes a long way in reducing the potential loss.

Early warning on how much of stress & where will help drive the farmer already integrated on the platform to identified location where the stress is detected. Farmers should be able to upload image taken from his mobile which gets linked to the corresponding land parcels. The high-resolution image uploaded by farmers can go a long way in detecting the root cause of stress including pest attacks.

c) Identify stress

d) Root cause analysis and identification of cause

e) Proactive intervention & advisory to farmers to mitigate stress

f) Update yield forecast

6.9 Advisory

The following advisory will be provided to farmer through dedicated mobile application;

i. **Advisory to Department of Agriculture/ Horticulture**

Advisory to the department for the stress identification, weather pattern, cropping pattern with the area to be approach for solution with crop acreage and crop situation of the particular area. Advisory should be accessible through web platform as well as mobile application.

ii. **Advisory to extension functionaries**

Selective area information to the concerned extension functionaries for the subject narrated in the document. These advisories should be available to the field functionaries through mobile application. Field functionaries will be extension officers and other officials as deemed necessary by the authority.

iii. **Advisory to farmers**:

Generalised advisory to all farmers

Advisory which are general in nature should be disseminated to all the farmers of the given area. Generalized advisories should be at Block level and it should highlight specific region if any concerns are there.

Farmer mobile application should have the facility for

- To integrate the weather data from Automatic weather stations (AWS), IMD and any other reliable weather data sources. Weather forecast should include forecasted rainfall, temperature, humidity, wind speed and solar radiation.
- providing Soil preparation advisory services at beginning of the cropping season
- To provide crop management practice to the farmers at each crop growth stage

- Backend platform of the mobile app should have the facility to maintain crop knowledge database which includes recent best package of practices for individual crops

iv. Personalised advisory

Provide mobile based facility for registered farmers, where farmer can pin their farm to get crop situation and personalised advisory. Provide farm specific personalised advisory. Personalized advisories should be at the parcel level. Personalized advisories are to be generated using the satellite data however the mobile application should have the provision for farmers to upload image through their application. Department will be responsible for the registration of farmers or on boarding them to the platform.

Subject for advisory:

a) Advisories on sowing and harvesting time

Information on best time for sowing will help farmers to plan their sowing related activities in advance. Also, Identification of crop wise planting dates spatially will to identify areas which are behind in sowing, which will help department analyse reason and implement the contingency measures. Creates advisories for farmers on best possible sowing date based on weather prediction. Also, creates additional reports at the end of season analysing the sowing pattern for the identified crops based on planting date by using multi temporal satellite data on basis or the time period given by department. Identify the probable harvesting date by using satellite data integrated crop models.

b) Advisories on crop stress

Crop condition and stress identification at early stages of the crop is essential for farmers to do necessary action in time and also agriculture department to better monitoring of crop health and yield. Assess the crop health condition of each crop periodically through remote sensing and field visits. On abrupt change of crop health or such anomalies in any area of the state, should be detected automatically by machine learning and provide advisories to farmers. Information provides to the department with detailing of the area, crop situation, acreage and cause of stress as an additional report as well.

c) Advisories on pest and disease infestation

Early identification of a crop disease or pest can lead to faster interventions with resulting reduced impacts on food supply chains. The development of deep learning-based pest and diseases symptoms identification approach which is integrated with mobile applications. Farmer mobile application will provide advisories to farmers in order to prevent the possible outbreak especially an epidemic situation. Also, regular reports will be received by the agriculture department which should include the disease/ pests in area, extent of damage. Pest & disease spread analysis should be done by satellite data and it should be supported by the field survey.

d) Advisories on soil moisture stress and Irrigation Application

Sufficient levels of soil moisture are essential for optimum plant growth and high crop yields. To determine the quantity of moisture in the soil is crucial importance for crop production to avoid water stress, but also for the mitigation of adverse environmental impacts due to over-irrigation as well as for the conservation of water resources. Thus, selected partner agency would develop an indirect method for estimating soil moisture data where soil data, remotely sensed data mainly microwave data should be utilized. Derived soil moisture should be used to provide personalized irrigation advisory to farmers to advice on irrigation requirement and application. Selected partner agency would to also provide additional reports and maps to department on estimated soil moisture and irrigation requirement at village level.

e) Advisories on weather pattern

Selected agency would provide analysis with past and current weather data and forecast the weather pattern. The agency would analyse the inputs/ dataset on weather situation provided by the department using machine learning and generate forecast and advisory accordingly.

f) Advisories on price forecast

Selected partner agency would provide advisories on price forecast. It should identify the farmer using his farm location and should inform the rates of nearby

APMCs so that farmer can decide the maximum return of his produce. The advisories should be started when the crop is at the maturity stage.

g) Advisories on alternative crop

The selected agency would suggest alternative crop in the coming season in order to maximize real return. These advisories should consider the crop sown in the current season, soil quality, irrigation facility, current irrigation score etc.

Features of mobile application:

- facility to register farm boundaries through GIS map tools where Farmer can digitize the farm boundaries by walk or draw a polygon on the high-resolution satellite image
- facility to record cropping season, crop details and irrigation facility details of each survey number
- To provide contextual crop advisories to individual farmers based on the crop type and phonological stage of the crop sown. Have option to view and analyse the optimum sowing date based on the weather data
- To generate Crop Activity Calendar for the entire crop lifecycle automatically based on the sowing date input from farmer registration
- To provide Irrigation management advisories based on the WRD data, Crop data, Soil data and rainfall data
- Should be providing advisory on best possible time for harvesting based on the forecasted weather and crop calendar so the farmer can plan the activity well in advance
- Backend platform of the mobile app should have the capability to predict pest and diseases using crop models and should provide controls advisories as preventive action.
- Backend platform of the mobile app should have the capability to predict the expected harvesting date for each crop based on the sowing date and varying weather parameters in season
- To disseminate disaster forecast, context specific damage mitigation advisory to respective farmers based on the age and stage of the crop.

- Provision to display the irrigation score to the farmer based on his plot's Agro climatic zone, weather condition, crop etc.
- Monitoring of farmer's assets (his agriculture land) and how it could be enhanced
- Farmer should be able to see the cropping calendar where ideal time for sowing, plantation etc. are displayed to the farmers
- A community club facility should be there where farmers can access training materials in the form of videos on various topics of interest including cultivation techniques should be given. It should also have a provision to share the data with the fellow farmers. The topics could be related to training, Govt. policies and schemes etc.
- Real time advisory on area under cultivation across crops and its impact on price realization for the farmers
- Proactive advisories on ideal acreage across crops to avoid over supply in the market

7 Blockchain Enabled Platform for Traceability: Applications and Analytics

7.1 Overview

Block-chain enabled platform for traceability through its different layers and components shall act as a Decision Support System (DSS) for the Ministry to respond to real-time events by consuming data feeds from different data sources and by processing information out of data sets.

7.2 Proposed solution

In view of consolidation of existing information/data parameters and enablement of unified monitoring, the department aim to implement an integrated Blockchain platform to capture, track and monitor the real-time information of activities related to traceability. The development of the envisaged Blockchain platform will have clean data in the system and follow the principles such as open standards, loose coupling, data sharing, mobile and cloud-first, scalability, agility, single sign- on, and ease of use. The blockchain enabled Platform will also host new modules to capture data and insights for

existing and envisaged processes as well as programs run by the department. Further, it is planned to enable online and offline mobile and web-based application, which will make information accessible via a dashboard and reports, to key stakeholders to assist in decision-making and thereby promote effective agricultural transformation across the states.

7.3 Integrated Blockchain platform

The section provides an indicative Blockchain platform architecture, to be developed by the department.

Indicative features for an integrated Blockchain Platform:

a) **Adherence to standards:** Integration technologies that conform to industry standards will be considered. This allows applications and data sources to be interoperable, easily maintained and replaced.

b) **Prebuilt APIs over custom built:** Use of native, pre-defined APIs (when available) will be preferred over building new ones. This enables faster implementation of new capabilities.

c) **Real time integration**: Where applicable, real-time integration between applications is preferred over replicating data across systems. Replication increases risk and complexity since data will need to be synchronized across all copies.

d) **Asynchronous, message-based interaction:** Asynchronous, message-based interaction (where applicable) is preferred over synchronous integration to keep the applications easy to integrate, decoupled and independently scalable

e) **Minimize hops**: Data should follow the shortest path when moving from one component to another. Minimal hops are desirable to reduce complexity, maintain quality of service and reduce latency.

f) **Secure services:** Application and data integration services are designed with key security considerations to protect the business and reduce risk also; it is envisaged that the proposed platform should be well-established and a globally recognized platform with essential features as follows:

- Scalable: The platform should offer cloud-based models, be robust with tolerance to failures, adaptability to technological changes/advance capabilities in managing security and privacy concerns
- Horizontal: The platform should allow integration/interoperation with different technologies, devices, protocols, and ICT solutions/applications as well as with the existing /new Platform of the Ministry.
- Open-source technology: The platform should include provisions for data access by any third parties and be modular to enable scaling-up/reuse by the third parties accordingly
- Standards based: The platform should have provision to support transition to federated database architecture which follows the principles and standards laid out by Agri Stack in order to make it compliant with the standards for shared services platforms to avoid being captive by any proprietary technologies.

