सत्यमेव जयते

मत्स्यपालन, पशुपालन और डेयरी मंत्रालय
MINISTRY OF FISHERIES,
ANIMAL HUSBANDRY & DAIRYING

NATIONAL
DAIRY
DEVELOPMENT
BOARD

NATIONAL
DIGITAL LIVESTOCK MISSION
BLUEPRINT

Contents

Abbreviations

AI	Artificial Insemination
AI/ML	Artificial Intelligence/Machine Learning
APEDA	Agricultural and Processed Food Products Export Development Authority
API	Application Programming Interface
ASHA	Accredited Social Health Activist
CAGR	Cumulative/Compound Annual Growth Rate
CSR	Corporate Social Responsibility
DAHD	Department of Animal Husbandry and Dairying
DBT	Direct Benefit Transfer
FLW	Front Line Workers (Veterinarians, Livestock technicians, Pashumitras etc)
FMD	Foot and Mouth Disease
GDP	Gross Domestic Products
ID	Identification
IDSP	Integrated Disease Surveillance Programme
INAPH	Information Network for Animal Productivity and Health
IT	Information Technology
IVF	*In Vitro* Fertilization
NADCP	National Animal Disease Control Programme
NADRS	National Animal Disease Reporting System
NAIP	Nationwide Artificial Insemination Programme
NDDB	National Dairy Development Board
NDLM	National Digital Livestock Mission
NLP	Natural Language Processing
OCR	Optical Character Recognition
PPR	Peste des Petits Ruminants
RDDL	Regional Disease Diagnostic Laboratories
TB	Tuberculosis
QA/QC	Quality Assurance/Quality Control
SPV	Special Purpose Vehicle

EXECUTIVE SUMMARY

Vision

*To create a **farmer-centric, technology-enabled ecosystem** where the farmers are able to realize better income through livestock activities with the right **information** and enabling **infrastructure** to obtain timely, high quality **services** and **access** to **markets** as a result of well-functioning, connected systems that optimize for **sustainable economic opportunities** and **health** of both the animals and the people.*

Context

The Livestock sector has a unique combination of being the backbone of the rural livelihood while also showing consistent growth and export potential. Over 60% of rural households have livestock as part of their economic activity and livelihood. Livestock is a source of reliable income and a source of upward economic mobility for the poorest, while also being a net exporter and has shown a steady 6% Compound Annual Growth Rate (CAGR) over the past five years.

However, we have not yet fully tapped into the potential of all aspects of the livestock sector to lift millions of farmers' livelihood across the whole country. Various national and state programmes operate largely in silos. There is limited participation of the private sector and the ability of the farmers to access the markets. Limited animal identification among other reasons has resulted in less than 4% of animals being covered through insurance. Farmers often do not have adequate knowledge or empowerment to seek services from the government or take advantage of the market. As a result, our ability to improve the productivity of the animals, control diseases that affect both the farmers and the people and ensure quality products that supply to both the domestic and export markets has been limited.

To address these issues comprehensively, the Department of Animal Husbandry and Dairying (DAHD) in the Ministry of Fisheries, Animal Husbandry and Dairying along with the National Dairy Development Board (NDDB) is undertaking this ambitious, overarching programme as a National Mission to build enabling framework and incentive systems for making a step change in the sector.

Goals of National Digital Livestock Mission (NDLM)

- To create a **'farmer-centric system'** where modern information infrastructure and applications enable farmers to seamlessly access services and information through an intentionally designed national digital architecture
- Build a mechanism for **Direct Benefit Transfer** (DBT) programmes
- Enable improved **participation of the private sector** so that both the farmer and market can seamlessly access each other regardless of the location or size of the farmer's holdings resulting in a ***'connected livestock market for India'***
- Create robust **closed-loop breeding systems, disease surveillance/control programmes** and **traceability programmes** for the livestock sector
- Promote **linkage between the R&D systems to the field** so that best quality science is informing the implementation without delay by improving the functioning of various national and state programmes in service of the farmers
- Better alignment between various national and state programmes, and build an architecture that **enables States to create and manage their own programmes**

Key building blocks of NDLM

1. **Identification:** Unique identification of animals will become the foundation for all livestock programmes. There is an ongoing effort to tag all the 50 crore major livestock species (cattle, buffaloes, sheep, goats, and pigs) in the country with a unique identification number. With NDLM, we envision the purpose of this identification system to serve as the foundation for all of the state and national programmes, enable farmers to maintain and share their digitally signed animal records, access government services in a seamless manner, trade their animals and interact with the market for various inputs or to sell their products.
2. **Enhanced mobile applications for the farmers** (eGopala) that enable access to services, maintains relevant animal records and enhances the ability to sell products. This programme will focus on **simplicity, integration, and user-centric designs** such that user experience and continuous improvement will be a priority. Similarly, Front-end digital applications for the **Front-Line Workers** (FLWs) such as veterinarians and livestock technicians to maximize their ability to provide services to the farmers, eliminate the current paper-based reporting systems, while also ensuring accountability.
3. **Backend IT systems** of the government agencies involved across the various livestock programmes such as breeding, disease control, product traceability etc., are intentionally designed, well-managed and able to seamlessly interact across the systems within the public sector as well as interface with the private sector.

4. **Interoperability:** This will be built from the design stage such that the system is based on an open API based format, to make information, regardless of where it is managed, is accessible for the purpose needed whether it is for disease management or ability of the farmer to sell the product for a premium as a result of better management of the animals.

5. **Better analytics layered on the data systems.** The quality of the data generated from the field determine the utility of the analytics. Our goal is to not only create a system where high-quality data is generated but **promote analytic methods such as Artificial Intelligence and Machine Learning (AI/ML)** to derive better value from the data in programmes such as disease prediction, diagnostics, animal management and product traceability.

6. **Data privacy and data standards** for the ecosystem that enables better management of data thoughtfully and rigorously, at the same time not hindering the progress of the sector in service of the farmer.

7. **Incentive mechanisms:** Currently, government subsidies largely flow through the implementers or implementing agencies. We envision implementing **eVoucher** based and other **direct benefit transfer (DBT) mechanisms** to route the same subsidies to align the incentives of various stakeholders of the system and put the power in the hands of the farmers to demand and choose the best services that meet their needs.

8. **Dedicated entity (Special Purpose Vehicle)** to operate the key elements of the digital architecture and provides sustainable management of the architecture. This entity will be aligned with the mission of the Ministry, yet operates with independence and stays at the leading edge of innovation. It will serve as a resource for the Ministry, states, implementing agencies on the necessary technical aspects and data analytics (such as disease modeling and AI/ML related analytics).

