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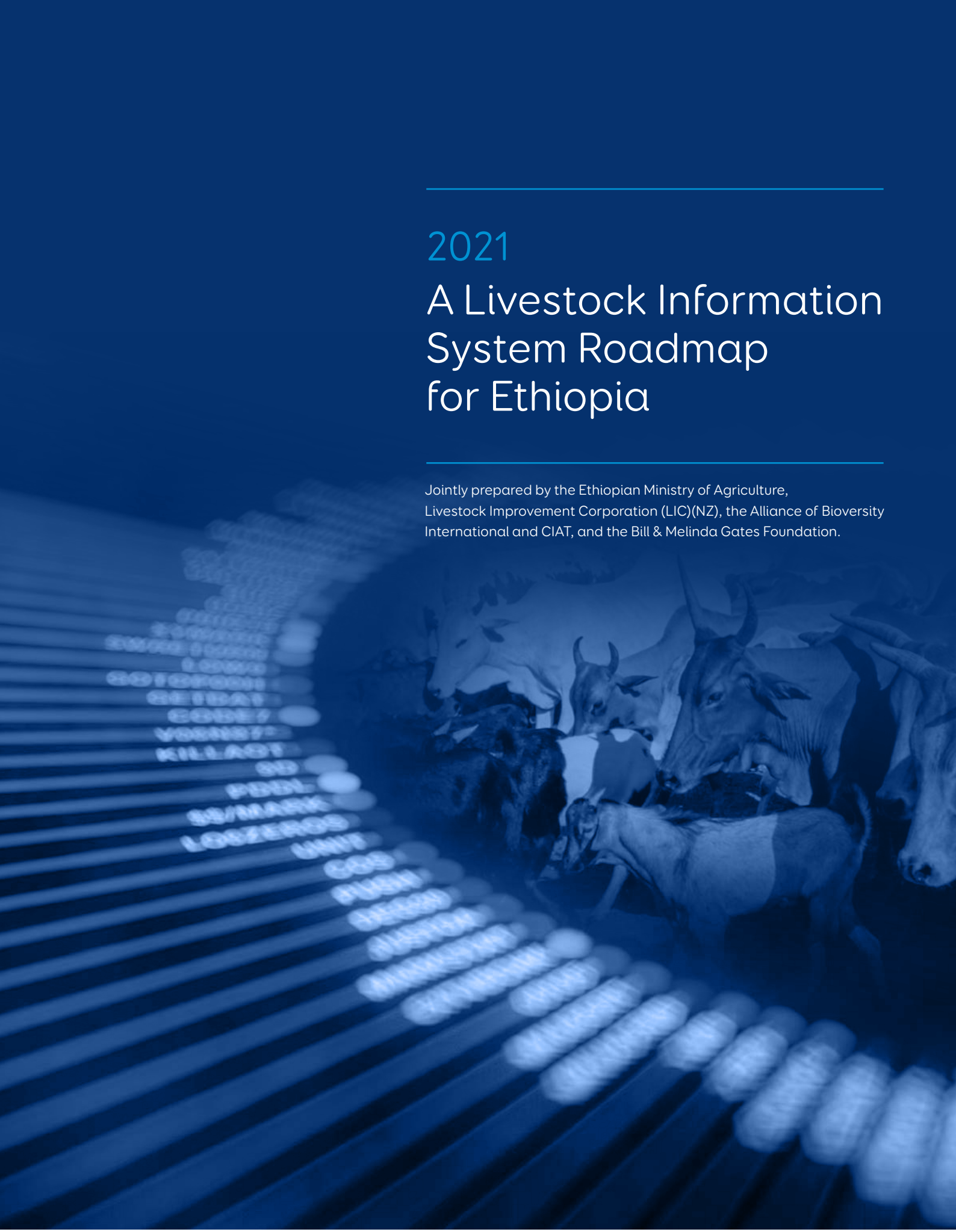
A Livestock Information System Roadmap for Ethiopia

Jointly prepared by the Ethiopian Ministry of Agriculture, Livestock Improvement Corporation (LIC)(NZ), the Alliance of Bioversity International and CIAT, and the Bill & Melinda Gates Foundation.