To design the Blockchain Platform, integrated with new and existing applications, the detailed scope of will be:

- Leverage key data parameters identified from existing applications in As-Is, To-Be and FRS document, to design and develop consolidated, easy to use and intuitive dashboards. This is to be equipped with search, filter and compare capabilities, and notifications, alerts, and warnings.
- Enable data map, to identify the starting (Source) application on one side with all the objects to be captured into the Blockchain Platform and all the relevant information about those objects next to it.
- Develop the platform with capabilities to connect to Agri Stack in order to make it compliant with the standards for shared services platforms to avoid being captive by any proprietary technologies.
- Where applicable, enable real time integration between applications over replicating data across systems. Also, application and data integration services to

be designed with security considerations to protect the business and reduce risk

- Design and development of the (online and offline) mobile and web- based applications and ensuring the interoperability with the Blockchain Platform.
- Development of the APIs to push/pull the data from these systems. Adopt integration technologies that conform to industry standards as preferred. This allows applications and data sources to be interoperable, easily maintained and replaced.
- Use of native, pre-defined APIs (when available) is preferred over building new ones. This enables faster implementation of new capabilities.
- The proposed Blockchain Platform should capture real time data from the field and other systems. Perform data consolidation, validation and conditioning on the data fetched from various systems to ensure data accuracy and utility. The system should also support data capturing from flat files like excel, XML, etc.
- Develop data sharing mechanism between the integrated MIS application and the new Agri stack platform of the Ministry, to exchange data to create layers onto the Agri stack platform with the help of GIS technology tools and represent the output on maps and reports.
- Create provision for multi device interaction and interoperability to enable data collection from IoT based devices to generate presentable output in future.
- Enable big data and analytics for voluminous data collection, handling and interpreting.
- Create different data marts to store data sets of a parameter from all sources within the same database to provide unique output in least possible amount of time.
- Blockchain Platform will provide dynamic dashboards with predefined filters and drag and drop functionality for stakeholders to generate the reports as per their requirements.
- Develop use-case testing, to ensure integration will work exactly as intended

under the specified conditions of the end user.

- The platform will offer cloud-based models, be robust with tolerance to failures, adaptability to technological changes/advance capabilities in managing security and privacy concerns.
- The developed system will be easily scalable to accommodate new applications as well as enhanced datasets along with the user base on the developed system.
- The department will facilitate and provide training of the Blockchain Platform to the state, and relevant stakeholders. The department will prepare the user manual, training calendar, etc.
- The department will set up a dedicated helpdesk to support the stakeholders with application related queries for the entire duration of the assignment.
- The department will support maintenance and change request of the developed Blockchain Platform application and allied modules.

7.4 Application Development

- The Punjab Agri Export Corporation Limited (PAGREXCO)will be responsible for configuration, designing, developing, testing, implementing, and hosting of the Blockchain Platform and allied modules, on cloud as per the scope of work. The platform and modules developed will be evaluated against the SRS as approved by the various stake holders.
- The applications, portal and platform will follow open standards and will be based on the concept of One Web, i.e., it should be able to render properly on all type of devices of all sizes like Laptops, Desktops, Mobiles, Tablets, etc.
- The PAGREXCO will develop the Blockchain Platform including mobile and Web-portal along with all the necessary modules, utilities, system drivers and documentation in line with industry best standards, including product updates, technology upgrades and patches to run on the selected operating system(s) and hardware, according to the solution.

7.5 Testing (UAT) and Performance & Load Testing

- Once the platform and application development / customization have been completed by the department, the department will thoroughly test the application at their end. Detailed test plans, test cases and test reports will be prepared by the department and then submitted to the stake holders for approval.
- PAGREXCO will carry out Unit Testing, Integration Testing and System Testing as per the approved plans and the department will submit all Test-completion reports to the stake holders after the end of each testing phase.
- PAGREXCO will also have to create a Regression Test Suit for the stake holders. This will consist of end-to-end test cases across all the modules of the Blockchain Platform. This Regression Test suit needs to be executed following any changes in the system throughout the duration of the contract and its test results are to be submitted to the stake holders. The department will have to update and refresh the Regression Suit throughout the duration of the contract also periodically.

7.6 User Acceptance Testing (UAT):

- The department will develop the UAT Test plan and a detailed User acceptance procedure. The same would be reviewed and agreed by different stakeholders.
- UAT would be applicable once the entire Blockchain Platform is completely ready and all the modules under the Contract are ready and linked.
- The UAT environment has to be hosted on cloud and the test cases have to be created by the department.
- For all tests performed by different stake holders, the department will prepare the test reports and submit them to the stakeholders for approval.
- Defects identified in any round of UAT by the stake holders would be communicated to the department. The department will do the needful to troubleshoot or resolve the defects and resubmit the application to the stake holders for UAT. This iterative process for UAT will be performed till zero defects

are shown by the department for the test cases developed.

- The department willkeep all required documentation like test cases, test results, test assumptions, traceability matrix, etc.

7.7 Load Testing

- The department will develop scripts for performance critical scenarios to test loading conditions on the server. These would be reviewed and agreed by the Ministry.
- The department will also be responsible for gathering the test data, run analytics to understand realistic usage and setting up the infrastructure for these loading tests.
- For all tests, the department will be responsible for monitoring the tests, updating the tests based on latest system build while providing timely reports for each test to various stake holders.

7.8 Security Testing

- The department will be responsible for Web Penetration security audit, External Penetration testing, Mobile Application Security Testing etc. to identify bugs and system vulnerabilities if any.
- The testing would include independent analysis of the networks, simulation of both external and internal hacking scenarios to test the system and devising methods and processes for audit of web portals as well as mobile applications.
- Reassessments shall be carried out to ensure successful closure of vulnerabilities.
- The department will carry out the Security audit of the MIS application and infrastructure through STQC/ STQC empanelled agency and only after successful certification, the platform will be deemed fit for offering services.

7.9 Software Documentation

An indicative list of documentation to be prepared by the department is as follows:

- Detailed design document detailing technical architecture (Platform and Applications)
- Database infrastructure architecture, including cloud, clustering/ mirroring, backup & recovery strategies, defining data structure, data dictionary as per standards laid down by Government of India
- Detailed System Requirement Specifications (SRS), Software Design Document (SDD) for the platform, applications and other components and also additional requirements as may be identified in consultation with the different stakeholders during the requirement study phase.
- The SRS and SDD approved by different stakeholders will form the baseline for all subsequent phases of platform and application development and deployment from a requirements perspective (e.g., for testing, identifying change to requirements etc.). Detailed Collaboration and class diagrams also to be prepared. Further, the department will be responsible for:
    - User Requirement Specifications,
    - Installation guide,
    - Manuals (training, plans, etc.),
    - Certificates (security, audit, UAT, etc.) and
    - Complete working application Code
    - Technical User Manuals and User Manuals for all user types (both as standalone documents and integrated in the platform under the 'Help Tab')

7.10 Specifications for Application Development-Blockchain Platform

The department will design and build the DSS component on the platform and indicative specifications for the same are as follows:

- The platform will have capability to augment and support daily incremental load.
- Understanding, mapping and define rules for migration from different sources.

- The infrastructure will have data quality and data profiling capacities.
- Data standardization techniques will be included to clean data at migration level.
- The tool will be capable to handle extraction, transformation and loading of both structured and unstructured data from various data sources.
- The tool will be robust to build analytical reports.
- The Blockchain Platform will be capable to handle large volumes of data and have the capability for different techniques of statistical modelling.
- The solution will create a single source of truth by integrating disparate data from multiple sources and use that for analysis.
- The solution will have built-in, or integrated tools for enterprise grade ETL operations from a large array of traditional and non-traditional data sources and should have high performance transformation capabilities
- Proposed solution will have capabilities for online analytical processing.
- The proposed solution will be capable of search-based data discovery.
- All tools in the solution will comply with same security, access, administration attributes.
- It will allow for connectivity with proposed RDBMS. Compatibility with leading Operating Systems is must.
- Solution will have an in-built Backup, Archive, and Restore solution to protect data and ensure availability after System hardware failures, Application failure or corruption, Data corruption or loss, user errors or Disasters.
- The solution will have the capability to provide refresh-only capability to a user group.