Progress to date towards achieving these goals:

NDLM has taken into consideration the learnings from the various state and national programmes that have provided input from the field not only in the animal husbandry sector, but also in other nation-scale programmes such as Aadhaar, National Digital Health Mission and innovations in the financial sectors in India. Extensive consultations with individuals and groups involved in these efforts as well as key stakeholders such as states, the private sector and subject matter experts have led to this first draft that articulates both the vision and the proposed approach. In addition to the discussions that have taken place as part of the NDLM design process, it builds on the learnings of other major efforts that have been launched over the last few years.

- In terms of animal identification, over 15 crore cattle and buffaloes (representing more than half of the bovine population of the country) have been tagged with a unique 12-digit Pashu Aadhaar number. Remaining animals are slated to be tagged in 2021 and expand this process to sheep, goats and pigs
- Basic digital applications in the form of Information Network for Animal Productivity and Health (INAPH) have been implemented in the field and key lessons are being accumulated in the form of feedback on aspects that work, and where improvements are needed
- Over the last decade, disease reporting systems such as National Animal Disease Reporting System (NADRS) have been launched and the input from the field on how a disease reporting system needs to be reworked is being incorporated into the current thinking. Flagship breeding programmes such as Nationwide Artificial Insemination Programme (NAIP) have both informed the design of NDLM, and also will be better enabled as a result of it

Building a comprehensive, inclusive, and forward-looking architecture to support and stimulate all aspects of a complex sector such as livestock is a major undertaking. COVID-19 has shown both vulnerabilities as well as resilience, resourcefulness, and technological capabilities of India. We believe that this is an appropriate opportunity to take on the challenge of realizing the full potential of India's livestock sector.

This document aims to articulate the vision, details, and roadmap of NDLM and serves as a basis to seek wider input in the shaping of the overall programme.

CHAPTER 1

OVERVIEW OF THE DIGITAL ARCHITECTURE

1.1. Digital Architecture

1.1.1. Overview

Currently, the programmes and digital systems operate largely within silos. Front Line Workers (FLWs) which are largely made up of veterinarians, livestock technicians and various extension workers operate with a multitude of largely paper-based or web-based systems that create unnecessary reporting burden, as well as the data as result is often difficult to use for continuous improvement on time. As a result, various national and state schemes that get implemented in the field operate largely independently, with limited transparency, and farmers are often not fully aware or not equipped to demand services.

In terms of the backend of the system, most data sit in multiple databases of various implementing agencies. In disease management alone, there are various implementing agencies responsible for different diseases, diagnostic labs, state institutions, and the private sector that supplies the medicines or vaccines that are largely disconnected from each other. This, together with the suboptimal front-end systems, has created major challenges across the programmes to provide seamless, high quality service to the farmers.

Through NDLM, we will be redesigning both the front end and the backend systems that are connected from the beginning *(Figure 1)*.

A major area of focus will be to redesign the application system for the farmers and and FLWs to carry out their day-to-day activities. This is analogous to how the country has moved from paper-based registries to the digital systems in the case of FLWs in the human health space (ASHAs and Anganwadi workers) transforming their ability to provide services. User-centric design will be used to ensure this system has the following features.

- Single platform for all the workflows (disease management, breeding, routine administration, etc.)

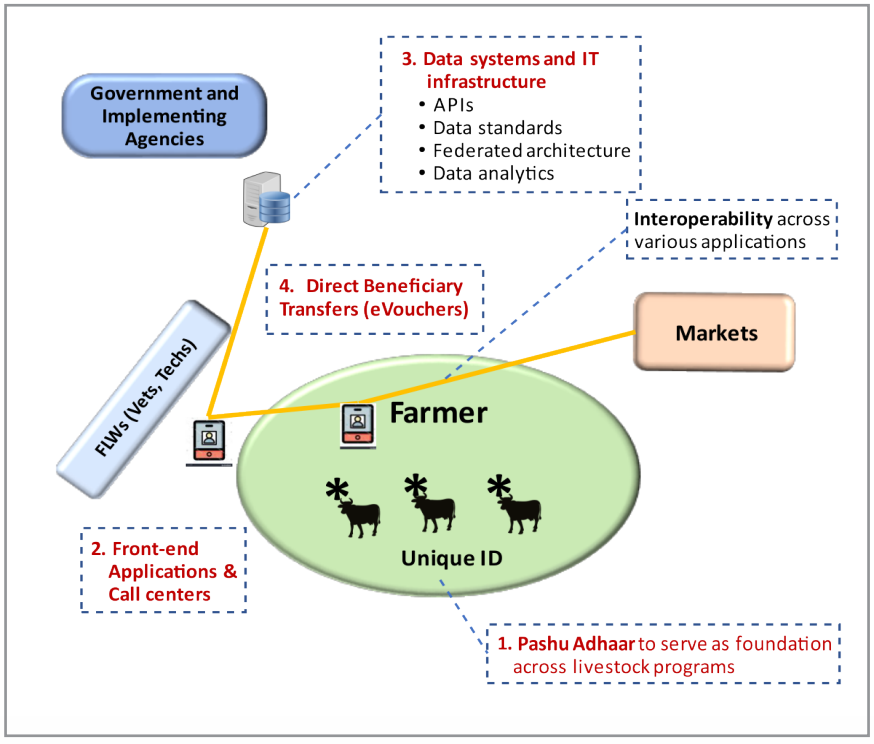

Figure 1: Key components of NDLM

- Mobile/web interface, online/offline capabilities, and robust minimalist design to ensure that it can work in the rugged field systems and cater to different language requirements across state boundaries
- Technology-enabled call centres that connects to farmers to services at anytime, anywhere
- Major emphasis on **automation** (e.g., scanning of the animal ID, vaccine vials, semen straws, eVouchers etc.) to provide ease of reporting and improved quality of data, that also can create a system of transparency and accountability
- **Clear linkages to the farmer:** We envision that with the creation of this front-end system, with every interaction of the FLWs with the animals, farmer can easily access and maintain a record of their own animals in terms of the productivity and health. This is analogous to the ability to manage their own electronic health records by the people under National Digital Health Mission
- **Connections to the backend systems:** Field activities carried out by the FLWs make up the bulk of the data for the system today in the public system. Therefore, all the data generated as a result of disease control programmes in the field (e.g., vaccination), breeding (e.g., artificial inseminations) or disease outbreak reporting will be designed such that there is a seamless flow of information to the appropriate entities and back to the field to enable the most optimal functioning at various levels

To achieve this vision, in addition to re-designing the front-end systems, a major effort will be needed to upgrade the back-end systems as well. Today, when a veterinarian sends a sample for diagnosis of a suspected case of the disease in an animal to a lab, there is not an easy way to send the samples, accompanying animal information and to receive timely results from the lab digitally. Also, the accumulated information from the lab as a result of these activities, which form a rich source of information on the status of the animals or prevalence of diseases is not managed in a way to integrate information from other multiple sources, look at longitudinal trends and enable better analytics for a given geography. The COVID-19 crisis has shown us that diseases do not respect geographic or species boundaries. Goal of NDLM is to build a connected livestock disease programme that can integrate with wildlife and human disease systems to inform us about the movements and control of zoonotic diseases.