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This report has been prepared for the purposes of guiding the development of a livestock information system in Ethiopia. It is comprised of a combination of research and insights from Livestock Improvement Corporation (LIC), the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT). It is supplied with no warranties attached, either express or implied. To the extent permitted by law, LIC and CIAT will not be liable to any person for any loss, damages, costs or expenses arising directly or indirectly from using this report or any information contained within it.

Message from the Ethiopian Ministry of Agriculture

Ethiopia has the largest livestock population in Africa and over 80% of the country's population depends on the sector for income, employment and nutrition among other benefits. Despite the importance of the sector, productivity has remained relatively low compared to other agricultural nations. The Ministry of Agriculture (MoA) has recognised the challenge of delivering agricultural prosperity for Ethiopia without having access to regular, reliable, timely and useful information. The current state situation of poor quality data coupled with fragmented systems and limited analytical capacity has not been conducive to enabling the government to plan, implement and monitor livestock growth strategies.

The solution is a fit-for-purpose livestock information system that has guidelines around data integrity, allows interoperability between multiple existing and new information systems, fills data gaps, provides analytics and disseminates appropriate information to stakeholders. This livestock information system is critical for monitoring progress towards strategic goals, allowing evidence-based decision-making for governmental policy, increasing production and productivity, streamlining supply chains, reducing operational costs and improving smallholders' access to information, inputs and markets. The system may also enable the government to mitigate the effects of drought and animal disease outbreaks in Ethiopia.

This report summarizes the current state of existing livestock information systems in Ethiopia and sets out a blueprint of what a future livestock information system that would fulfil stakeholder needs would look like. The architectural costed roadmap is the pathway forward starting from the current state and ending with the optimal future state.

The MoA would like to thank Livestock Improvement Corporation (LIC) and the Alliance of Biodiversity International and the International Center for Tropical Agriculture (CIAT) for technical support, and the Bill & Melinda Gates Foundation (BMGF) for their financial support to bring this roadmap to fruition. The initiative has been a collaborative effort with a wide range of actors from across several ministries within the Ethiopian Government. I would like to express my gratitude to staff within MoA, as well as the Central Statistics Agency (CSA) and Ministry of Trade and Industry (MoTIn) that have contributed their knowledge to this roadmap.

Although digital transformation in Ethiopia is at an early stage of development, this roadmap would enable us to take advantage of digital opportunities that will shape our future. There is a sense of urgency to mobilize critical stakeholders to drive this initiative forward, unleash the potential of the Ethiopian livestock sector and improve the productivity and wellbeing of the Ethiopian people.

H.E. Oumer Hussein Oba, Minister, Ministry of Agriculture, Federal Democratic Republic of Ethiopia

Team members and contributors including representatives from the Ethiopian Ministry of Agriculture during the consultative workshop at the start of the roadmap development.

Message from the Project Team

The development of the Livestock Information System Roadmap was carried out from 2018 to 2021 and was made possible by financial support from the Bill & Melinda Gates Foundation. The contribution of the Ethiopian Ministry of Agriculture to make livestock experts available to provide insights into existing data systems and data requirements is gratefully appreciated.

We acknowledge experts from across Ethiopia who have dedicated their time, effort and substantial knowledge to ensuring best possible outcomes for the sector through the aLIVE (a Livestock Information Vision for Ethiopia) project including but not limited to:

Epidemiology Directorate, Livestock Identification and Traceability Directorate, Livestock, Extension & Certification Directorate, Veterinary Public Health Directorate, Quarantine Import Export Inspection & Certification Directorate, Disease Prevention and Control Directorate, Feed Resource Development Directorate, Urban Agriculture & Livestock Investment Support Directorate, Export Abattoir Inspection and Certification Directorate, Meat, Hide and Skin Directorate, ICT Directorate, Policy, Planning, Monitoring & Evaluation Directorate, Agriculture Input Marketing Directorate, National Animal Genetics Improvement Institute (NAGII), National Animal Health Diagnosis & Investigation Center (NAHDIC), Ethiopian Institute of Agricultural Research (EIAR), Agricultural Transformation Agency (ATA), Veterinary Drug and Animal Feed Administration and Control Authority, National Tse-Tse Fly & Trypanomosis Control & Eradication Institute, National Veterinary Institute, Ministry of Trade and Industry (MoTIn), Ethiopian Meat & Dairy Industry Development Institute, Regional Livestock & Fisheries Bureaus/Agencies/, Addis Ababa City Urban Agriculture Commission, Dire Dawa City Urban Agricultural Commission, Central Statistical Agency, Ethiopian Milk Processors Association, Ethiopian Veterinary Association, Ethiopian Animal Health Assistant Association, Ethiopian Animal Production Association, International Livestock Research Institute (ILRI), International Center for Agricultural Research in the Dry Areas (ICARDA), International Food Policy Research Institute (IFPRI), Intergovernmental Authority on Development (IGAD), Food and Agriculture Organisation (FAO).

