ADeX

GOVERNMENT OF TELANGANA

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

WORLD ECONOMIC FORUM

ADeX OVERVIEW

Index

ROLE OF DATA EXCHANGE IN AGRICULTURE

Agriculture plays a significant role in the Indian economy and is the largest source of livelihood in India employing 60 percent of the nation's workforce and contributing to about 17 percent of its GDP. The government of India has implemented several initiatives to support agriculture, such as providing subsidized fertilizers, irrigation facilities, crop insurance, and minimum support prices for certain crops. Schemes like Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) provide direct income support to farmers. There is also a growing emphasis on the use of technology and innovation including the adoption of precision farming techniques, remote sensing, drones, and the promotion of digital platforms for market access and information dissemination.

As technology plays an increasing role, the effective exchange of agricultural data has become critical for the sustainable development and success of the sector. The ability to collect, analyse, and share agricultural data has the power to revolutionize farming practices, drive innovation, and empower farmers, researchers, and policymakers alike. Agricultural Data Exchange refers to the seamless flow of information and insights among stakeholders in the agricultural ecosystem. It involves the sharing of diverse datasets, such as weather patterns, soil conditions, crop performance, market trends, and best farming practices. This exchange allows for informed decision-making, improved resource management, and enhanced productivity across the entire value chain. One of the key drivers behind the need for agricultural data exchange is the growing complexity of farming systems. Modern agriculture involves an intricate interplay of variables, from climate variability and pest outbreaks to market demands and changing consumer preferences. By exchanging data, farmers gain access to valuable information that can help them optimize their operations, make timely adjustments, and mitigate risks.

Furthermore, agricultural data exchange fosters collaboration and knowledge sharing among different stakeholders. Researchers and agronomists can access real-time data to develop innovative solutions, improve crop varieties, and refine agricultural practices. Policymakers can leverage data insights to formulate evidence-based policies that address pressing challenges, promote sustainability, and support rural development. Most importantly, start-ups and other innovators in the agricultural ecosystem can create new applications and services for the farming ecosystem, improving farmer productivity and making their lives better. Some examples of the innovative applications include- smart farmer credit to improve access to loans and financial benefits; smart farmer insurance to obtain access to insurance services; various forms of targeted, customized advisories in areas such as pest, soil and market conditions; better ways of sharing farming equipment and leveraging community support; and even improved ways of maintaining farm records to better delineate boundaries and ownership. In all these cases, easy, standardized, secure, access to high quality agricultural data is the key.

The benefits of agricultural data exchange extend beyond individual stakeholders. By facilitating the exchange of data, the entire agricultural community can leverage collective intelligence and drive systemic improvements. It enables the identification of industry-wide trends, the benchmarking of performance, and the dissemination of best practices. This collective effort contributes to the growth and competitiveness of the agricultural sector as a whole.

DATA EXCHANGE PLATFORMS AS DIGITAL PUBLIC INFRASTRUCTURE

The Hon'ble Prime Minister of India spoke about Digital Public Infrastructure (DPI) during his speech to the U.S. Joint Session of Congress. He stressed the importance of DPI for our Nation and of India's willingness to help the Global South build their respective DPI platforms by leveraging India's experience and technology. As commonly defined, DPI is comprised of a set of digital platforms and IT systems that serve public good, forming the foundation for the nation's digital economy. Three aspects of the digital economy are envisaged as part of the foundation - the triad of personal identity, financial payments and data exchange. The first two are quite mature and well-established in India through, respectively Aadhar and UPI. The third aspect, data exchange, is very diverse and unique within each sector.

Exchanging data to enable the creation of applications or services is complicated for a wide variety of reasons. In fact, the availability of data is the single hardest issue when an application developer wishes to create an application to deliver a public service. The ability for application developers and particularly start-ups to experiment and innovate with new data-driven services must be fostered. Hence the need for a data exchange platform, which must provide the following capabilities:

- **Discoverability of data:** Most innovators and organizations waste a lot of resources in finding and acquiring appropriate data. The ability to identify pertinent data with a searchable catalogue is an essential aspect of a Data Exchange. The catalogue must be programmatically searchable and contain standardized meta-data descriptions.

- **Standardisation of API's and data models:** A major drain on resources is dealing with heterogeneity. Different data providers represent data in different formats, and this imposes costs and complexity on application developers. Creating standards for controlling data access: Data providers must have the ability to control who can access a data asset, in part or whole, and restrict access until an agreement is in place or payment is complete.

- **Policy-based and consent-based data sharing:** A policy-driven architecture is one where data is shared with a data consumer in a manner consistent with a specified data sharing policy. For personal data, a data exchange will preserve the privacy of such data by ensuring that any personal data is shared only if explicit consent is provided by the concerned individual.

- **Anonymisation and De-identification:** Data Exchanges must provide tools for data anonymisation i.e. to erase or encrypt all personally identifiable markers in a dataset. In addition, techniques such as differential privacy must be used to avoid the risk of de-anonymisation through triangulation.

- In addition to these functional requirements, there are several non-functional requirements that a data exchange designed for DPI must satisfy.

- **Decentralisation & Federation:** There must be no requirement to centralise control or storage of data. Each data provider must retain full control and possession of their own data. There may be hundreds of Data Exchanges, based on sectoral or application requirements. A catalogue of catalogues will provide a federated single-system view of the set of Data Exchanges, with the ability to search across them.