To achieve this, key entities involved in the sector will be assessed for their system capabilities and upgradation needed to achieve connected, federated architecture.

1.2. Technical specifications

The digital architecture solution for the NDLM (also referred to as LiveStack) is an ecosystem that has been designed under the auspices of India Enterprise Architecture (IndEA) and follows the guidelines and reference models of the same. The overall solution is a multi-layered set of loosely coupled components, built on the following principles.

a. **Platform design approach:** Federated design for seamless information flow and integration with multiple stakeholders/systems related to the livestock sector and other external systems like Aadhaar, Digilocker, Payments, etc.,

b. **Opensource technology stack** to minimize technology dependency and to enable platform-agnostic portability.

c. **Open standards:** Defined standards for easy inter-operability, encourage the ecosystem to innovate and avoid any vendor lock-in across compute, network, storage, security and software components.

d. **Omni-channel enabled, responsive and accessible** with voice, web and mobile app interfaces across all external and internal applications/services using APIs.

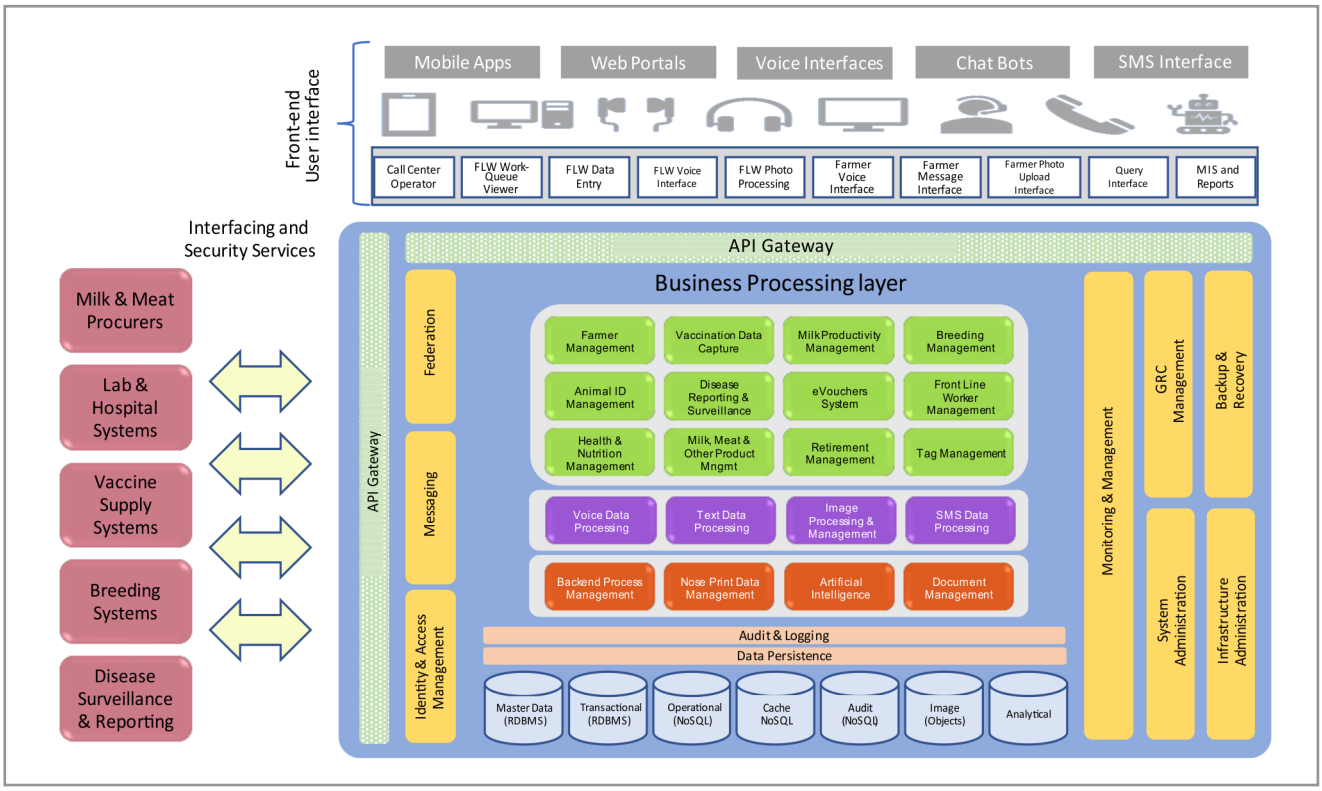

Figure 2: Overview of the technical architecture of LiveStack

e. **Deployed on the cloud** using container orchestration and with the required redundancy and fail-over mechanisms to enable high availability and without any vendor lock-in to any specific PaaS components.

f. Standardized micro-services architecture and design to enable using Twelve-Factor app principles to build secure, modular, scalable, reliable, maintainable and configurable systems/code base.

g. **Security and Privacy by design** to ensure all interface, data and applications are protected during initiation, transit, and rest. Enable near real-time fraud analytics with feedback loops.

h. Extreme automation to enable predictable and reliable agile delivery during the test, build, deployment, configuration, and monitoring.

i. Data-driven approach to ensure both business and technology telemetry are emitted at the right source for near real-time processing to make informed decisions by all users of the ecosystem.

j. **Auditability and Traceability of transactions by design.** NDLM should be capable to easily retrieve information to help resolve grievances proactively and at scale. The NDLM system configurations shall be audited to ensure continuous system integrity.

The digital ecosystem shall comprise of the following layers:

1. Data Layer:

The data layer shall consist of **standardized, federated**, and **interoperable** data, with consistent **definitions**, distinct **ownerships** and sources of truth, well-laid-out **synchronization** mechanisms, secure **sharing** and **access** management **protocols**. Some of the major kinds of data in the data layer will include.

a. **Master Data:** The nearly static attributes about various entities such as Animal Master, Tag Master, Village Master, Semen Straw Master, Farmer (Animal Owner) Master, Front Line Worker (FLW) Master, Roles Master, Vaccine Master, Vaccine Vial Master etc.

b. **Relationship Definers:** The data that show the linkage between various elements such as tag to animal linkage, animal to farmer linkage, FLW to village linkage etc. These data elements will be less dynamic than transactional data, but less static compared to master data.

c. **Transactional Data:** Data that changes during day-to-day transactions and operations such as the latest vaccination status of an animal, the current pregnancy status, villages visited by an FLW during a particular day, vaccines administered by the FLW in a day and so on.

d. **Audit Data:** All business services/transactions shall be audited with the right information. The retention duration of audit data is configurable by application based on the business needs.

e. **Analytical Data:** Data aggregates to enable all stakeholders to make informed decisions such as,

   i. Pre-built aggregate data sets at defined gradual intervals for system-wide consumption across various users for ready consumption.

   ii. Raw data for power users to do deep-dive analysis for defined recent past data (e.g., 6 to 12-month data set).