To all those who have been involved in guiding the aLIVE project to this point, thank you for your input, advice and perspectives particularly during the trying times over the COVID-19 pandemic. It has been inspiring to see such passion for the Ethiopian livestock sector and will be exciting to see this journey evolve.

Jason Schrier (LIC), Simon Parry (LIC), Simon O'Connor (LIC), Sintayehu Alemayehu (CIAT), Lidya Tesfaye (CIAT) and Alemayehu Regassa (MoA, CIAT)

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List of abbreviations

ADGG	African Dairy Genetic Gains
ADNIS	Animal Disease Notification & Investigation System
AFBS	Animal Feed Balance Sheet
AI	Artificial Insemination
aLIVE	A Livestock Information Vision for Ethiopia
API	Application Programming Interface
ATA	Agricultural Transformation Agency
ATVET	Agriculture Technical Vocational Education and Training
AU-IBAR	African Union's - Inter African Bureau for Animal Resources
AWS	Amazon Web Services
BMGF	Bill & Melinda Gates Foundation
BRIDGE	Bridging Rural Income through Inclusive Dairy Growth in Ethiopia
CAHW	Community-Based Animal Health Worker
CGIAR	Consultative Group for International Agricultural Research
CIAT	International Center for Tropical Agriculture
CRA	Cloud Risk Assessment
CSA	Central Statistical Agency
DBMS	Database Management System
DOVAR2	Disease Outbreak & Vaccination Reporting System 2
EIAR	Ethiopian Institute of Agricultural Research
ETL	Extract, Transform and Load
ET-LITS	Ethiopian Livestock Identification and Traceability System
Existing-LIS	Existing Livestock Information Systems
EAICD	Export Abattoir Inspection and Certification Directorate
FAO	Food and Agricultural Organization of the United Nations
FEWS NET	Famine Early Warning System Network
FTP	File Transfer Protocol
Future-LIS	Future Livestock Information System
GIS	Geographic Information System
GTP	Growth and Transformation Plan
IAM	Identity and Access Management
IAMS	Identity and Access Management Security
ICAR	International Committee for Animal Recording
ICARDA	International Center for Agricultural Research in the Dry Areas
ICT	Information and Communication Technology
IFPRI	International Food Policy Research Institute
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institute
JSON	JavaScript Object Notation
KMS	Key Management Service
LIC	Livestock Improvement Corporation
LIT	Livestock Identification and Traceability
LITS	Livestock Identification and Traceability System
LIVES	Livestock and Irrigation Value Chains for Ethiopian Smallholders
LMP	Livestock Master Plan
MoA	Ministry of Agriculture
MoTIn	Ministry of Trade and Industry
NAHDIC	National Animal Health Diagnosis and Investigation Center
NAGII	National Animal Genetic Improvement Institute
NLMIS	National Livestock Market Information System
NVI	National Veterinary Institute
ODK	Open Data Kit
OIE	World Organization for Animal Health
PAID	Public Private Partnership for Artificial Insemination Delivery
PAP	Pastoral and Agro-Pastoral
PLEWS	Predictive Livestock Early Warning System
PRIME	Pastoralist Areas Resilience Improvement and Market Expansion
QIEICD	Quarantine Import Export Inspection and Certification Directorate
REDFS	Rural Economic Development and Food Security
Roadmap-LIS	Livestock Information System Roadmap
RVL	Regional Veterinary Laboratory
SILABFA	Laboratory Information Management System or SILAB for Africa
SLA	Service Level Agreement
SMS	Short Messaging Service
SNNPR	Southern Nations, Nationalities, and Peoples Region
SOP	Standard Operating Procedure
TOT	Training Of Trainers
UPS	Uninterruptible Power Supply
URL	Uniform Resource Locator
USAID	United States Agency for International Development

Livestock information system roadmap overview

"A Livestock Information System Roadmap for Ethiopia" is a guidance document that sets out a path for the development of a livestock information system for Ethiopia. It encompasses discrete steps covering system development, resource and capability requirements, and governance implementation that can be followed to produce a bespoke information system. This system is a key component of the Ethiopian digital strategy and will accelerate progress on the delivery of Ethiopia's strategic plan for agriculture (Ten-Year Strategic Development Plan, 2021).