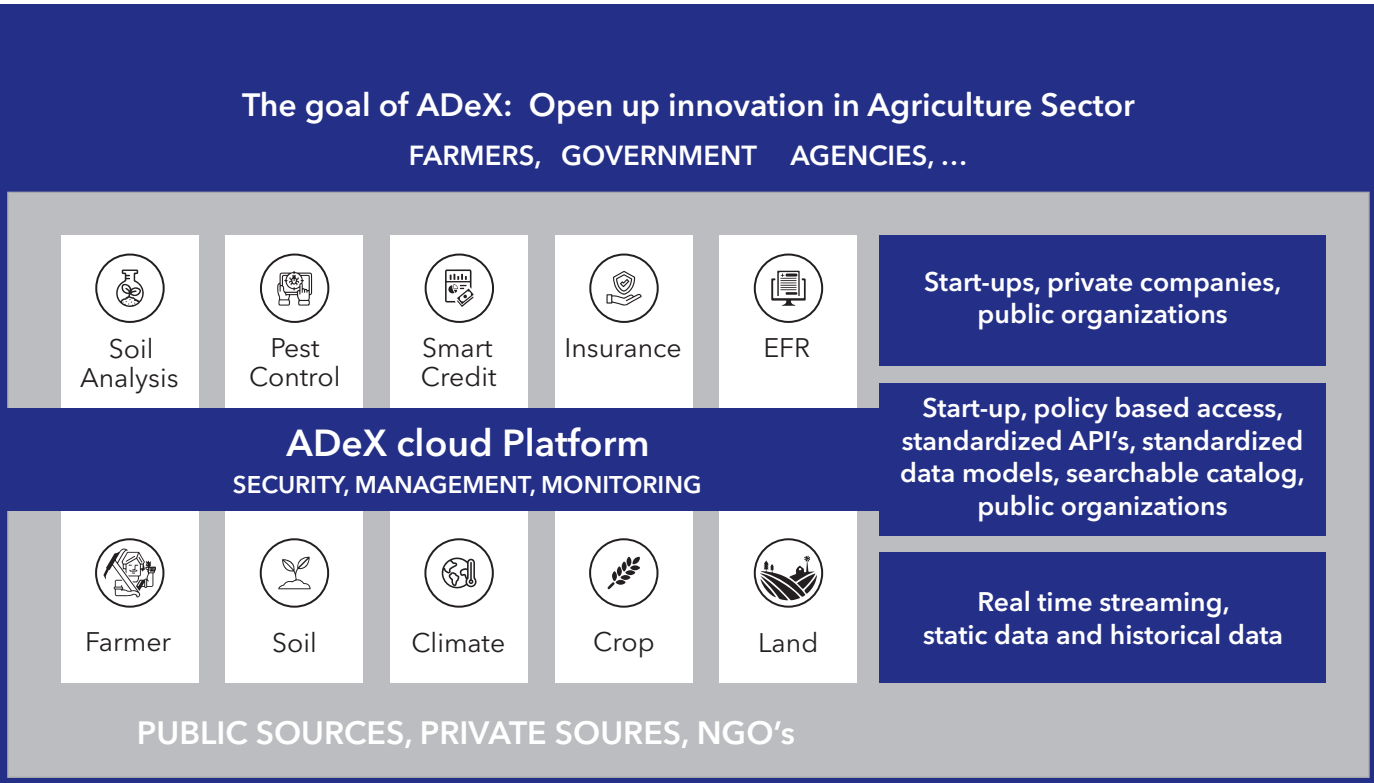
- **Open source:** The exchange should be designed to be an opensource software system. In general, any DPI must be based on open source, or it will be under the control of a proprietary vendor. This will also enable all Data Exchanges within the country to be based on a common open source code base that can be sub-setted and customized for specific deployments or sectors.

These requirements are very different from those of an **Open Data Portal** as a Data Exchange can control who can get access based on defined policies. The requirement for decentralisation and federation is essential for DPI and makes the design of a data exchange quite different from data sharing platforms common in enterprise settings such as **Data Warehouses and Data Lakes.**

ADeX- THE DATA EXCHANGE PLATFORM FOR AGRICULTURAL DATA

The Government of Telengana, the Indian Institute of Science, Bengaluru, and the World Economic Forum have collaborated over the past year to create the nation's first Agriculture Data Exchange (ADeX). The Agricultural Data Exchange (ADeX) is a platform that embodies all the requirements of the DPI mentioned earlier and is intended to address data sharing in the Agricultural sector. ADeX is based upon the India Urban Data Exchange (IUDX), a pioneer in enabling the use of data for public good and created in IISc under the auspices of the Ministry of Housing and Urban Affairs. IUDX has enabled a variety of platforms, tools, and applications that have benefitted urban citizens.

Often the biggest barrier in creating innovative applications and services to help farmers is the availability of agricultural data. Start-ups and other companies involved in such efforts can spend many weeks or even months searching for data and petitioning for access. ADeX democratises and standardizes access to agricultural data, helping innovators focus on solution creation for the farming ecosystem. The cloud-based software platform facilitates the secure, standards-based exchange of data between users of agricultural data (e.g. agri application developers) and agricultural data providers (e.g. Government Agencies, Private Companies, NGO's, Universities, etc).



ADeX has the potential to revolutionize the way we approach farming. By embracing data sharing, stakeholders can harness the power of information to drive innovation, improve sustainability, and secure food production for a growing global population.