   By design, anonymized data sets are to be used to protect privacy in the analytical data stores. Transactional data stores should not be used for reporting and all the required data should be emitted by the application services as events.

f. Operational Data: Temporary store to hold meta data related to a business transaction that require orchestration between micro-services. This data store should be treated as a temporary store for a specific transaction processing and all end state information shall be captured in either master data, transactional data, or audit data stores based on the business transaction.

2. Application Layer:

The application layer shall comprise of **Microservices**, which essentially are self-contained programme elements that are built to '**do one thing and do it well**'. The Microservices shall be exposed as **RESTful APIs** for invocation and utilization securely via the **API Gateways**. Most of the system logic ideally will reside in the application layer.

The Microservices shall be built using **open source technology** stacks to enable maximum **platform-agnostic portability and flexibility.** The microservices may be packaged and bundled and offered as a comprehensive offering or individually, for specific functions, for invocation or plug and play, as need be to ensure the underlying data integrity responsibility is with the respective micro-service.

Key types of micro-services include those used for data access, data insertion, data update, data deletion, rules-based and other calculations, work and business processing, analytics, user management, reporting and so on. Some of the key Micro-services of the Stack include those that manage the master data (e.g., Creation of an Animal ID plus its corresponding attribute linkages – Tag ID, Breed etc.), those that manage transactions (e.g., update the milk amount produced in a day by a cow, update the vaccination data etc.) and those that do calculations (e.g., calculate the productivity of the cow, calculate the incentive for artificial insemination) etc.

3. User Interface Layer:

The user interface layer is the **collection** of all the **internal** and external **interfaces** that are accessed by the **institutional** and **individual** users for performing the various functions needed for successful livestock operations, through the LiveStack.

The interfaces can be mobile applications, web pages, websites, bots, IVR systems, desktop (client) applications or external interfacing systems that consume the Microservice APIs through the API gateway with secure Identity and access management.

4. Operational Layer:

The operation layer shall enable near real-time 24x7 automated monitoring of all business services, systems/application performances. Where required, self-testing tools like service ping utilities shall be developed and deployed to ensure all the layers of the services are working as expected.

This operational layer shall be extremely automated for quick identification, isolation and resolution of any issues using open-source monitoring tech stack proposed in NDLM solution architecture.

5. AI/ML Layer:

The AI/ML layer shall enable seamless access to quality data to train, build new inference models that shall enhance end-user experience while interacting with NDLM systems/services. The data pipelines required to achieve an ideal AI/ML environment shall not be an afterthought and designed from the beginning.

The inference services required shall be designed to work both on edge and/or backend.

6. Automation Layer:

Continuous Integration and Continuous Delivery (CICD) shall be part of the first principles to inculcate quality delivery of the code using automated pipelines. The goal of the CICD pipeline is to automate Unit, Functional, Integration, Security (vulnerability & penetration testing), Benchmarking tests using the opensource stack proposed in NDLM solution architecture from the beginning.

NDLM system shall be deployed using automated deployment scripts using auditable configuration management, service discovery and appropriate versioning of packages.

1.3. Use of technologies such as eVouchers for Direct Benefit Transfer (DBT) programmes to empower the farmers

Currently livestock programmes remain heavily subsidized through various central and state schemes. Most of this subsidy flows through the procurers, semen centres, providers ultimately to the farmers. In the case of breeding programme for example, farmers are often either unaware of what semen is available and being administered to their animals, and not empowered to demand services. We envision the integration of key technologies such as eVouchers as a means of DBT, where farmers get an eVoucher that is redeemable for a specific purpose (e.g., money for AI service), which when configured to work with the mobile application mentioned above, will empower the farmers to demand better services.

With a successful design and implementation, we will be able to move the subsidies from flowing through low-cost service to a model where the cost of the service reflects true cost, while farmers are provided with eVouchers to obtain the service that best suits their needs. For example, today most of the efforts at choosing the best bulls, supply of the bulls to the semen centres, and operation costs of the semen centres are heavily subsidized. We can see a model where instead of government subsidies flowing through this pathway, semen will be sold near the cost of production in the market, while the government subsidies flow in the form of eVouchers to the farmers who need it the most while the overall programme continues to become sustainable.

This model can address many current issues that hold this programme back.

- All the transactions can be tracked. It empowers the farmers to choose the best service
- With other components of NDLM, where performance indicators of the system and the FLWs being transparent to the farmers (semen quality indicators, performance of different AI indicators such as AI efficiency), will result in demand for better services
- eVouchers being able to be redeemed by only registered technicians, it will prevent unregistered, untrained practitioners from being either brought into the system or weeded out

In addition to digital infrastructure, NDLM creates an opportunity to integrate and promote key technologies that are coming out of our investments in the R&D pipeline such as genomic selection of better quality bulls, genomic chips available for farmers to ascertain the breed and genetic quality of their animals, In Vitro Fertilization (IVF) for rapid multiplication of elite animals and sexed semen for increasing the proportion of female calves born to name a few.

CHAPTER 2

DETAILS OF PRIORITY PROGRAMMES UNDER NDLM

2.1 Breeding programmes

A robust breeding programme is an essential component of the livestock system. Even though India has made remarkable progress in the dairy programme, the progress has been restricted few places. The average production of Indian cattle is still 8 kg/day for exotic or cross-bred cattle and about 3 kg/day for indigenous cattle. Over the last seven years, we have seen only 1 kg increase in average yield in exotic breeds and no increase in the indigenous breeds. This is despite a big untapped potential of the indigenous breeds of cattle as well as buffaloes that also possess key adaptability characteristics to Indian climatic conditions.