7.11 Visualization and Reporting

- The Reporting tool will have robust visualizations such as graphs, charts, and histograms.

- The reporting tool will have sliced and dicing features facilitating ad-hoc management reporting on the fly.
- The reporting tool will have basic statistical modelling properties, so that users can create clusters, regression analysis, and other modelling techniques dynamically.
- The reporting tool will generate output data in various formats.
- The Reports generated by the system will be made accessible through API or an interface (for portal) to be viewed by the authorized users. The tool should enable different types of users to perform analysis on data across the Enterprise without the need to Subset / sample / create multiple views of data. The interface for the authorized users should be simple with user friendly features such as drop-down list, drag and drop utilities etc., and should be built with focus on users with elementary statistical knowledge.
- The management console will be Web based and should not require any client installation.
- The solution will provide a common management console to monitor multiple systems in Test, Development, production systems across multiple instances and across locations
- Proposed solution will be capable of seamless integration with leading Office tools both for import and export of data and reports in multiple formats. The solution should allow data to be accessed from any industry standard data source using native connectors. It should also allow data load jobs to be scheduled to automate the process of loading data into the system for Analysis
- Data Visualization tool capable of interactive visualizations. Preference will be given to tools with auto charting facilities.
- The solution will have the ability to format (page size, row, columns, fonts, colours, tables etc.), allow data manipulation (slice & dice multidimensional data on the fly, pivoting, sorting, ranking, rearranging columns, etc.). The solution will

have drill-down capabilities (ability to drill down to various levels of a hierarchy).

- The solution will have the capability of raising exception triggers (e.g., email notification). Should provide for exception reporting (ability to set certain thresholds).
- The solution will have user friendly GUI to allow easy generation of reports and exporting capabilities (ability to export resulting data to other applications such as Excel, Notes, CSV.).
- The solution will have integration capabilities e.g., ability to integrate in existing portal. The solution will be able to publish all the reports on the portal and have the ability to archive reports.
- The solution will be able to distribute reports and also have the ability to save data for later use or to a local PC/laptop or for other users to view. It should support offline viewing. It will be able to send reports electronically to other users.
- The solution will be able to sort/filter without re-querying.
- The solution will have the ability to schedule reports.
- The solution will provide for a browser-based interface to view reports

7.12 Hosting Operations & Maintenance

I. The Blockchain Platform will be hosted on the department cloud. The cloud will provide flexibility and scalability in terms of compute and storage requirements of the solution. Additionally, a DR will be hosted on the cloud.

II. The department will be responsible for the sizing of the required cloud infrastructure, system software and other components needed and determining the specifications of all components in order to meet the requirements of the project.

III. The department will be responsible for all system integration services including hosting applications, system software and other components on the cloud

IV. The department will do the Operations and Maintenance of the entire blockchain

platform is taken care of post go-live.

7.13 Application Database

- Database will have perpetual licenses. They will have proven scalability credentials to cater to any system load.
- The Database will support multiple languages as well as Unicode.

7.14 Platform and Application Security

The department will comply with the following guidelines for Application security:

- Conduct load testing and security audit of the platform by STQC empanelled agencies after every major update in the application.
- Build a complete audit trail of all transactions (add, edit and delete) using transaction log reports, so that errors in data, intentional or otherwise, can be traced and reversed. This includes Source IP and timestamp logging for all the transactions as per the requirements of IT Act 2000 and IT Act 2000 amendment 2008.
- Chose the most appropriate level of security commensurate with the value of the function for which it is deployed. This also includes documenting evidence of the security practice adopted along with its considerations.
- Implement data security to allow for changes in technology and business needs.
- Equip the system to handle all exceptions.
- Build the application ensuring that none of the top 10 vulnerabilities listed by Open Web Application Security Project (OWASP) exist in the application. Additionally, the application needs to be developed with the most secure coding practices prevalent in industry.
- Conduct independent code review.
- Take appropriate steps for database security like Access Control, Encryption and Auditing.

Separation of environments: The department will ensure separation of production, test, QA and development or similar environments on the cloud. Developers should only have access to the development environment, unless there is a business need authorized by the state, for purposes such as troubleshooting a problem that cannot be duplicated in the development environment. In such scenarios too, the access given to developers should be read-only role with minimal privileges and their actions must be audited. The department will create roles proactively, so that when a problem does arise, unnecessary access is not granted as a quick solution.

Secure configuration: To properly address database security, the department will deploy tools required to automate the entire secure configuration life cycle. This includes database discovery, security scanning, configuration lock down, automated remediation, etc. Security consideration must be given to the database itself, as well as the surrounding environment, including the underlying operating system and applications. Some of the key areas that should be considered when securing the database by the department are as follows:

- Default Accounts
- Users and Roles
- Exposed Passwords
- Patching
- Privileges and Permission
- Parameter Settings
- Password Management
- Profiles
- Auditing
- Listener Security

7.15 Integration

- The department will integrate these applications and other components like database to the MIS platform and support the integration and hosting.
- Integration of Data Services:

- SMS Gateway
- Email Gateway/SMTP

7.16 System Logs

Department will maintain various system Logs to ensure system integrity and effective system monitoring. All application logs need to be maintained by the department. Out of these, the logs for the most recent two years need to be maintained in active mode. The remaining logs can be maintained in passive mode. The department will maintain logs for systems and components like (but not limited to) the following:

- Applications
- Database
- Interfaces with External Systems
- Uniform Communication Platform
- SMS Gateway
- Document Management System
- Content Management

7.16.1 Adherence to Standards

The blockchain platform complies with defined industry and open standards:

- Compliance with guidelines stated under the Agri Stack standards
- Compliance with Open standards: The proposed system would be designed based on open standards and Open API policy in line with overall system requirements, in order to provide for good interoperability with multiple platforms and avoid any technology or technology provider lock-in. The system should adhere to all open standards guidelines and other guidelines relevant to the project as issued by Government.
- Compliance with Standards for State Portal, SSDG, GIGW and forms Framework: The department while developing the Application will take cognizance of the technicalities of the State Portal, SSDG, GIGW and e-forms

framework and any other guidelines issued in this regard by the Government. The departmentalso ensure that all content of the Department's Portal is as per the State Portal Framework guidelines.

- Compliance with Industry Standards: In addition to above, the proposed solution has to be based on and be compliant with industry standards (their latest versions as on date) wherever applicable. This will apply to all the aspects of solution including but not limited to its design, development, security, installation, and testing. The suggested architecture must be scalable and flexible for modular expansion. It should ensure ease of integration with software / applications developed using common industry standards since the solution may be linked and connected to other sources, (websites, contents, portals, systems of other administrations etc.) there may be loose/tight integration with backend system of other departments depending on individual service processes. The solution architecture should thus have provision to cater to the evolving requirements of the Department.

7.16.2 Training

- The department will provide training for the first 6 months on the usage of the MIS application and allied modules, new business processes and other technology or any other training requirements.
- The department will train the stakeholders of the project.
- The department will prepare detailed training plans covering at least the trainings to be conducted, targeted audience, location, dates for training, duration and training content. The department should submit the detailed training plan to the Ministry and execute the approved plan.
- The department will create training material and manuals in English and local language.
- The department will create functional training for all applications/ modules that will be used for new induction, transfers and promotions.
- The department will create the training environment where Master Trainers

provide hands-on training to users, should be an exact replica of the live application which should allowing entry of dummy data, etc.

8 Data Management

Data is a valuable asset. Data in the Agriculture sector is generated across a variety of applications, across various organizations to better serve the Indian Farmers. However, this multiplicity of data owners often causes problems related to accuracy, consistency, and accessibility of right data at the right time. There is a need to bring together a large amount of data and provide a holistic view of the information with the aim of improvement of the Indian Farmers and the Agriculture Sector.

- Demand-side stream which can give better understanding of specific properties and characteristics of urban processes, e.g., buildings services, government-to-citizens services, and provide solutions for improvement.
- Supply-side stream to monitor incidents and crisis situations and the respective responses and solutions with the aim of drawing conclusions and recommendations.
- Analytical stream to identify data patterns and correlations in order to derive predictions for urban innovation, provide impact assessment, and demonstrate the challenges and opportunities in urban development.
- Standardization stream to bring the ICCC Data in line with the national and international standards like IS 18002:2021, ISO 8000 etc.