The Livestock Information System Roadmap is the outcome of a collaboration between Livestock Improvement Corporation (LIC)(NZ), Ministry of Agriculture (MoA), Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), and the Bill & Melinda Gates Foundation (BMGF).

1.

Background

Agriculture is one of the pillars of the Ethiopian economy and the overall economic growth of the country is highly dependent on the success of the agricultural sector. Livestock is an integral part of the agricultural sector and the contribution of live animals and their products to the agricultural economy is immense. Livestock production plays a substantial role in Ethiopia through the provision of food, income, employment and many other contributions.

Given the importance of the sector, the Government of Ethiopia has formulated policies and strategies to overcome livestock productivity problems such as low production of local breeds, devastating disease outbreaks, poor artificial insemination uptake and feed shortages. The Ethiopian government has set a number of targets across livestock species, including milk, meat and poultry production. Outlined in the Ten-Year Strategic Development Plan and previously in the Growth Transformation Plan II (GTPII)[1], the aim is to not only meet national food demands, but to also achieve national food security and create an economic engine by replacing imports with locally produced food and exporting surplus foodstuffs. The Ten-Year Strategic Development Plan targets accelerated growth in agricultural productivity by increasing crop and livestock productivity through improving the application of good agricultural practices and improving extension services. Furthermore, the plans envisage the use of increasing agricultural inputs, a strengthened marketing system, and enhanced research and development activities, to sustainably increase agricultural productivity to meet the growing demand for food, industrial raw materials, and foreign currency earnings.

1. Government of Ethiopia (2016) Growth and Transformation Plan II (GTP II) (2015/16-2019/20). National Planning Commission

In 2021 the MoA developed the Ten-Year Strategic Development Plan and this will help to achieve livestock sector development. This plan sets out a series of objectives pertaining to health, genetics and feed that are required to generate the desired higher incomes and animal productivity, i.e.:

- Improve income and livelihood options for farming and pastoral communities through increased productivity and competitiveness;
- Modernize agriculture and ensure national food and nutrition security;
- Raise exports of agricultural output and substitute imports;
- Make agriculture a viable and profitable enterprise through value addition;
- Create rural employment opportunities;
- Enhance livestock health access and quality;
- Preserve animal genetic resources and increase pastoral research;
- Improve the development of animal feed and access to markets; and
- Develop livestock specific extension packages for each livestock type.

A prerequisite to demonstrating the improvements needed to reach the targets in the national plan is having the technology and resources to measure agricultural outputs. Not only do data assist in monitoring and evaluating progress, but they are crucial for stakeholder decision-making that will lead to the envisaged improvements in the livestock sector. One key impediment to agricultural development in Ethiopia is the current state of the livestock information systems. The systems are impacted significantly by variable quality input data and limited analytical capacity resulting in a lack of timely and accurate information flowing to stakeholders such as the government, livestock keepers, health professionals, researchers and traders. Furthermore, the information systems in place struggle to deliver the data required due to a lack of interoperability between the existing data systems, gaps in the available data, timeliness and comparability of data inputs, and lack of regulation and guidelines around data integrity. To date, this has prevented the government from implementing and monitoring the livestock growth strategies recommended in the GTPII and the Ten-Year Strategic Development Plan.

The MoA has recognised the challenge of delivering agricultural prosperity for Ethiopia without having access to regular, reliable, timely and useful information. Therefore, the government is proactively looking to develop a fit-for-purpose livestock information system that has guidelines around data integrity, allows interoperability between multiple existing and new information systems, fills data gaps, provides analytics and disseminates appropriate information to stakeholders. The system would be used not only by MoA, but also the Ethiopian Institute for Agricultural Research (EIAR), ILRI, National Animal Genetic Improvement Institute (NAGII), Agricultural Transformation Agency (ATA), Central Statistical Agency (CSA), MoTIn, Regional Bureaus, farmers and pastoralists. The information will be used by the Ethiopian Government and Regional Bureaus for policy planning, monitoring performance against the national plan, regional benchmarking and resource allocation. The information can also be used to drive productivity at farmer level by enabling a herd improvement scheme to deliver improved genetics and by evaluating available feed.