2.1.1 Current challenges:

- Coverage of artificial insemination is low (30-35% in many places). The efficiency of artificial insemination (No. of AIs needed/conception) is low and it forces the farmer to spend money repeatedly for sub-standard service.
- Farmers do not have adequate information on which semen is available in stock, information on the bull (e.g., breeding value), and the merits and demerits of using the particular bull semen given the needs of the farmer.
- Data entry in the field is either a paper-based summary reporting or a separate activity that needs to be carried out as opposed to being part of the activity itself.
- There is a large group of unregistered and untrained livestock technicians that operate in the country. It results in farmers often having to choose this workforce either because of lack of alternatives or lack of awareness.
- Mainly, the incentive system for the system which wants to achieve certain targets, for the technicians who carry out most of the breeding activities and farmers who would like to see best outcome for their animals is not well aligned.

2.1.2 Vision for the breeding programme under NDLM

Our goal is to create a robust 'closed-loop breeding system' that allows for better accountability, while making it easy for the field staff to perform their routine duties and reporting not being a separate exercise but part of the workflow itself. It is also about providing a framework and vision for the implementation new technologies.

All the elements of NDLM are essential and complement each other to create this closed-loop system. **The use of animal ID system** in every interaction is an essential part of the implementation. Through the front end systems that will be developed, we envision requiring the capture of animal ID and the service provided with every interaction between a FLW and the animal in an automated way (e.g., scanning), through the lifecycle of the animals such as insemination, pregnancy diagnosis, delivery of a calf and all the future touch points with

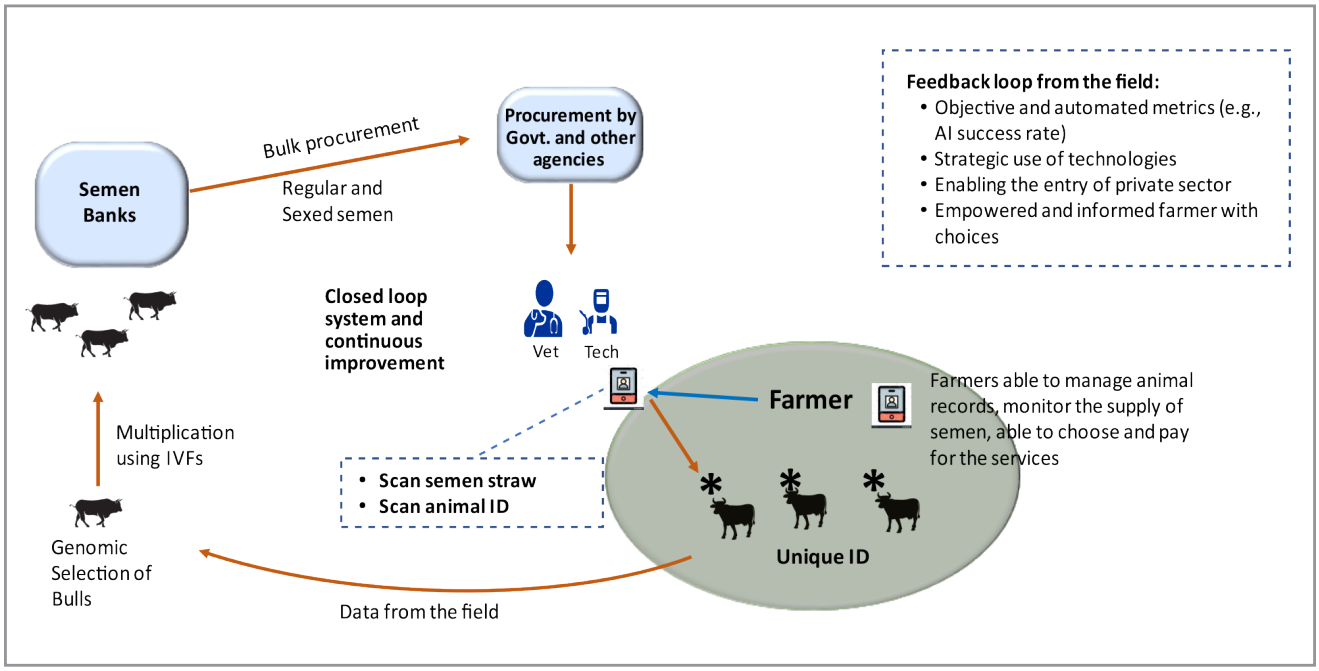

Figure 3: Vision for breeding programme under NDLM

that calf. If these two actions can be configured with simple steps, without requiring separate reporting, the entirety of data on various aspects of the breeding programme can be accurately and in real-time be captured. This system also enables better introduction of newer technologies such as sexed semen, genomic chips and in vitro fertilization in the future.

2.2 Disease control programmes

Disease control is one of the most important pillars of livestock programmes. Uncontrolled livestock diseases such as Foot and Mouth Disease (FMD) drastically affect productivity and exports. Zoonotic diseases such as brucellosis, TB, rabies etc affect the health of both animals and humans. Recent outbreaks of avian influenza and African swine fever have shown the pandemic potential of these diseases. Even though we have a major vaccination programme for FMD and Brucellosis, there is still a long way to go to realize the dream of being free from FMD status, which allows India to export livestock products to the developed markets.

2.2.1 Current challenges

Currently, there are many challenges we need to overcome.

- Disease reporting system is not dynamic, connected across diseases, state lines, and programmes
- Incentives are not aligned. For example, there is a barrier to reporting a disease because our system is punitive for those who report it, as opposed to incentivizing it. As a result, diseases often go unreported

- Zoonotic diseases are often tracked independently. For example, rabies or anthrax outbreak in animals is tracked separately from humans, even though they are connected to the same source in the field
- Limited use of data from a diverse source or analytics such as AI/ML, disease prediction systems to get a comprehensive, real-time picture of disease outbreaks

2.2.2 Disease surveillance and reporting

An important aspect of disease control is being able to have a bird's eye view of the emerging livestock diseases. This forms the first step in our ability to prevent, control, and respond to disease outbreaks. For us to be able to have a robust disease reporting system, it needs to have direct linkages to the field. That is, disease reporting cannot be a separate activity, that relies on a stand-alone reporting system, as it currently operates. Instead, the source of the data from multiple levels and activities in the field should be designed to be automatically pulled, integrated, and analyzed. Therefore, we envision setting up an integrated disease surveillance system that has the following features.