The PAGREXCO intends to develop robust Data Management capabilities that puts in place a mechanism to not only share the data amongst different departments but also a set of tools and technology to better use this data for decision making. Integrated data plays a vital role in understanding the problem in the right context and providing a solution which is in the interest of administration as well as citizens. All data generated through this project, shall belong to all the stakeholder departments and should adhere to following data principles to ensure its usability and usage on a longer run. The Data Architecture for all blockchain platform Data under scope:

ID	Data Principle	Description
P1	Accuracy	Blockchain platform Data stored will be as correct as possible for an object, whereby the object must have the right values and must be represented in a consistent and unambiguous form in alignment with known frameworks such as OWL and RDF when possible and appropriate.
P2	Completeness	Blockchain platform Data will reflect what is recorded based on a standard schema that defines completeness. Metadata that defines and explains the raw data should be included with explanations and formulas for how data was derived and calculated.
P3	Timeliness	Blockchain platform Data will be available in a timely fashion. They will be made available as quickly as they are collected and processed, based on data priority defined according to the time sensitiveness of utility and value.
P4	Privacy	Except Open data, direct access to all other data will be prohibited
P5	Confidentiality	Data will be disseminated data only to authenticated and authorized stakeholders (both internal and external) through applicable data fiduciaries. Use of APIs to be mandated where data access is permitted.
P6	Machine Readable	Blockchain platform Data will be stored in widely used file formats that easily support machine readability, interpretation and processing. Files will be accompanied by documentation related to the format and how to use it in relation to the data.
P7	Non-Redundancy	Blockchain platform Data will be acquired, stored in a timely manner, and made available for multiple/generic purpose reuse to avoid data duplication, and promote data consistency and quality.
P8	Permanence	Blockchain platform Data will be released for online consumption and available in archives and in perpetuity as defined in the policy for the type of data.
P9	Consistency	Blockchain platform Data will be consistent across different systems. Data written to the storage must be valid according to all defined rules, including constraints, cascades, triggers, and any combination thereof. When data is aggregated from multiple sources there shall be

ID	Data Principle	Description
		consistency in measurement of variables throughout the datasets.
P10	Non-Repudiation	Blockchain platform Data will include source information like the owner, device which generated the data and also store the hash values of computed on the original data to cater to non-repudiation.

Following additional principles need to be applied only to Open data:

ID	Data Principle	Description
OP1	Non-Discriminatory	Access to Agriculture Sector Open data by the public will not contain any barriers to use. Any person will be able to access open data published at any time without having to identify him/herself or provide justification for gaining access.
OP2	Non-Proprietary	Agriculture Sector open data will provide for freely available alternative formats to allow the public to avoid costs for consuming data in specific formats. Removing this cost makes data available to a wider pool of potential users.

8.1 Functional Capabilities

The department intends to implement a robust Data Management framework that puts in place a mechanism to not only share the data amongst different departments but also a set of tools and technology to better use this data for decision making.

This section describes the Data Management capabilities of the Data that Department needs to implement using appropriate tools and solutions to ensure compliance of blockchain data to principles as well as to ensure data is useful for usage on a longer run.

Data Governance: The department will ensure that the data policies and standards are adhered to as needed to account for blockchain platform for Agriculture, including but not limited to:

- **Data privacy policy**: describing the Department's obligations towards the privacy rights of its service users
- **Data retention / archival policy**: describing how long data should be kept and the conditions for data archival or retirement
- **Open data policy:** describing when and how the agency should publish its data for public use
- **Data classification standards**: describing the criteria for categorizing data into different access levels depending on need-to-know basis and the risks associated with getting the data into the wrong hands
- **Domain-specific data standards**: describing domain-specific controls for collecting, organizing and managing data

Data Architecture: Data architecture pertains to Processes, systems and setup required to store, access, move and organize data. The data architecture helps define the steps to collect, integrate, enhance, store, and deliver data to decision makers (managing Director, Department heads of Agriculture/ Horticulture, etc.). The department will identify the data needs of the department (regardless of the structure), and design and maintain the master blueprints to guide data integration, control data assets, and align data investments with business strategy. Data architecture will capture the following at minimum:

- Data movement and transformation automation through data driven workflows.
- Facilitation and optimization for future Big Data architecture decision making.
- Creation of Data Models that capture business requirements and present them in a structured way.
- Data architecture should be effectively designed (e.g. ingestion, data storage, cleansing) to handle the variety, volumes and velocity of big data, allowing it to be easily understood and retrieved by different users.
- Data management capabilities should be designed to manage structured and unstructured datasets.
- Distributed database file system technologies (DDFS) to host and manage the information coming from large volumes of unstructured data.
- Big data streaming technologies to handle high frequency of incoming data that

needs to be collected, aggregated, and processed in batch and real-time.

- Common data models that would be deployed to prevent unnecessary data transformation and overcome application semantic differences. As such, data exchanges would use the schemas that codify canonical data models.

Data quality: Data quality is the ability of data to satisfy the stated business, system, and technical requirements of the Agriculture Sector. The department will implement the following functionalities:

- **Data Cleansing**: Maintenance of data to fit defined blockchain Data Standard for enhanced interoperability and decision making.
- **Data Profiling**: Systematic analysis of data to gather actionable and measurable information about its quality.
- **Data Traceability**: Tracking of the lifecycle of data to determine and demonstrate all changes and access to the data.
- **Data Compliance**: Ongoing processes to ensure adherence of data to both enterprise business rules, and, especially, to legal and regulatory requirements.
- **Data Monitoring**: Routine checking and validation of data against quality control rules to ensure quality and format consistency.

Master Data Management: The department will create a centralized database of data entities used by multiple application across the Department.

Metadata Management: The department will enable metadata management for all blockchain Data under scope. Metadata describes what each data element recorded means and this meaning remains consistent across applications. Metadata can be categorized as technical metadata or business/operational metadata.

Data Processing: This pertains to ingestion of IoT or other data sources in real-time or batches. Batching can be done to ingest data through execution of a series of programs without manual intervention on a scheduled basis. Streaming is presentation of ingested data that is being received continuously to analytics engines and dashboards. The data processing shall, at minimum, be capable of the following:

- **Data Ingestion**:

- Filter, aggregate, summarize and / or transform data from structured sources
- Enable scalable storage
- Integrate Master and Reference Data
- Handle historical data in bulk
- Handle incremental data, e.g. data synchronization
- Apply soft and or hard deletions of data

- **Auditing:**
  - Track historical changes of data
  - Enable logging of services, users and requests for data
- **Ontology (semantics) definition**:
  - Create data schemas/ catalogues that are understandable by both humans and machines
  - Capturing and storing data about data or Metadata
  - Creation of data models
  - Allow for easy search of data schemas based on keywords, tags and various contextual information

Data Transformation: The department will enable Data transformation which includes a certain set of activities like conversion of data from one format to another, enrich data by merging data from multiple sources, perform aggregation function i.e., create summary of data, or cleanse data of null values.

Data warehouse: Data warehouse capability pertains to Storage and consolidation of data from multiple sources in a relational store for querying. A data warehouse is different from database in a lot of ways including how it stores the data, the purpose of the stored data, the duration of the data stored, as well as the format in which the data is stored. The department will also need to closely govern the creation, storage, maintenance and usage of blockchain Data by ensuring, at minimum, the following data principles are adhered to across agencies for storage and retention:

- **Creation:**
  - Datasets are available when needed.

- Datasets used are understandable and clear.
- Datasets are accessible to all members of the intended audience to conduct day to day business activities.
- Datasets created are trusted, accurate and as complete as possible

- **Storage & Retention:**
  - Data stored is stored securely
  - Data and document retention shall be retained as long as agencies deem their current usefulness and historical relevance
  - Data shall be maintained in current storage per their economic useful life
  - Data retention must satisfy any current data retention policy
- **Usage and Maintenance:**
  - Usage of data stored and retrieved should be consistent for the purpose for which the data is intended
  - Data retrieval requests and fulfilment should be reviewed and monitored for adherence to current security policies and standards.
- **Retirement**:
  - All data nearing end-of-life shall be first retired to a secure offline or near-line storage repository for cleansing
  - Disassociate metadata from the data to remove identification
  - Set up a plan to temporarily remove data for retirement to test impact

Data Integration &Interoperability: Data Integration and interoperability are both enablers of data exchange between two or more systems. The department will need to implement a middleware that translates the data from one system into something that the other system can understand to achieve the following objectives:

- Translation of internal service and data formats for external platform compatibility and consumption.
- Translation of internal protocols for external platform compatibility and consumption (e.g. SOAP to REST).