In 2020, the Ethiopian Government further reinforced the need for improved information systems by releasing the Digital Ethiopia 2025 strategy document[2]. This guiding document proposes an inclusive digital economy approach that will catalyze the realization of Ethiopia's broader development vision and continue to develop a knowledge-based and prosperous society. Agriculture was identified as one of four key pillars in the strategy and building a Digital Agriculture platform was at the forefront of the digital transformation. This platform would comprise "an integrated system that offers new insights that enhance the ability to make decisions and subsequently implement them". The Livestock Information System Roadmap set out in this report describes a recommended pathway from the existing state of the livestock information systems in Ethiopia to an end state where a bespoke system delivers high quality, useful data that meets the needs of key stakeholders. Development of the Livestock Information System Roadmap occurred between 2018 and 2021 with funding and support from the BMGF.

2. Government of Ethiopia (2020) Digital Ethiopia 2025 Strategy – A Digital Strategy for Ethiopia Inclusive Prosperity.

1.1 Scope

Information system

In this report, an 'information system' is defined as a formal organizational system that integrates components that collect, process, store and disseminate data to stakeholders. The six components of the information system are:

- Data content;
- Data collection;
- Data flow;
- Data management;
- Database infrastructure; and
- Governance.

Livestock

The roadmap for the livestock information system will have the capacity to accept information on any livestock species, but for the initial stage, it is targeted towards the following livestock:

- Cattle (70.3m)
- Goats (52.5m)
- Sheep (42.9m)
- Camels (8.1m)

Source: CSA 2020/21

1.2 Purpose

The Livestock Information System Roadmap (Roadmap-LIS) sets out a series of steps that can transform Ethiopia's livestock information systems from their existing fragmented state (Existing-LIS) to a custom-designed, state-of-the-art system (Future-LIS) that will deliver significantly more value to stakeholders in the agricultural sector. It is envisaged that the Roadmap-LIS will be used by the Ethiopian MoA as a tool to guide them and other partners, towards the development of a national information system that will be used to monitor the progress of, and contribute to greatly enhanced value generation from the agricultural sector.

Improved information quality, quantity and timeliness resulting from the Future-LIS will assist the MoA to achieve its strategic goals as set out in the Ten-Year Strategic Development Plan which will be completed in 2030. The goals are to:

- Reduce poverty;
- Achieve food and nutritional security;
- Contribute to economic growth (GDP);
- Contribute to exports and foreign exchange earnings; and
- Contribute to climate mitigation and adaptation.

The MoA has identified the following strategic objectives for the next ten years in which human resources reform remains the key driver for change.

Agricultural cluster:

- Crop market-oriented value chain development;
- Livestock market-oriented value; and
- Linkage with agro-industries.

Livestock sector development:

- Private sector in ranch development;
- Infrastructure including quarantines; and
- Strengthen the livestock health system.

Sustainable natural resource development and utilization:

- Irrigation development; and
- Sustainable land management.

Strengthening input supply system:

- Seed policy implementation;
- Distribution system;
- Blended fertilizer & chemicals;
- Public Private Partnership (PPP) in input system;
- Regulatory functions; and
- Mechanization.

Market oriented extension:

- Private sector participation in extension services;
- Agricultural Technical Vocational Education and Training (ATVET) (demand-driven training centers);
- Technology application in extension; and
- Professionalizing extension management.

Export promotion:

- Coffee;
- Horticulture;
- Livestock & their products; and
- Oil seeds & pulses.

Import substitutions:

- Wheat productivity;
- Poultry development; and
- Palm oil production.

Digitization

- Digitizing agricultural extension and agro-advisory services; and
- National livestock market information system.