- Multiple sources of data to be integrated – reporting from the farmers and FLWs, data that is pulled automatically from the field activities, outbreak reporting, data from diagnostic centres, etc., all feeding into the same system, which can appropriately be weighted and integrated
- Farmers should be able to use their front-end system (e-Gopala) to access services when their animal is sick in multiple channels (calling the Veterinarian directly or calling the veterinary dispensaries, call centre, and so on). There should be features built into access care remotely (telehealth). Meta-data from all these interactions make up a rich source of data reporting
- Both the front-end applications and back-end systems to be redesigned so

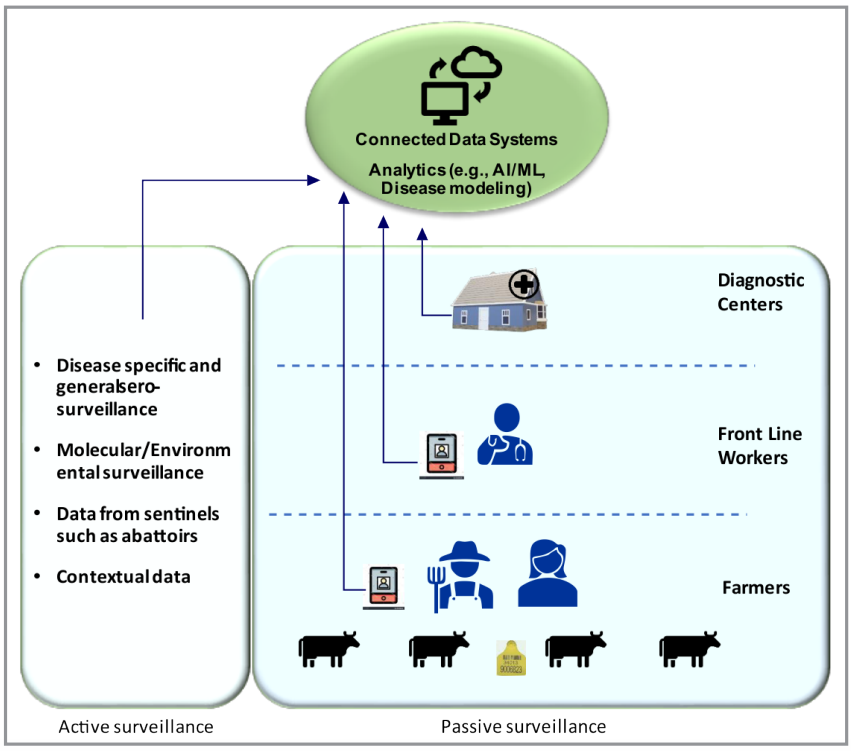

Figure 4: Vision for disease surveillance system under NDLM

that the daily activity of FLWs forms the main aspect of the disease reporting programme. For example, when a veterinarian diagnoses a disease as part of a visit and treats the animal, the front-end application should enable the veterinarian to carry out that activity seamlessly and become the source of the data for the disease incidence without needing a separate reporting activity to be fulfilled

- When a veterinarian or a farmer sends a sample from an animal to one of the accredited laboratories across India, that diagnosis should become the source of disease incidence
- Despite all these routine activities, there will still be a need for reporting outbreaks of notifiable diseases. The front-end application should be designed to have a workflow for this, that makes it easy for the FLW to provide syndromic reporting, the ability to take pictures of the animals or lesions, etc. In the future, for example, we can envision AI/ML applications that could be built such that they get an immediate probable diagnosis based on the symptoms coupled with image recognition algorithms
- Routine surveillance activities need to be enhanced so that there is multi-pathogen surveillance. Abattoirs can serve as good sentinels to keep the pulse on the disease prevalence in the surrounding areas. Novel approaches such as environmental molecular surveillance that is currently being successfully used in surveillance of polio, typhoid and more recently SARS-COV-2 can further augment the active surveillance approaches in animal diseases
- Back-end systems to be connected via APIs such that information from various disease management entities, RDDLs, and state diagnostic labs are connected, and there are data standards in place to ensure such integration to carry out modeling and prediction of diseases
- We envision the integration of key zoonotic diseases from the animal health (Brucellosis, TB, rabies, avian influenza, anthrax, etc.) to be connected to the human health systems which manage such data so that as a country we can better respond to the zoonotic disease threats in the form of **One Health** system

With these systems in place, the opportunity to have integrated data systems and analytics can be made feasible without the need for investing in a standalone disease reporting system (Figure 3).

In addition to building the digital architecture to capture the disease outbreaks, there is a need for change in the way it is handled. The current system is punitive to those who dutifully report a disease outbreak. For example, if a veterinarian reports an FMD outbreak in her area because there are consequences for having a disease outbreak reported in that administrative unit, it is seen as an inconvenience by the higher authorities resulting in accusations of not

properly carrying out vaccinations by the veterinarian herself. As a result, the system is set up to disincentivize disease outbreak reporting. This needs a change in both the mindset and incentive structure for the system to work, even with the best-designed digital reporting architecture.

Well functioning front-end application, when routinely used by veterinarians to offer treatment, prescribe medicines also serves as an accurate source of information on the use or overuse of antibiotics and AMR surveillance.

Importantly, having a national level robust disease reporting system that draws information from daily field activities, combined with multiple active surveillance activities allows for accurate estimation of disease outbreaks and provides multiple options for triangulation and validation. This will further boost India's ability to accurately maintain its reporting obligations to international bodies such as OIE-WAHIS (OIE World Animal Health Information System).

2.2.3 Disease control; vaccination and treatment

Currently, many diseases affect the animals in the form of FMD, hemorrhagic septicemia, black quarter, Swine Fever, Brucellosis, PPR, etc. Many of these diseases have effective and affordable vaccines that we can make in India. However, there is a general lack of coordinated efforts across national, state, and disease control entities which results in sub-optimal vaccine coverage. We outline the following principles to address these issues.

- Ensure that the animal **ID becomes the foundation** for all vaccination efforts. With each vaccination, FLW should be able to link the animal and that vaccine vial, doing away with the entire paper-based or summary data reporting.
- A serious focus on vaccine quality will be needed. As a result, the digital information pathway from vaccine supply, QA/QC, transport (cold chain maintenance where appropriate), vaccinations in the field, reporting and management will be streamlined across the diseases
- Currently the process of disease **diagnostics, treatment and animal ID** is not linked to each other. This will be redesigned intentionally such that when samples from the field are sent to the concerned diagnostic facilities (state or regional), it is digitally linked to animal ID, results from the labs are sent back to the field in a timely and traceable way to enable better treatment and management of the animal. We also envision these diagnostic facilities to become part of the national network over time such that information can flow in an automated manner to necessary databases
- Currently sero-surviellance and sero-monitoring are done on a limited basis and even when samples are collected with much effort, they are used for tracing a single disease

as opposed to getting a comprehensive picture of the disease prevalence. In addition to addressing this opportunity with comprehensive sero-surveillance approaches, the data flow of that activity will need to be streamlined with access to the data by the researchers