Data Exchange: The department will enable Data Exchange which pertains to sharing ingested and analyzed blockchain Data via Data APIs, Dashboards, as well as Sandbox

for working on open data sets with various stakeholders based on blockchain Data policy.

- **Open Data Management**: Management and accessibility of open datasets in useable formats and enablement of query generation on these datasets.
- **Data Visualization**: Manipulation and placement of data in a visual context such as infographics, dials and gauges, geographic maps and charts.
- **Dashboarding**: Integration of information from multiple components into a unified display to facilitate development.
- **Unique Data Environment**: Isolation of computing environment in which a program or file can be executed without affecting the production environment of the services. Agriculture Sector Open Data will be shareable with Data Exchange Platform via integration using Web Services (SOAP or RESTful Service).

Data Protection: Data protection is applicable throughout the "collection to retention" lifecycle of the data in the department. While implementing data protection, the department must keep in mind that they should be fair in data collection, use the data for specific purpose only and collect only the information needed for that purpose, keep the data accurate and only for as long as it is needed. Bidder should ensure that data is safe and secure at all times.

Following capabilities need to be developed on a longer run by the department (PAAGREXCO):

- **Analytical Modelling**: Bidder needs to enable Analytical model creation and cognitive computing capabilities for data insights generation.
- **Model Building**: Analysis and generation of mathematical representations of the system and its services, including the statistical models used to understand behaviours and patterns.
- **Model Deployment**: Deployment of models in an automated fashion, without the need of a human intervention in moving code or operate the target machine where the code shall run.
- **Model Validation**: Use of various measures of statistical validity to determine

data or model problems.

- **Big Data Algorithms**: Design and development of algorithms to access large amounts of data from large data storage through queries and derive streaming and real-time analysis from them.
- **Machine Learning**: Automatic development of models based on training data as well as back-propagation, or feedback loops enabling the ability to test and retrain the model while processing production data.
- **Statistical Learning**: Prediction of business metrics and variables for the future based on historic data.
- **Data discovery & mining**: Bidder needs to enable Data synthesis and visualization methods in preparation of advanced data modelling activities. Analysis of data sets through visual and graphical methods to summarize their main characteristics. Development and management of workflows to conduct analytics on data. Registry of information for reusable components of many types, which are used to build, document and test data mining tools

8.2 Indicative KPIs

The performance of the data management is dependent on a number of factors including its adoption by users of the department and how well it is implemented. There are a number of metrics that can be used to measure the performance and adoption of a data management capabilities such as:

- **Data Quality**: Department can measure the improvement in data quality by monitoring KPIs such as ratio of data to error, number/percentage of empty values in the dataset, etc.
- **Data Governance**: Some of the Indicative KPIs that can be monitored to evaluate the success of data governance implementation in the department are:
    - Percentage/Number of departments where data principles are adhered
    - Percentage/Number of information systems data elements that share a data functionality
    - Percentage/Number of business processes that utilize data principles

- Percentage/Number of production reports (outputs) that utilize data principles
- Percentage/Number of people that use data elements
- Percentage/Number of integrated business processes
- Number of Data Governance Policies Established

- **Functional KPIs to be monitored**: Data Management capabilities shall be empowered by implementation of the domain use cases listed in this RFP. While the above listed metrics are indicative only, Department may decide to form a committee to monitor the progress and performance of the data management platform. Department may also decide to carry out performance benchmarking exercises with the help of an external agency and it would be expected that the department shall tune the system to ensure those benchmarks are adhered to.

8.3 Geographical Information System Overview

GIS is the foundation Layer of the blockchain for Agriculture Sector. The department will implement a open source GIS software for the planning, development and management of the Agriculture Sector for sustainable growth. GIS shall provide location-based to the Agriculture Sector stakeholders.

8.4 Functional Requirements

Functionally, the open source GIS system should provide the following capabilities at a minimum:

a) Base Maps: Common set of Base Maps, over which the Agriculture Sector functions can collaborate or a spatial decision support system. The Base Maps can be topographical, satellite image, street maps etc. on which different layers of information can be geo-referenced, like property, land use, water supply etc.
b) Data ingestion from different sources: Government Data bases, Enterprise systems, sensors, e-governance applications, Survey Tools like GPS, Drones, GPR, LIDAR, Rest APIs etc.
c) Analysis: It shall facilitate a different type of trend and pattern base analysis, generating hotspots, concentration and dispersion patterns, interpolations,

statistical models, based on what-if modelling and predictive modelling may be undertaken

d) Workflows: Location based workflows to generate alerts with locational intelligence and dashboards for status monitoring.

e) Visualization & Dashboards: Creation of workflow enabled/dynamic dashboards for monitoring, tracking and performance analysis of different Agriculture Sector segments against thresholds/benchmarks.

8.5 DC-DR/Cloud Infrastructure

8.5.1 Overview

The DC-DR/ Cloud Infrastructure/services are planned by the Department and shall support multiple stakeholders in their effort to deliver various urban services for meeting citizens' requirements. Whether Department chooses the Cloud or On-Premises model, the Agriculture Sector ICT infrastructure shall meet certain key functional requirements and it should cover at the minimum, but not limited to, the following infrastructure components:

- Compute Infrastructure
- Data Storage Infrastructure
- Data Networking
- Security
- Agriculture Sector applications

The department is expected to propose the solution that meets following minimum requirements.

8.5.2 Functional Requirements

The Department (PAGREXCO) has identified Data Center, near line Data Center and Disaster Recovery Center as one of the important core IT components for efficient delivery for the citizen services. The Department has considered [Cloud based/On-Premises/Hybrid model] to meet the requirements of ICCC.

While subscribing to Cloud to suite the functional, scalability and performance requirements, Various prevalent deployment models (IaaS, PaaS, SaaS) may be adopted to design and deploy the use cases. These different cloud models may be used in combination in a manner that is similar to that used in a traditional IT environment, with underlying infrastructure supporting platforms and services.

- **LaaS model**: The Department may choose this model to utilize only the virtual machines, storage services (IaaS) from the CSP and deploy/manage their own application or database software.
- **PaaS model**: The Department may opt for taking platform services (e.g., database, containers, developer tools, AI/ML capabilities) where the application/database software including the underlying Virtual Machines is managed by the CSP.
- **SaaS model**: Where available, the Department may take the entire software as a service (referred as SaaS) without having to invest on the application development, middleware licenses and underlying infrastructure. The mix of the above models for an application typically depends on the application (e.g., granularity of control) and business (e.g., need for ease of management) requirements.

In case of On-premises model, the system shall be hosted in the site identified by Department, which shall be either the existing Data Centre (SDC) or existing/newly created facility for the department. Some of the indicative key components to be considered are listed below:

- Agriculture Sector Applications
- Compute
- Storage
- Data Networking
- Cyber Security
- Infrastructure Management System
- Passive Infra and Physical security

The department (PAGREXCO) is required to provide a robust, fault tolerant infrastructure with enterprise grade SLAs with an assured uptime as per SLA defined in the Vol-3 of the RFP. The department (PAGREXCO)shall not delete any data at the end of the O&M period (for a minimum of said days beyond the expiry of the O&M period) without the express approval of Department. The Solution/Services proposed by the department is broadly categorized into the following components

- DC-DR Build services- (in case of On-premises option)
- Cloud service
- IT implementation services.
- Operations and Management

a) The department shall ensure the following functional requirements are met

#	Parameter	Functional Requirement	Bidder's Response (How functionality shall be met)
1	Availability	DC and DR shall be operational 24 x 7 x 365 with no single point of failure (NSPoF) at any of the following component level: o Power o Cooling o Fire protection o Data Network o IT infrastructure o Physical security	
2	Certifications	DC and DR shall comply with the following standards: o Tier III or above by UPTIME/TIA-942 o ISO27001, ISO 27017, ISO 27018, ISO 20000-9, ISO/IEC 20000-1. The CSP should be MeitYempanelled /MeitY funded under GI Cloud (MeghRaj) Initiative	
3	Audit Rights with provisioned cloud services	Management console to the Department. The department shall allow review of the provisioned resources (e.g., cloud services, network & security controls,	

		utilizations etc) and view the configuration of each; Logs of all user activity within an account and any other logs (e.g., n/w traffic, account activity, resource inventory, configuration history, and configuration change) that are captured for audit purpose. The CSP must provide access to the cloud	
4	Cloud Services	department shall provide details of all the IT services procured from the CSP along with: o Availability parameters o SLA parameters o Cyber Security Controls The procured list of services by department shall meet all the functional requirements specified in the RFP	
5	DR Location	As per MeitY guidelines	
6	DR Services	DR Management services shall provide facilities to measure the RTO and RPO parameters regularly. RPO: Amount of data loss tolerable to Department RTO: Time required to resume services in DR for Department Procured list of services by department shall meet all the functional requirements for the IT infrastructure given in the RFP DR Management services shall enable Department to carry out automated DR switchover both in cases of emergencies and during planned DR drills DR Management services shall enable Department to carry out phased restoration to switchback services to normal operations in DC	

b) Responsibility Matrix – CSP and department.