- For farmers, ADeX will unleash new applications that can provide valuable insights into crop yields, soil health, and weather patterns, helping them to make more informed decisions about planting, irrigation, and harvesting. This can lead to increased productivity, higher yields, and greater profits. These new applications will be created by a wide variety of public and private sector entities, who will be able to create value for farmers and also for themselves.

- For researchers and analysts, ADeX can form the platform for access to large diverse datasets, enabling sophisticated AI/ML techniques to develop new insights that can improve crop production and sustainability. By sharing data, researchers can collaborate more effectively and accelerate progress toward solving complex challenges facing the agriculture industry.

- Government agencies can use agricultural data exchange to inform policy decisions and monitor trends in the industry. This can help to ensure that regulations and programs are effective in promoting sustainable farming practices and supporting rural communities.

- For start-ups and other innovators, ADeX brings truly revolutionary benefits. Companies involved in the development of applications for the agri sector can spend many weeks or even months searching for data and petitioning for access. Now, in a matter of minutes, they can find pertinent data within ADeX, petition for access if the data is not open, and quickly get their application online using standardized interfaces and data formats that do not depend upon the specific of the data provider.

Various third parties and Agritech start-ups have started building applications and solutions on ADeX, unleashing the power of data for the farming ecosystem. Several solutions have already been created, and more are in the pipeline. One major category is Advisory applications that improve farmer productivity. For example, a Market Advisory application helps farmers check on various sources of data from agricultural markets and use that data to optimise market access. Similarly, a Pest Prediction Advisory application accesses district-specific pest data across thirty-three districts of Telangana and creates targeted pest alerts based on dynamic weather and prevailing pest conditions. Another important category of applications, Smart Farmer Credit, democratises access to credit, allowing Banks and Financial institutions to estimate more effectively the credit-worthiness of farmers, enabling faster disbursement of loans or other financial support. The data for all these applications was easily obtained from ADeX through standardized methods and interfaces, saving months in overall development time and effort.

A key part of any data sharing platform is the underling policy rules and mandates. To this end, the Telangana Agricultural Data Management Policy 2022 (ADMP) aims to streamline and codify the processes, responsibilities, norms and practices related to agricultural data management for the general benefit of all stakeholders, primarily farmers. Its main goal is to ensure that agricultural data is managed efficiently to advance the agricultural sector, while always protecting the rights of individuals. The policy is created around four stakeholders in the data chain viz. Data Principal (e.g., Farmer), Agriculture Information Provider (e.g., Agriculture Department), Agriculture Information User (e.g. Startups), and Data Service Provider (e.g. Data Processing Companies) to ensure a comprehensive platform for all data related to the agricultural sector of the State. ADeX implements the ADMP as it is currently drafted. However, the platform is flexible enough to be rapidly modified to adopt other data management policies as required.

SOME TECHNICAL DETAILS OF ADeX

ADeX does not store any data itself, but provides a standards-based catalogue of available agricultural data, a comprehensive set of authorization and consent management capabilities, standardized API's and data models to make data available, and a suite of analytics to help the creation of use cases and solutions that can benefit farmers and the farming ecosystem.

Like IUDX, ADeX is a highly scalable, interoperable, open source and secure platform, based on state-of-the-art software methods and practices. The platform provides full control to the data owners as to what data to expose and to whom. Built-in accounting mechanisms enable connect with payment gateways which will form the foundations for a data marketplace. The whole platform is developer friendly, via definitions of open APIs (application program interfaces) and data schema templates (formats for interpreting data), so that a whole new application ecosystem gets created.

The primary objective of ADeX is to improve access to relevant and reliable agricultural data to facilitate collaboration and partnerships among various stakeholders in the agricultural ecosystem. Since a lot of this data, will be personal data, the focus is on prioritizing data security and privacy, and on ensuring consent from farmers before sharing personal data. This is the major difference from IUDX, which was predominantly focused on non-personal data.

The ADeX platform comprises the following interfaces:

- Management interface
- Consent interface
- Discover interface
- Authorization interface
- Resource interface
- Identity interface

The Agriculture Information Provider (AIP) and/or the Data Service Provider (DSP) can maintain and manage the meta-data of the resource and their associated access control policies using the Management (M) interface. They can provide, maintain and manage the Consent forms of a resource and requests for a resource provided by an Agriculture Information User (AIU) using the Consent (C) interface.

The Agriculture Information User (AIU) and/or the Data Service Provider (DSP) can use the Discovery (D) interface to identify the resources available with the ADeX platform. On discovery, they can obtain a Consent for the resource using the Consent (C) interface. After obtaining the Consent, they can use the Authorization (A) interface to request access tokens which can be presented to the Resource (R) interface for accessing the resource.