- **Disease monitoring** is a complex activity that cannot rely on a single source of data or as a separate activity of reporting as it is envisioned currently. We will redesign this system to be much more agile and field-appropriate such that data from multiple sources (from farmers or field workers reporting a disease, diagnostic laboratories, or sero-surveillance) can be integrated appropriately in a more dynamic manner
- Emphasis to be given on **high quality disease modeling**. Data quality is a major constraint in the present form to achieve any progress with disease modeling. With improvement in the data quality and data flow, we would like to enhance country's capability to apply the best analytics in the form of disease modeling. This is possible when the data is of high quality and follows a set of standards such that multiple parameters can be integrated. Since there is no dearth of analytic groups in India, we would like to ensure that multiple groups are engaged in this activity such that there is growing awareness and training of the future analytic capability in the country. SPV will become a thought partner and analytic hub to provide that capability across stakeholders
- Data access is a key part of all these activities. Therefore, appropriate **data standards and well-designed, interoperable backend IT systems** that are professionally managed and that can integrate data from multiple sources will be needed. These will be governed by open API systems

2.3 Market interface and product traceability system under NDLM

2.3.1 Overview

The livestock sector in India is still lacking vibrant private sector participation beyond limited areas. The government's role is to create an enabling environment for the private sector to thrive and only step in areas where there is market failure to ensure equity in terms of access to services for the farmers. Therefore, interface with the private sector is intentionally built to be minimalist, enabling and creates a win-win for both the farmers and the market entities.

We envision enabling private sector participation through two key aspects, a) Building of appropriate interfaces as part of the digital architecture to enable information flow, and b) Incentive systems to ensure better functioning of the markets.

Currently, the ability of the farmers to find the markets and for the markets to find the farmer is largely word of mouth. In the case of cattle trading, for example, it is a challenge for a

farmer in Karnataka who wants to buy a high-quality Murrah buffalo from Haryana or sell products beyond the limits imposed by geographical limitations. We will be applying robust user-centric design principles to enable the connection between the farmers to markets via farmer-facing applications as well as eMarkets.

Access to relevant data for the improved functioning of the markets is a core priority. Currently, we do not have access to reliable disease incidence data and their trends across the country, which is critical for making decisions for both the private sector (such as a vaccine manufacturer) and governments to enable better vaccination programmes. Similarly, access to market-based analytics is also limited. With the implementation of the NDLM, appropriate data standards, and analytics built on top of that, we envision a much more seamless flow of information to be enabled for various users including the private sector.

Through NDLM, we envision a system with the following key features.

- Unique ID of the animals forms the basis of all interactions with the public and private sector for the farmers
- The insurance industry is incentivized with appropriate government support as well as the right infrastructure to operate and increase both the coverage of livestock insurance as well as the variety of products suitable for the farmers, which is crucial for surviving unexpected catastrophe especially with the increasing impact of climate change
- The ability of the private sector to create farmer-facing applications is enabled and incentivized. For example, many startups are creating resources that help farmers to maintain all the information on the animals in one place that is continuously updated, provide access to both markets as well as services such as telemedicine to care for the animals, and so on. Goal of NDLM is to enable such private sector participation which in turn creates value for the farmers

Currently, there is very limited trading of livestock happens through the organized sector. This is especially limited in the case of sheep, goats, and pigs. We would like to enable more vibrant trading of both livestock and livestock products for all the species.

2.3.2 Product traceability programmes

FAO states that if food is not safe it is not food. However, it is only possible to assure food quality if it can be traced through its pathway from production to consumption. Until now, the ability to track livestock products such as milk, other value-added products in dairy, meat, etc., had been limited. This was due to the lack of a widespread animal identification system, streamlined food quality standards, and the absence of a traceability system. With the universal coverage of major livestock species with a unique ID and the end-to-end digital architecture that is envisioned as part of the NDLM, we will be uniquely set up to address the issue of product traceability.

2.3.2a Milk and dairy products

On the dairy products, we have seen the private sector has started stepping into the traceability aspect.

- There needs to be infrastructure enabled to trace milk quality from the point of origin through the value chain until milk and dairy products are consumed. This will prevent the mixing of higher quality milk with the lower quality and hence allow for higher quality milk to be diverted to premium value-added products stimulating that industry. Additionally, prices realized through selling milk, when coupled with quality, will serve as a positive feedback loop to the farmer and raises the quality of the whole system
- To achieve this, through NDLM, we will enable the LiveStack (unique ID system, and associated digital infrastructure) to be able to interface with the private sector, which will stimulate more participation from them with the profits that can be generated through this sector
- We envision farmers with their animals that are uniquely tagged, their mobile applications that can maintain an accurate log of the management of animals (treatment, vaccination, health status, etc.), as well as their ability to interface with the market, will serve as a foundation for the product traceability system

There is interest in the private sector to tap into this market. Our goal is to create enabling infrastructure that incentivizes these entities to build business solutions on top of this foundation of LiveStack and the government's role will be to ensure better regulation

2.3.2b Meat products

Similarly, the meat industry today is held back because of the lack of quality assurance and product traceability. For example, India is the largest exporter of buffalo meat. In the year 2019-20, export of buffalo meat stood at 1.15 million tonnes worth $3,175 million. However, due to the lack of a traceability system, India's ability to export to premium markets is limited. Following section provides an overview of the main nodes in the buffalo meat value chain;

i. Farmers: With their animals that are tagged with a unique ID and up-to-date animal records make the foundational layer of this system.

ii. Animal trader: The trader holds the animal for a short duration and hence recording the trader details is not an essential requirement of the traceability system. However, a system for registration of the trader and maintaining the identification number of the animals traded by him will strengthen the traceability system.

iii. Abattoirs: More than 80% of the buffalo meat produced in India is exported. Meat is produced and packaged in Agricultural and Processed Food Products Export Development Authority (APEDA), New Delhi registered export-oriented abattoirs. There are about 80 APEDA registered abattoirs that process, package, and export buffalo meat from the country. A module can be developed for recording the identification number of the buffaloes entering these abattoirs and maintaining the traceability trail by designing a traceability labelling system on the meat package as it moves through the meat value chain. The traceability label can help in tracing back the source of the animal and the abattoir in which the meat was produced.

iv. Wholesaler/ Retailer: If the meat is sold domestically, the retailer can register onto the traceability system and upload the traceability details of the package sold.

v. Consumer or importing country: With the help of the traceability labelling, the consumer or the importing country will be able to trace back the farm of origin of the buffalo and the abattoir in which the meat was produced.