An indicative list of the responsibilities between CSP and department is as below:

#	Control	CSP	department
1.	ISO 27001 Compliance & Certification – CSP Managed Infrastructure	Y	N
2.	ISO 27017 Compliance & Certification	Y	N
3.	ISO 27018 Compliance & Certification	Y	N
4.	ISO 2000 Compliance & Certification	Y	N
5.	Physical Infrastructure (hardware, software, networking, and facilities) under the responsibility of the CSP - Data Center Physical Security & Environmental Controls - Supply Chain Security - Personnel Security - Network Security: Firewall and Other Boundary Devices - Network & Security Continuous Monitoring - Asset Management, Maintenance, and Refresh - Configuration and Change Management - Vulnerability Management - Information Security Incident Response & Management - Resource / Capacity Planning - Business Continuity and Resiliency - Media Protection - Decommissioning / Secure Equipment Disposal	Y	N
6.	Hypervisor Security and Patch Management	Y	N
7.	Host Operating System (Security, Patch Management)	Y	N
8.	Conduct a well architected framework review	Y	N

	of deployed infrastructure and workloads. Submit the report to Department once a year		
9.	Conduct a security review of all the deployed infrastructure and submit reports to Department once a year	Y	N
10.	Virtual Infrastructure (e.g. Compute, Storage) Provisioned in Cloud under the responsibility of the MSP - Network & Data Security - Continuous Monitoring - Incident Management - Content Lifecycle Management - Capacity Planning - Backups & Archival - Business Continuity - Provisioning & De-Provisioning of Cloud Services - Termination / Deletion	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
11.	Guest Operating System (Security, Patch Management)	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
12.	NOC / SOC for the Virtual Private Cloud (VPC) Environment Provisioned in Cloud by the MSP using the audit trail, configuration logs, access logs, network traffic logs,..	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
13.	Cloud Services - Load Balancers - Virtual Isolated Network - VPN Gateway - Firewall	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
14.	Service to monitor, store, and analyze log files	Provides Self-Service	Implementation / Configuration /

	from various cloud services provisioned in the Cloud	Capabilities	Monitoring Responsibility
15.	Auto Scaling Capability	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
16.	Service to record API calls - identity of the API caller, the time of the API call, the source IP address of the API caller, the request parameters, and the response elements.	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
17.	Service to capture resource (cloud services) inventory, configuration history, and configuration change notifications to enable security and governance	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
18.	Notification of security and privacy events affecting Cloud services	Provides Self-Service Capabilities	Monitoring/Necessary Action Responsibility
19.	Up-to-the-minute information on service availability and notification of interruptions to each individual service and a full status history of each individual service health.	Publishes Information	Monitoring/Necessary Action Responsibility
20.	Alerts and remediation guidance when underlying cloud services are experiencing events that may impact the provisioned services. View into the performance and availability of the cloud services underlying the provisioned resources.	Publishes Alerts & Guidance	Monitoring/Necessary Action Responsibility

21.	Services to optimize costs & identify security gaps	Provides Self-Service Capabilities	Monitoring/Necessary Action Responsibility
22.	DDoS Protection Service	Y	N
23.	Web Application Firewall (WAF) Service	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
24.	Identity & Access Management Service	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
25.	Multi-factor Authentication Service	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
26.	Key Management & Encryption Service (Data at rest and Data in Transit)	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility
27.	Uptime SLAs for Cloud Services	Y	N
28.	Transition Out/Exit Management - Services to export Virtual Machine Images Services to export customer content/Data	Provides Self-Service Capabilities	Implementation / Configuration / Monitoring Responsibility

c) Security Compliances and Governance

While selecting the CSP, the department shall ensure compliance to following security controls for cloud services:

- The CSP/Service Provider should be empanelled by MeitY for providing cloud services. The CSP's facilities/services shall be certified to be compliant to the following standards: ISO 27001, ISO 27017, ISO 27018, ISO 20000-9, ISO/IEC 20000-1. SOC1, SOC2 certifications. CSP/Service Provider shall take appropriate measure for their cloud services to secure Department's content against accidental or unlawful loss, access, or disclosure.
- The CSP/Service Provider shall comply with any security requirements

applicable to CSPs/Service Providers published (or to be published) by MeitY or any standards body setup / recognized by Government of India from time to time and notified to the CSP/Service Providers by MeitY as a mandatory standard. (Refer MeitY published guidelines/reference document)

- The CSP/Service Provider shall meet all the security requirements indicated in the IT Act 2000, the terms and conditions of the Provisional Empanelment of the Cloud Service Providers and shall comply with the audit criteria defined by STQC directorate.
- Incident Management shall be done by department.
- Periodic secure code review shall be performed for cloud applications and compliance to secure software development lifecycle.
- Data encryption at rest / transit depending on sensitivity of data shall be implemented using Department managed keys, which are not stored on the cloud. Data communications should be encrypted in transit and no access over public network should be allowed
- Appropriate encryption mechanisms such as “two-way” shared key symmetric encryption, “two-way” public/private key asymmetric encryption, “one-way” salted hash encryption, etc. should use to secure data at any tier of the application. Due care must be taken to ensure that cryptographic modules used by the application are compliant with international standards both from vendor and algorithm perspectives.
- Key management process shall be properly documented and should entail key distribution plans which detail out the scenarios in which key management components are encrypted or decrypted and their physical form
- The CSP/Service Provider shall undertake to treat information passed on to them as classified. Such Information shall not be communicated / published / advertised by the CSP to any person/organization without the express permission of the Department.
- department shall inform all security breach incidents to Department on real time.

- CSP/Service Provider shall ensure data confidentiality i.e. the data shall not be accessible by anyone other than the Department, unless legally required and related risk shall be covered by CSP/Service Provider.
- E-Discovery shall be included as clause in SLA with CSP/Service Provider. It is the process of locating, preserving, collecting, processing, reviewing, and producing Electronically Stored Information (ESI) in the context of or criminal cases/proceedings or investigation. Logging and reporting (e.g., audit trails of all access and the ability to report on key requirements/indicators) must be ensured.
- The Law Enforcement Agency as mandated under any law for the time being in force may seek access to information stored on cloud as provided by the CSP/Service Provider. The onus shall be on the CSP/Service Provider to perform all due diligence before releasing any such information to any such law enforcement agency. The process for release and transfer shall be detailed in the agreement and approved.
- CSP/Service Provider must ensure location of all data related to Department to be stored in India only. The CSP/Service Provider must explicitly detail the access to data being stored and guarantee that there shall be no access to the data or its derivatives to any other commercial entity or any access to foreign entities.
- The CSP/Service Provider's services offerings shall comply with the audit requirements defined under the terms and conditions of the Provisional Empanelment of the Cloud Service Providers (or STQC /MEITY guidelines). The Audit, Access and Reporting Requirements should be as per the terms and conditions of the Provisional Empanelment of the Cloud Service.
- CSP/Service Provider's exit Management Plan shall include - Transition of Managed Services & Migration from the incumbent cloud service provider's environment to the new environment and shall follow all security clauses for smooth transition.
- SLA with department shall cover performance management & dispute resolution

escalation. Guidelines on Service Level Agreement issued by MeitY lists out the critical SLAs for cloud services.

- Identification and problem resolution (e.g. helpline, call center, or ticketing system) mechanism must be defined and approved
- Change-management process (e.g. changes such as updates or new services) must be defined with sufficient staging and testing.
- Appropriate segregation of Virtual Private Cloud (VPC) security rules defined as part of firewall should implement role-based access management, Logging and monitoring.
- VPN gateway must be setup to ensure controlled access, appropriate security rules must be employed to encrypt outward data flow, IDS, IPS, API Gateways to be setup and ELB logs to be maintained for any activities and access and exceptions to carried out in the cloud setup, Database logs to be routed as part of the Logging VPC setup.
- Digital Certificate shall be implemented for secure access.
- Web Application Firewall must be provided, Host IPS must be setup on all the Web servers, Web servers must be configured as per the CIS hardening guidelines and baseline security requirements, logging and monitoring should be enabled.
- Application access between hosted Agriculture Sector applications shall be segregated, internal infrastructure and external traffic, Role based access must be defined, hardening of database instances as per the CIS baselines configuration guidelines in the cloud setup must be ensured, Logging and monitoring must be enabled.
- The proposed CSP/Service Provider architecture may have multiple Data Centers grouped through a low-latency network to support redundancy, higher degree of High-Availability and Fault Tolerance.
- The CSP/Service Provider should adhere to the model framework for cyber

security (K- 15016/61/2016-SC-1, Government of India, and Ministry of Urban Development) and also section 7.8 of this RFP. The certification requirements for CSP/Service Provider for this model framework shall be as per MeitY guidelines.