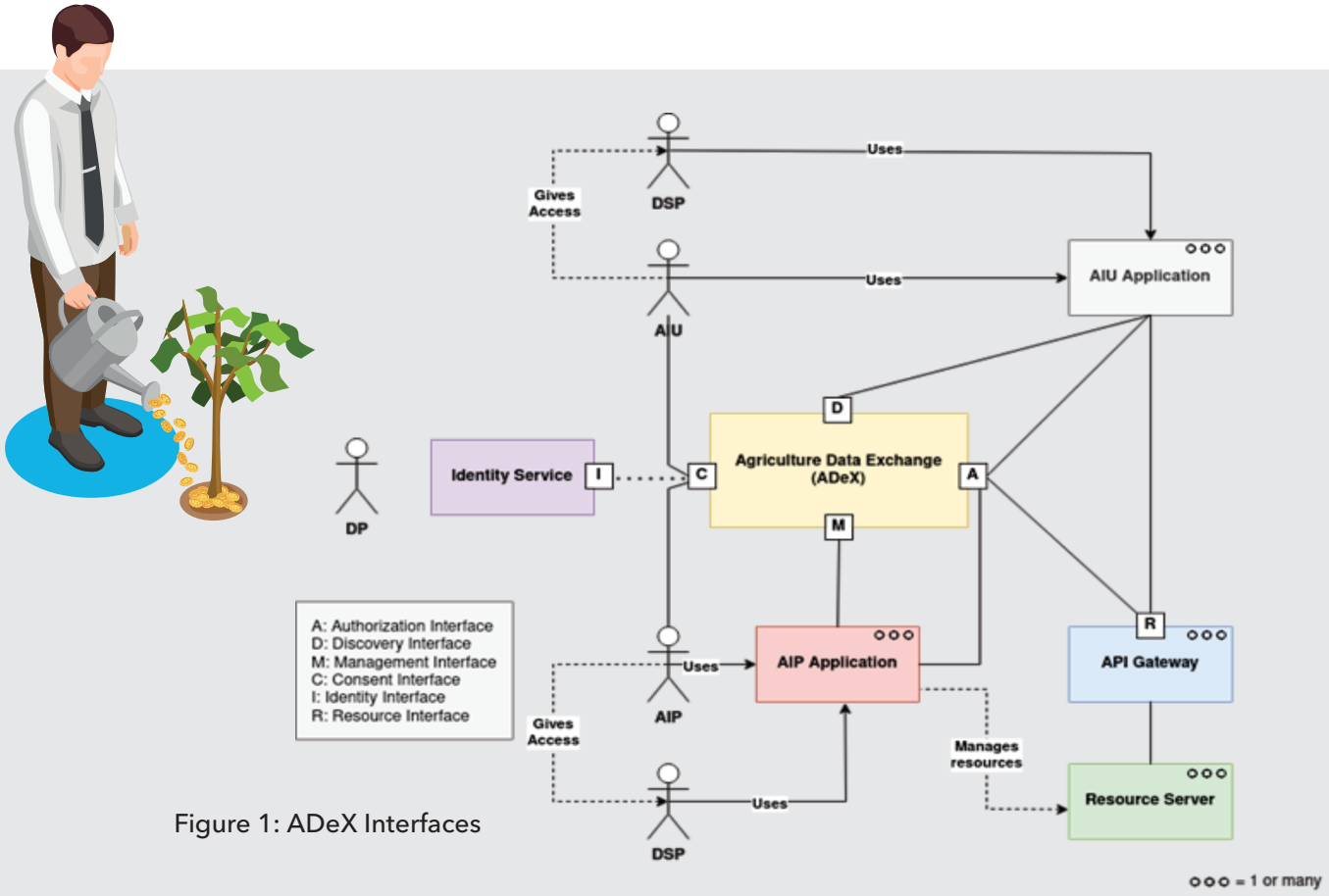


Figure 1: ADeX Interfaces

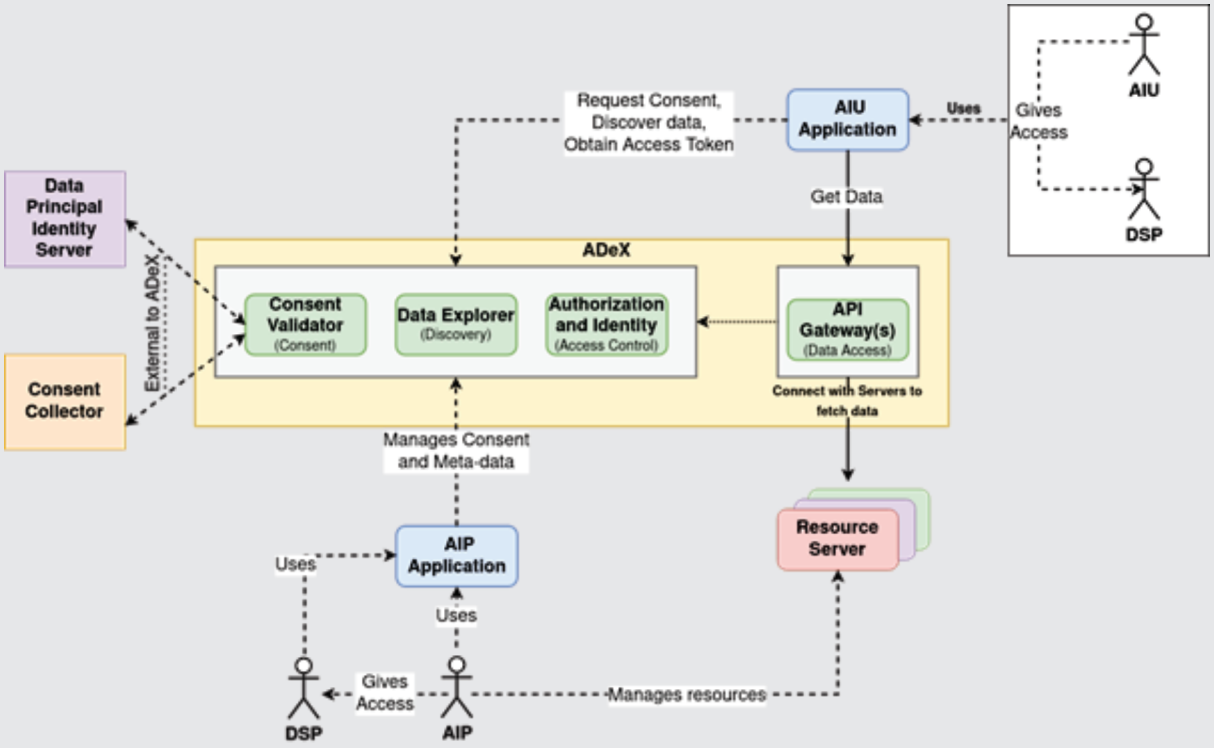


Figure 2: ADeX High Level Architecture

ADeX system is comprised of the five core components that are mentioned below:

1. **Data Explore Service:** This service is used for the discovery and management of meta-data of the data available with the data exchange. This service shall be used by any AIP, AIU and DSP to onboard or discover datasets in ADeX.
2. **API Gateway Service:** This service is used for serving the data associated with a resource in encrypted or unencrypted format with an AIU after verifying the authorisation token. This service shall be used by any AIPs, AIUs and DSPs who wish to use ADeX.
3. **Authorization and Identity Service:** This service is used for user profile management on ADeX and requesting access tokens which can be presented at the API gateway for accessing resources. This service shall be used by any AIP, AIU and DSP who wishes to use ADeX.
4. **Consent Validator Service:** The purpose of the Consent Validator Service is to manage the lifecycle of Data Principal consent for personal data. This service shall be used by AIP, AIU and DSP who have registered with Authorization and Identity Service.
5. **Consent Collector:** The purpose of the Consent Collector is to obtain consent of a Data Principal for sharing their personal data. This shall be used by AIP, AIU and DSP to interact with DP for obtaining consent.

BENEFITS OF ADeX

Some more specifics on the benefits and value of ADeX are provided below.

Benefits for the Data Providers:

1) Lower development costs and quicker turnaround times. This is supported by:
   a. The capacity to reuse the code from effectively implemented use cases.
   b. The capacity for implementation modularization.
   c. The availability of top-notch remedies through the market.
2) Based on the changing needs of the users, the standardised and open platform allows for much better flexibility and vendor choice.
3) Data providers will be able to more efficiently monetize their data thanks to the data economy that the ADeX platform has allowed.
4) Embedding community and entrepreneur innovation. The marketplace for plug-and-play applications that ADeX will enable will serve as the foundation for this.

Industry/Start-ups/Entrepreneurs benefits:

1) Improved ability to find skills and move projects forward quickly. This is done through standardized and proven APIs and data models for external access and internal interfaces between components.
2) Reduced development costs because of the open source code that provides a robust, royalty-free building foundation with standard interfaces that simplify implementation.
3) Ability to innovate. Developers can focus on innovation and differentiated value instead of building simple software.
4) System Integrators benefit from reduced heterogeneity. Thanks to the standardized ADeX interface, they don't have to deal with different platforms, each with specific features and limitations.
5) Start-ups and other entrepreneurs can easily create innovative new applications using standardized APIs provided by ADeX.
6) The data economy enabled by the ADeX platform makes it possible to leverage third-party data sources and monetize data more effectively.

Academia and Research benefits:

1) Improved access to data for research. It would promote multi-disciplinary research and analysis by making data available from various data sources.

USE CASES FOR ADeX

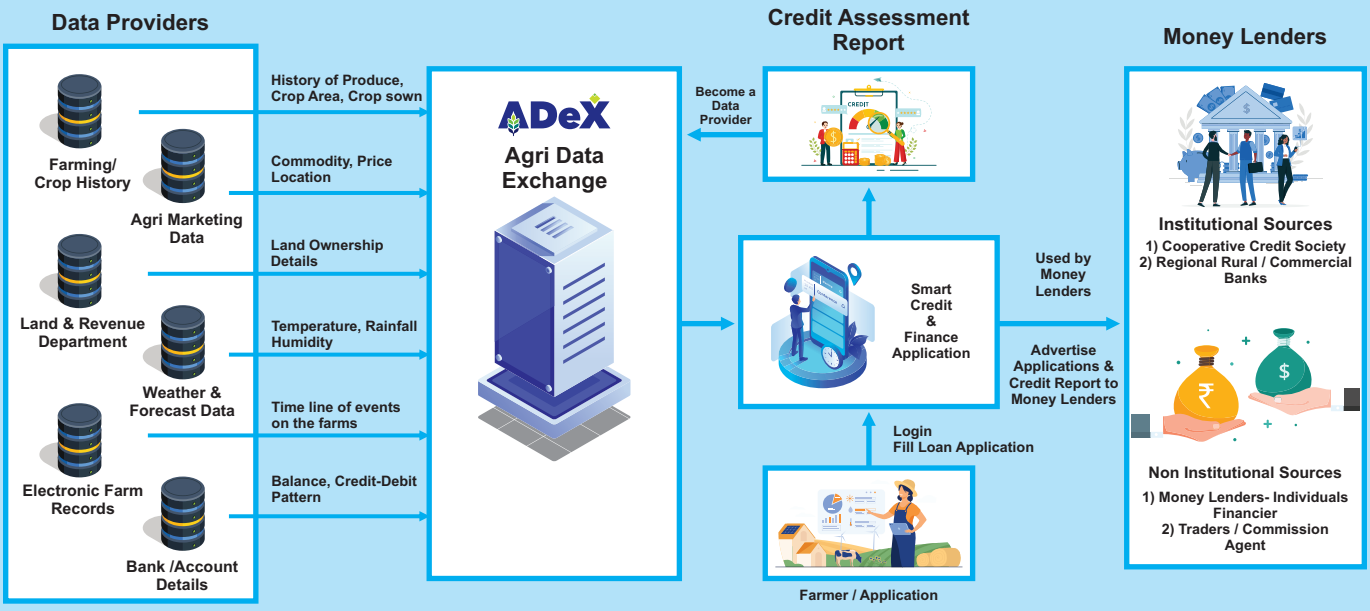
A few initial use case categories have been identified for ADeX, and several have already been successfully piloted by various parties. The use cases were selected to illustrate the value of ADeX and drive the initial development priorities. But the sky is the limit and it is expected that imaginative innovators will come up with many more examples as the use of ADeX grows.