2.3.3 Steps needed for the development of voluntary traceability standards

- Role of the government.
  - Certifications to be streamlined from the current multiple certification agencies
  - Regulation that export-oriented APEDA registered abattoirs only accept tagged animals with properly maintained records and maintain the database system
  - As part of the NDLM work, develop minimum database standards that these abattoirs need to maintain so that information between farmers, abattoirs, and central database flow seamlessly
- To strengthen the traceability-based quality assurance, apart from the identification of buffaloes and collection of corresponding data, farmers are also enabled to maintain their animal registries, which is enabled by farmer-facing applications such as eGopala. These records will include, but will not be limited to medication, vaccination, animal receipt and disposal details, which can be automatically updated with each interaction of the FLWs with the animals. For example, with each vaccination rounds of FMD, when the Veterinarian updates the vaccination status using his/her front-end app, the record for that animal on the farmers' end will be automatically updated and serves as a source of certification

- If the model farms can be certified, it will be easy for the export abattoirs to source their animal requirement to meet the importing country standards. Certifications such as '*Sourced from FMD free zones or organic farming practices*' will further help open up new markets. These incentives will further help drive the demand for vaccinations from the farmers, which is currently limited, and vaccinations are largely driven from the supply side
- For certification, private agencies can be empaneled who will visit the farm and issue the certificate after verifying the farm against the checklist
- A certification programme will be an incentive to organized farms following standard production practices

Although this segment is specific to buffalo meat traceability, by developing this in a modular fashion it can be applied to other sectors such as sheep and goats as well. Completion of tagging of sheep, goats, and pigs will significantly enhance the inclusion of these farmers via NDLM. This will enable bringing the sheep and goat farmers, who are until now not as well served by national and state schemes more into the organized sector and help raise their income levels.

CHAPTER 3

INSTITUTIONAL FRAMEWORK OF NDLM

3.1 Professional management of the digital architecture

Unique ID system of all the 50 crore animals that are linked to the farmers presents a major source of information that will need to be managed professionally, with data privacy controls in place. Management of the full technology stack is a critical function and there is a need for providing technical support for states and key stakeholders in the sector on an ongoing basis. In addition to this, there will likely be a need for this entity to manage additional data such as disease incidence and reporting for which there is not a natural place to be hosted. Therefore, we will be exploring the creation of a Special Purpose Vehicle (SPV) for the dedicated, professional management of this sensitive and important information that forms the basis for the entire NDLM. Existing structures and lessons learned from GSTN, UIDAI, NPCI, and other similar organizations were considered to arrive at the proposed structure.

3.2 Key responsibilities of the SPV:

- **Manage Animal ID system** and related information for the major livestock species including technology and process of tagging and maintenance nationally. It will also be exploring future field-appropriate technological enhancements to the tagging programme (such as biometry or photo-based system that rely on AI/ML)
- **Technical support to the states** and key entities (e.g., RDDLs, semen centres, APEDA slaughterhouses for exports) for IT upgradation and management

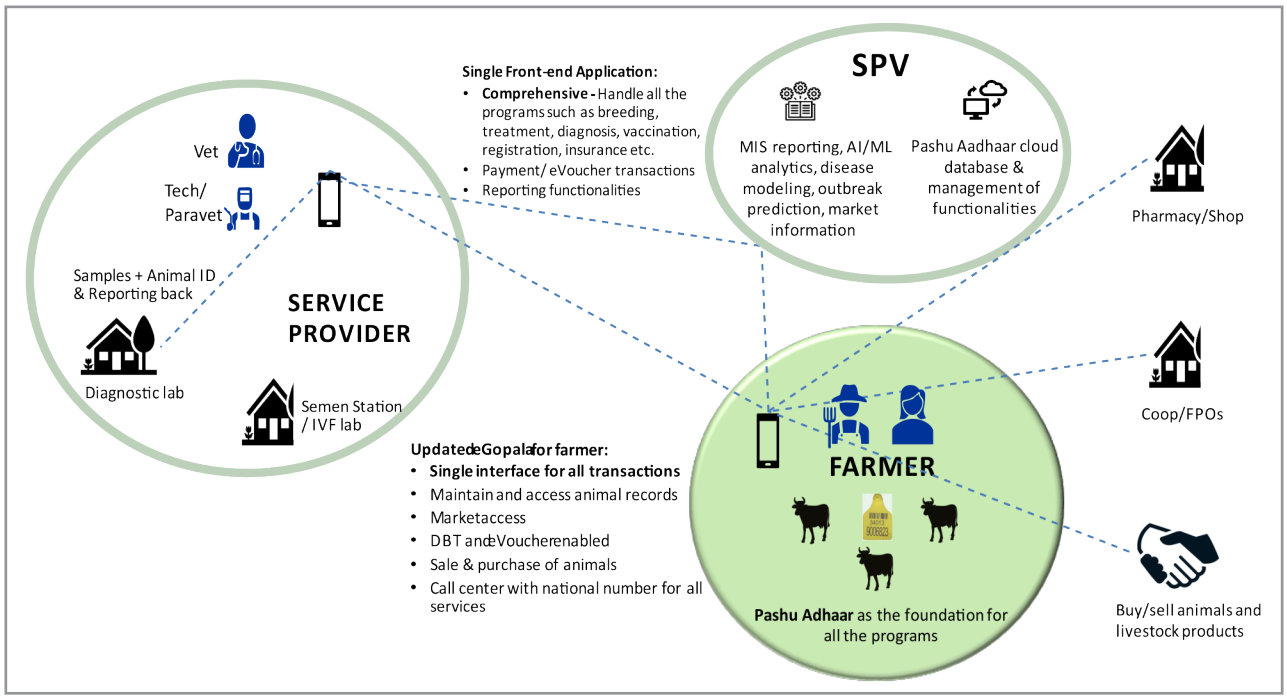

Figure 5: Details of the institutional structures and their interactions under NDLM

- Develop and manage key **data standards**, data systems, and repositories (disease data, select national programme data such as coverage of artificial inseminations, etc.)
- **Manage select front end applications** such as for FLWs and farmer facing applications (eGopala) and linkages among them
- **Develop and maintain necessary APIs** to enable connected programmes (e.g., product traceability, insurance programmes, linkages to human disease systems such as IDSP, etc.)
- House a nimble **analytics hub for AI/ML, disease modeling expertise** (Stay at the leading edge of innovations, analytic technical support to DAHD and other institutions involved in livestock programmes in the country) run as rotating short-term **fellowships from prestigious institutions across disciplines in India**

3.3 Key considerations for the SPV:

- Freedom and ability to hire the best management and technical talent
- Ability to procure proprietary software or other products to be proficient and able to stay at the leading edge of innovations
- Minimal political interference in the decision-making and day-to-day operations. However, remain aligned with the Centre and the states to represent public interest and responsibility to manage the data as per government regulations. It will be governed by a strong, independent board to ensure that the SPV remains nimble to meet the evolving needs with time
- Initial corpus and maintenance funding to come from DAHD and NDDB

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