- The department shall provide required DR planning. The following are the key DR requirements for the envisaged solution:
    - The solution should be designed for an Active-Active/Active-Passive DC/DR architecture. In case of Active-Passive architecture, then DR should be provisioned with ……% capacity as provisioned in the DC. System Architecture to be designed to achieve (i) [Zero min RPO and 30 minutes RTO] for critical applications and (ii) [15 min RPO and 30 minutes RTO for non- critical application]. [The Department may decide applicable RTO/RPO as per the uptime requirements.].
    - The department shall be responsible for provisioning of replication bandwidth between DC & DR.
    - The department shall offer services from DR at the time of outages in the DC.
    - All servers should be replicated, and automation must be part of the software functionality to failover/failback to the DR-DC adhering to the specified RPO and RTO.
    - Failover scenario: The proposed solution should allow pre-built recovery plans for various servers which includes target server configuration, IP configurations, network configuration etc. Test DR Failover scenario should not affect the primary server at all.
    - Failback Scenario: The proposed solution should ensure failback to original DC and should take care of replication of only incremental change (changed data after failover) from DR to DC.
    - DR drills needs to be performed half yearly (or as per Department requirements) to check for disaster preparedness and a report to be submitted to Department. The department shall also provide a plan for

handling the DR scenario including the roles and responsibilities for each stakeholder.

- department shall pre-check the feasibility of whether the application workload works seamlessly in case Active-Active scenario is proposed
- The department shall undertake to treat information passed on to them as classified in a secure way. Such Information shall not be communicated / published / advertised by the CSP/Service Provider to any person/organization without the express permission of the Department.
- department shall inform all security breach incidents to Department in real time.

8.5.3 Operations and Management

Operations and management require a robust framework to ensure that ICT systems perform at the required level.

Sr No	Parameter	Requirement	Deliverables
1.	Operations and Management processes design	The department will design appropriate operational processes for Department as below, but not limited to: o Resources on-boarding o Helpdesk services o Service catalogue o User Management o Change Requests o Service Requests o Incident Reporting and tracking o Security Emergency o Patch Management o SLA monitoring and reporting o Application on-boarding	1. Process documentation for each of the listed topics 2. Checklists as applicable (e.g., Application go-live checklist)
2.	Operations and Management services	The department will maintain the following 24 x 7 x 365 Operational and Management services and resources for: • Helpdesk services • IT infrastructure	1. Periodic Availability (uptime, downtime) reports 2. Periodic

		administration and monitoring • Network administration and monitoring • Security management and monitoring • Application and compute & storage performance monitoring • Data replication and DR readiness monitoring	resource utilization reports 3. SLA reports 4. Application performance reports 5. Security incident reports 6. Network bandwidth utilization reports 7. Service ticket reports 8. RTO and RPO reports
3.	DR drills	The department will be responsible for conducting periodic DR drills, min. 2 per year or as prescribed by Department	DR drills report
4.	Security Vulnerability and Penetration testing	The department will carry out periodic (min. 1 per year or as prescribed by Department) Security vulnerability and Penetration testing of the IT infrastructure, by CERT-IN empanelled Information Security auditors	Audit Report

The department will put an effective monitoring and management system be put in place with following minimum considerations:

#	Parameter	Requirement
1.	Functionalities	The proposed solution will include the following functionalities, but not limited to: o Helpdesk services o IT Asset and configuration Management o Network Monitoring and Management o Server Monitoring and Management o Application Monitoring and Management o End user response time monitoring and management o Incident Reporting and tracking o SLA monitoring and reporting

2.	Auto discovery capability	Proposed solution will have capability to automatically discover manageable elements connected to the infrastructure and map the connectivity between them. It should include, but not limited to: o Servers o Storage o Network switches o Routers o Any IP device
3.	Thresholds and alerts	Proposed solution will have capabilities to set various performance thresholds on devices and generate alerts in real-time, when those thresholds are breached Solution will have capabilities to send the generated alarms in real-time over (not exhaustive): o Mobile SMS o Email o On screen o Mobile App o WhatsApp
4.	Configuration Management	Capable of base lining device configuration and track all configuration changes
5.	Performance Management	Capable of monitoring and reporting minimum, maximum, current values of all parameters as below, but not limited to: o CPU o Memory o Storage I/O o Storage capacity o Network I/O o Network utilization o Processes o Users
6.	Analysis	Proposed solution shall be capable of performing various analysis. Some indicative lists are: o Root cause analysis o Performance analysis (historical and current) o Helpdesk process analysis o Incident and problem analysis

8.6 Cyber Security

8.6.1 Overview

The Department (PAGREXCO)has planned to consider the cyber security requirements in a comprehensive manner for the blockchain platform. The objective of the Department from Cyber security and privacy perspective is to:

- Deliver services to citizens in a safe, secure and reliable manner
- Protect the confidentiality, integrity and availability of the data processed
- Maintain the privacy of the personal data of the citizens collected
- Provide services in compliance to GoI Regulations with regard to the security and privacy of the data
- Protect the infrastructure and data from existing and emerging cyber security and privacy threats
- Create Cyber security awareness for all the stakeholders involved, and citizens at large
- Resolve cyber security incidents

8.6.2 Cyber security Requirements

The department will bring appropriate tools, technologies and solutions (which together shall be referred to as security solutions), deploy qualified and experienced cyber security and privacy professionals and implement appropriate policies to meet the security requirements.

8.6.3 Cyber Security Structure:

The department will deploy a team of qualified and experienced cyber security and privacy professionals which shall include Security Governance Expert, Vulnerability assessment and penetration tester, Security Network Architecture Expert, Security Risk and Compliance Manager and many others. The cyber security team will work in cohesion to implement and maintain the desired level of information security. This cyber security team will perform the following responsibilities:

- Provide information security directives, management direction, security strategy and support for information security initiatives

- Evaluate and constantly strive to improve the security posture of Department
- Develop and monitor a strategic, comprehensive information security program
- Ensure security solutions are implemented as per Department's security requirements

8.6.4 Cyber Security Framework

The department (PAGREXCO)will implement Cyber Security and Privacy Framework and security policies aimed at building a secure and resilient cyberspace The Framework will be designed to protect cyberspace information and infrastructure; build capabilities to prevent and respond to cyber-attacks; and minimize damages through coordinated efforts of institutional structures, people, processes, and technology.

This will be implemented based on the following guidelines / standards:

- Government of India guidelines on Data Security
- IT Act
- CERT-IN guidelines
- CMP guidelines on countering cyber-attacks
- International standards including ISO 27001
- NIST Cyber Security Framework

The department will ensure implementation of Agriculture Sector Cyber Security Policy and related procedures is in line with relevant national and international standards. The department will implement Standard Operating Procedures for smooth Operations and Maintenance of IT infrastructure. Security procedures including, but not limited to the following, shall be implemented:

- Asset management
- Change management
- User access management
- Patch management
- Back up management
- Incident management

- Communications security
- Supplier relationship
- Cryptography
- Secure software development
- Physical and environmental security
- Business Continuity and Disaster Recovery
- IOT Security
- Minimum security baseline (hardening) documents for:
    - IT systems and databases (e.g., operating systems, databases)
    - Network and security devices (e.g., firewall, switches, routers)
    - IOT devices (e.g. sensors, actuators)
    - Other systems (e.g. CCTV, OT, etc.)
    - Integration between various components

A security baseline document will define a set of minimum-security requirements which shall be met by any given service or system implemented in the blockchain platform. All systems/services shall be implemented ensuring the compliance to defined security baseline.

8.6.5 Cyber Security Governance

The department will put Cyber security governance in place to ensure cyber security aspects are considered for the Department in a comprehensive and continuous manner:

- The department will establish Cyber security organization structure with clearly defined security roles and responsibilities with skilled cyber security professionals throughout the duration of the contract
- The department will conduct Risk Assessment and develop a secure network architecture considering security across all the layers: Application, Data, Communication and Sensor layers.
- The department will facilitate management reporting in form of dashboard for security maturity across different areas on a regular basis
- The department will implement security controls as required for the protection of

the Department's services and data

8.6.6 Secure Design and Operations

The department will ensure that security is integral throughout the development life cycle of the blockchain platform. Block chain architecture shall be designed in a secure manner, considering security across all the key layers: Application layer, Data Layer, Communication layer, and Sensor layer in line with national and international standards, security policies and procedures, and Cyber security Model framework. The implementation and operations shall be performed in a secure manner in compliance to the Cyber security framework and policies and procedures as detailed above.