The details of the initial use cases are as follows:

Smart Credit and Finance for Farmers

Smart credit and Finance use case aims to bridge the gap between legit credit sources and applicants. This use case, with the use of data analytics and digital technologies, will enable financial service providers to create and assess the credit score from various public and private data sources and applicants will be able to avail the credit from authorized sources and at competitive rates. Some of the key features of the use case are:

- Farmers will be able to avail of loans from all types of reliable lenders at a cheaper rate
- Farmers will get to choose from multiple offers from the lenders against different interest rates and vice versa
- Loans will be available with minimal or no collateral
- The average issues like loans for higher interest rates and with collateral hardships and Agri credit fraud will be minimized for applicants and lenders

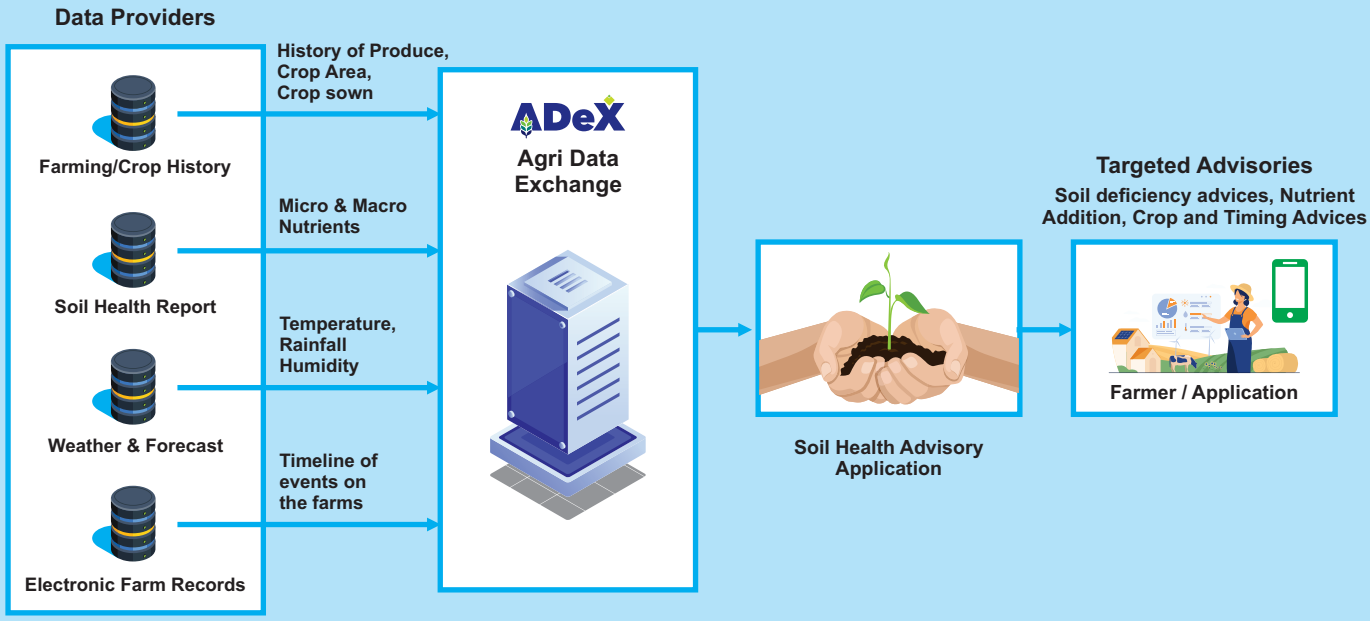


Allows the Banks/Financial institutions to weigh in the credit worthiness of the farmers, to disburse loans or provide other financial support

Soil Health-Based Advisory

Soil Health is one of the prime factors to be considered when it comes to the productivity of farmland and sustainable agriculture. Appropriately managing the soil health improves the resiliency of the farm by helping to reduce erosion, maximize water infiltration, improve nutrient cycling, and reduce the requirement for external inputs and hence capital. There is a dire need for an expert advisory and feedback channel through which farmers can benefit from the data-driven suggestions issued to rejuvenate the soil health. The soil health advisory application would consume the relevant datasets from ADeX viz. Soil Health Report parameters, weather parameters and historical events on the farmland and issue advisory to the farmer for the appropriate crop to grow next season, any soil treatment requirements etc. Some of the key features of the use case are:

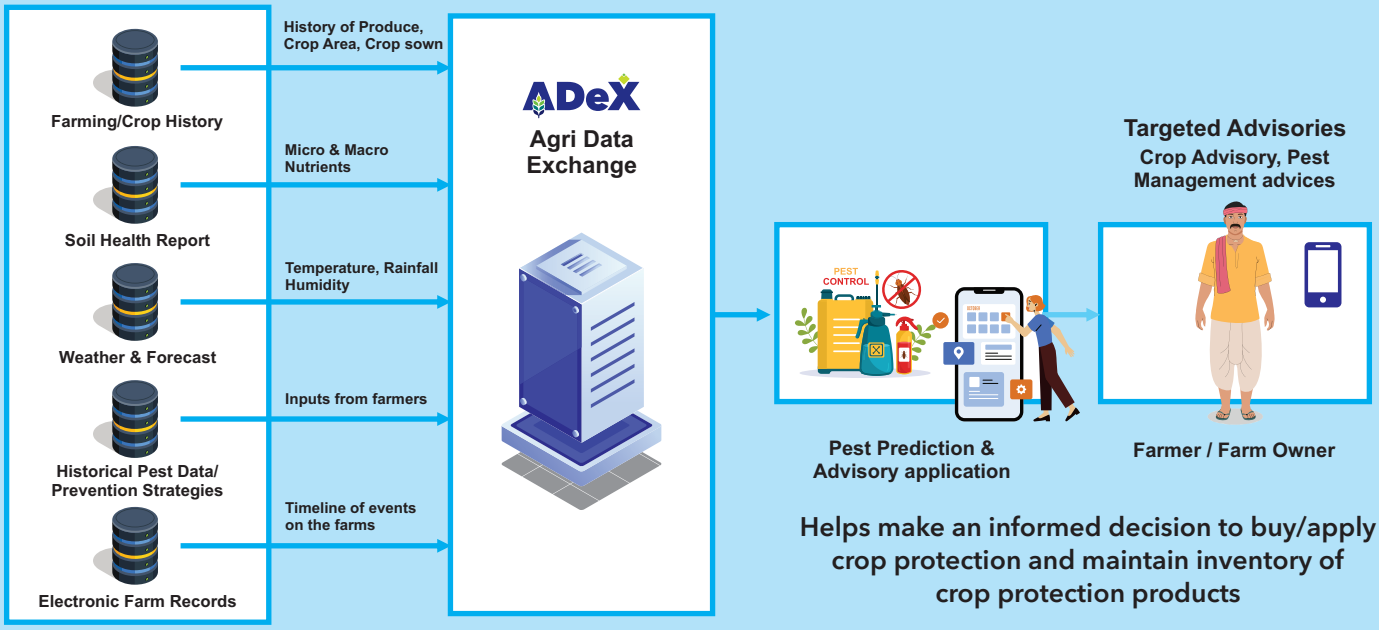
- Farmers will get a proper soil health record to can plan the future of their crops and land
- Farmers will receive advice based on soil nutrients to invest in crops that would provide higher yield and profit
- Regular soil monitoring for updated soil data
- Support in carrying out advised corrective measures



Supports intelligent irrigation planning on the basis of data analytics and provides information on various factors affecting soil health and corrective measures to be taken