8.6.7 Information Security Assessment

The department will ensure perform Information security assessment of the blockchain services and related applications before Go-Live and on a regular basis after the Go-Live to ensure continuity of cyber security for the Department. The assessment will be performed in line with defined policies and procedures, international standards, Government of India guidelines and Regulations. The assessment shall include the following:

- Security network architecture
- Network Topology and placement of security products in the network
- High-Level Design (HLD) and Low-Level Design (LLD) documents
- Security operations review including change management, incident management, back-up management
- Vulnerability assessment and penetration testing of all the applications and IT infrastructure
- Application Source Code review
- Configuration review of servers, databases, and network devices
- Compliance to Regulatory requirements

An Independence will be maintained during the assessment, and the team carrying out the assessment exercise shall be different from the implementation team. Systematic actionable need to be derived post assessment and necessary changes shall be

performed in a prioritized and timely manner to enhance the cyber security maturity. Volunteer disclosure process may be delineated along with collaboration with other groups.

8.6.8 SLA Management Framework

The department will establish an SLA management framework to monitor and report the SLAs on a regular basis.

The framework should cover the following:

a) Define SLA framework for the monitoring and reporting

b) Implement and review SLA monitoring tools in line with the SLA objectives

c) Establish the process for collection of raw data, and measurement methodology for the calculation of SLA

d) Analyze the SLA data and prepare SLA reports on a regular basis

e) Review and enhance the SLA management framework on a yearly basis to improve the SLA measurement and reporting

f) Penalty for non-compliance with SLA

8.6.9 Security Control for Cloud Services

The security controls for creating and managing cloud services shall comply with the following requirements. The department along with CSP/Service Provider shall ensure:

- The CSP/Service Provider will be empanelled by MeitY for providing cloud services. The CSP's facilities/services shall be certified to be compliant to the following standards: ISO 27001, ISO 27017, ISO 27018, ISO 20000-9, ISO/IEC 20000-1. SOC1, SOC2 certifications.
- CSP/Service Provider will take appropriate measure for their cloud services to secure Department's content against accidental or unlawful loss, access, or disclosure.
- The CSP/Service Provider will comply with any security requirements applicable to CSPs/Service Providers published (or to be published) by MeitY or any standards body setup / recognized by Government of India

from time to time and notified to the CSP/Service Providers by MeitY as a mandatory standard. (Refer MeitY published guidelines/reference document)

- The CSP/Service Provider will meet all the security requirements indicated in the IT Act 2000, the terms and conditions of the Provisional Empanelment of the Cloud Service Providers and will comply with the audit criteria defined by STQC directorate.
- Periodic secure code review shall be performed for cloud applications and compliance to secure software development lifecycle.
- Data encryption at rest / transit depending on sensitivity of data shall be implemented using Department managed keys, which are not stored on the cloud. Data communications will be encrypted in transit and no access over public network should be allowed
- Appropriate encryption mechanisms such as “two-way” shared key symmetric encryption, “two-way” public/private key asymmetric encryption, “one-way” salted hash encryption, etc. will use to secure data at any tier of the application. Due care must be taken to ensure that cryptographic modules used by the application are compliant with international standards both from vendor and algorithm perspectives.
- Key management process will be properly documented and should entail key distribution plans which detail out the scenarios in which key management components are encrypted or decrypted and their physical form.
- The CSP/Service Provider will undertake to treat information passed on to them as classified. Such Information shall not be communicated / published / advertised by the CSP to any person/organization without the express permission of the Department.

9 Project Costing

(A) Web and Mobile Application [Study, Design, Development, Testing, Implementation etc.]							
Sr No	**Description**	**Total**	**Year 1 (In INR)**	**Year 2 (In INR)**	**Year 3 (In INR)**	**Year 4 (In INR)**	**Year 5 (In INR)**
1	Development of Web Platform and Mobile Application using Digital Technologies (Study, Design, Development, Testing, Implementation etc.)	1	**11,100,000**	**6,075,000**	**7,083,000**	**8,292,600**	**9,744,120**
	Total		**11,100,000**	**6,075,000**	**7,083,000**	**8,292,600**	**9,744,120**

	(B) Center of Excellence for Artificial Intelligence& Machine Learning based Digital Agriculture Solutions								
	Description	**Number**	**Unit Rate (In INR)**	**Month**	**Year 1 (In INR)**	**Year 2 (In INR)**	**Year 3 (In INR)**	**Year 4 (In INR)**	**Year 5 (In INR)**
1	Digital Data Collection & Verification	1	3,00,000	12	3,600,000	4,320,000	4,680,000	5,040,000	5,400,000
2	Digital Data Creation and Verification	1	5,00,000	12	6,000,000	7,200,000	7,800,000	8,400,000	9,000,000
3	Satellite Image Cost	1	1,000,000	12	12,000,000	14,400,000	15,600,000	16,800,000	18,000,000
4	Weather Data Cost	1	500,000	12	6,000,000	7,200,000	7,800,000	8,400,000	9,000,000
5	Other Misc Cost	1	100,000	12	1,200,000	1,440,000	1,560,000	1,680,000	1,800,000
	Total				**28,800,000**	**34,560,000**	**37,440,000**	**40,320,000**	**43,200,000**
	(C) Set up of IT Infrastructure and Artificial Intelligence Lab								
	Description	**Number**	**Unit Rate (In INR)**	**Month**	**Year 1 (In INR)**	**Year 2 (In INR)**	**Year 3 (In INR)**	**Year 4 (In INR)**	**Year 5 (In INR)**
1	Open Source AI and Blockchain Platform	2	5,000,000	1	10,000,000	12,000,000	14,400,000	17,280,000	20,736,000
2	VAPT for Platform (First Year)	2	50,000	1	100,000	120,000	144,000	172,800	207,360
3	Load Testing and Performance Testing	2	50,000	1	100,000	120,000	144,000	172,800	207,360
4	Implementation of Agristack and CropSurvey	2	5,000,000	1	10,000,000	12,000,000	14,400,000	17,280,000	20,736,000
	Total				**20,200,000**	**24,240,000**	**29,088,000**	**34,905,600**	**41,886,720**

(D) Cloud Hosting Services									
	Description	**Number**	**Unit Rate (In INR)**	**Month**	**Year 1 (In INR)**	**Year 2 (In INR)**	**Year 3 (In INR)**	**Year 4 (In INR)**	**Year 5 (In INR)**
1	Cloud Hosting with DR services	1	1,500,000	1	**1,500,000**	**1,800,000**	**2,160,000**	**2,592,000**	**3,110,400**
(E) Training and Administration Cost									
	Description	**Number**	**Unit Rate (In INR)**	**Month**	**Year 1 (In INR)**	**Year 2 (In INR)**	**Year 3 (In INR)**	**Year 4 (In INR)**	**Year 5 (In INR)**
1	Training of Officers and Field Survey Staff(Quaterly)	1	200,000	4	800,000	960,000	1,152,000	1,382,400	1,658,880
2	Tranining of Famers (Monthly)	1	150,000	12	1,800,000	2,160,000	2,592,000	3,110,400	3,732,480
	Total				**2,600,000**	**3,120,000**	**3,744,000**	**4,492,800**	**5,391,360**

(F) Project Management Unit(PMU)									
	Description	**Number**	**Unit Rate (In INR)**	**Month**	**Year 1 (In INR)**	**Year 2 (In INR)**	**Year 3 (In INR)**	**Year 4 (In INR)**	**Year 5 (In INR)**
1	Project Management Consultancy for planning, Execution, Monitoring etc	5	250,000	12	15,000,000	18,000,000	21,600,000	25,920,000	31,104,000
2	Project Management team for technical and support services	1	150,000	12	1,800,000	2,160,000	2,592,000	3,110,400	3,732,480
3	Project Operational team for technical support	1	100,000	12	1,200,000	1,440,000	1,728,000	2,073,600	2,488,320
	Total				**18,000,000**	**21,600,000**	**25,920,000**	**31,104,000**	**37,324,800**
	Total A + B + C+ D + E +F				**82,200,000**	**91,395,000**	**105,435,000**	**121,707,000**	**140,657,000**