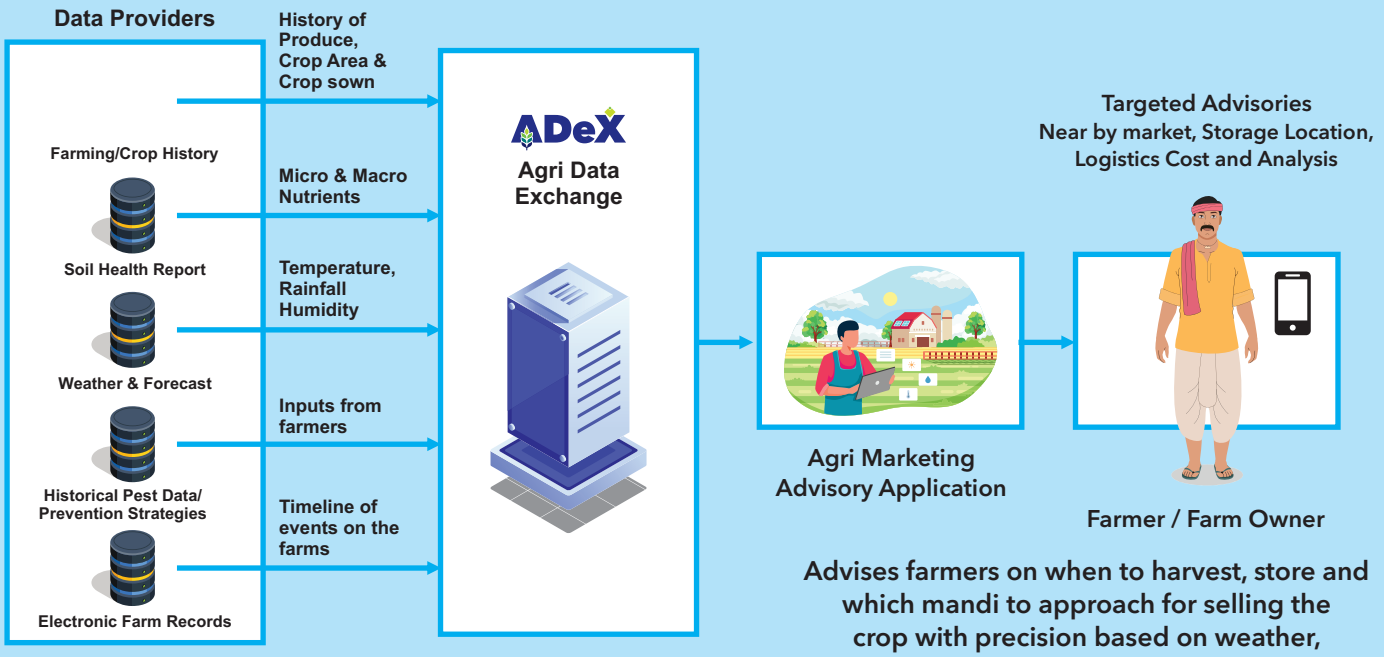
Pest Prediction and Advisory

Pests are a nuisance to the farming community as they not just destroy crops, but also post a threat to the area's biodiversity while degrading water, air, and soil health quality. To counter the above problem there is a need for data-driven and targeted proactive advisory, using which farmers can inculcate the preventive measures before the disaster happens with no or minimal loss. The advisory application would take in historical pest data for the farm and also for the region in general, superimpose it with other complimentary datasets like weather, proactive inputs from the farmers like images of the pest infected crop and make predictions regarding the crop and also issue advisory regarding the preventive measures.



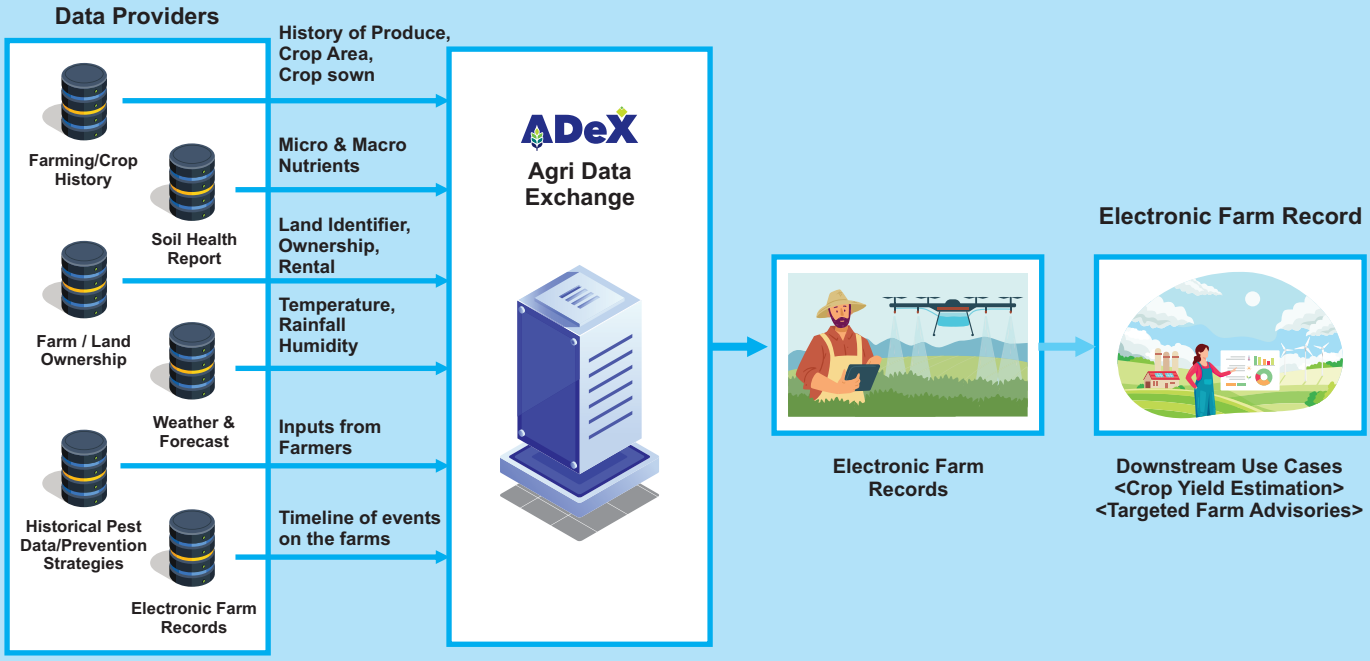
Agri Marketing-Based Advisory

This use case will help farmers make informed decisions on how to deal with their produce for maximum profit. The application would advise the farmers on when to harvest, store and which mandi to approach for selling the crop with precision based on weather, Agri marketing data and inputs from the farmer. Based on the advisory, farmers will be able to make right decision for marketing and will be able to get a good price for their produce.



Electronic Farm Records

Electronic farm records are the timeline of all the events that the farm has gone through. Such a database will act as a single source of information for various use cases like crop yield estimation, advisory for the current owner etc. This use case collects all the events that have happened on the farm, keeping the farm at center and makes available all the details via a unique identity, enabling farmers to access real-time information about their farms from anywhere in the world, helping them make informed decisions about their farming practices and improve overall productivity.



Provides comprehensive archival view of all the details of a farmer, the farmland, information on tools and equipment, crop details, etc. of the identified farmer/farmland

CONCLUSION

The widespread use of the ADeX platform will dramatically enhance the power of new data-driven services available to farmers and the agri ecosystem, and also increase the speed at which these can be created. As data providers see the value of sharing their data, it is expected to create a virtuous cycle -- more data will be collected and shared, which will enable new services to enhance the value of data collected, and so on. In addition, the burden on governmental resources will be reduced as private companies see the advantage of participating in this data ecosystem. Instead of waiting for governmental action to address issues, the culture will shift to self-empowerment where private companies and even individuals will use ingenuity to create data-driven solutions from ADeX-obtained data, without complicated procedures and approvals. The ultimate beneficiary of all these developments will be the Indian farmer and their quality of life.