These strategic objectives build on the foundations set by the Livestock Master Plan[3] (LMP). The LMP was a series of five-year development implementation plans that guided the implementation of GTP II. The LMP outlined the prioritized interventions to be undertaken to deliver the productivity gains envisaged by the MoA. The LMP specifically targeted:

- Improvement of dairy cattle through breeding interventions, combining artificial insemination using exotic semen with estrus synchronization in MRS (highland mixed crop-livestock moisture sufficient system) dairy systems and in peri-urban milk sheds throughout Ethiopia;
- Improvement of productivity of local breed animals (cattle, sheep, goats, and camels) for meat and milk through investments in genetic selection (recording schemes, etc.) and in animal health to reduce young and adult stock mortality, and by implementing critical vaccinations and parasite control programs;
- Increase of public investment in rehabilitating range and pasture lands to improve feeding and animal management to complement genetic and health improvements; and
- Increase of specialized commercial production units and—where conducive agro-ecological and market conditions prevail—consequent increases in animal numbers for all three commodities, and the adoption of appropriate genetic, health and feed technologies.

In order for progress against these objectives to be monitored, significant efforts to collect, analyze and report on data are essential. Currently there are gaps in the information systems and not all stakeholders are getting the information required for them to monitor advances towards achieving the objectives, as well as make timely interventions to help accomplish the objectives. Two key parts of this report are to understand the Existing-LIS (Section 2) and ascertain what an optimized Future-LIS might look like (Section 3).

3. Shapiro, B., Gebru, G., Desta, S., Negassa, A., Negussie, K., Aboset, G., & Mechal, H. (2015). Ethiopia livestock master plan: Roadmaps for growth and transformation.

1.3 Structure of this report

The purpose of a roadmap is to articulate what must be changed, why it must be changed, and in what sequence the change should be carried out. The development of the livestock information system roadmap (Roadmap-LIS) is described in Sections 2-6 of this report as summarised below.

Section 2: Existing-LIS

The Existing-LIS is defined as those information systems that are currently in use by the MoA and relevant stakeholders in the livestock sector in Ethiopia. It is important to understand the details and status of each information system especially in respect of where they satisfy stakeholder needs and where there are gaps. The information from this section will form the starting point of this roadmap.

Section 3: Future-LIS

The Future-LIS is defined as the optimal information system specifically designed for the Ethiopian MoA and relevant stakeholders. It incorporates information from a wide range of users around their data needs in terms of accuracy, content, analytics and timeliness. Future-LIS represents the completion point of the roadmap and describes a system that maximizes the potential impact of authorized users receiving accurate and timely information to monitor sectoral progress and to make informed decisions.

Section 4: Technical requirements

Based on the technical infrastructure of the Existing-LIS and the demands of the users of Future-LIS, the technical requirements needed for the transformation can be established. This section outlines the optimum technical infrastructure of the Future-LIS.

Section 5: Proof of concept

This section describes an end-to-end proof of concept that was carried out to demonstrate the simplicity, effectiveness and potential of the Future-LIS design.

Section 6: Roadmap-LIS development

The Roadmap-LIS development is the result of assessing all of the information gained during the extensive information-gathering phase and prioritizing a recommended pathway forward that will result in a livestock information system suited for Ethiopia's needs (Future-LIS). The Roadmap-LIS comprises a set of instructions and milestones that covers every aspect of the livestock information system as defined above and sets out proposed timelines and sequence of events.

1.4 Information required to formulate roadmap

A wide variety of information was required to inform decisions relating to the Roadmap-LIS. Information-gathering exercises were targeted at how the Existing-LIS was being used today and also what types of data these stakeholders require to carry out their functions optimally going forward. The information-gathering exercise collected data on the six components of information systems i.e.: data content, data collection, data flow, data management, data infrastructure and governance. This information was obtained by LIC and CIAT in collaboration with the MoA and affiliated organizations, and CSA as described in Section 1.5. The specific information collected is set out below and split by Existing-LIS, Future-LIS and Roadmap-LIS as the requirements for each varied.

Existing-LIS

To develop a roadmap requires having a deep understanding of the existing systems in place and ascertaining what is satisfying the needs of relevant stakeholders and where the information gaps are. To inform the Existing-LIS, information was sought to:

- Identify which livestock information systems are currently in use;
- Establish the purpose and scope of each database;
- Understand the types of data in each database;
- Identify the different data sources and their accessibility for each database;
- Identify the institutional data needs;
- Identify who is collecting the data that enters the database, the method used and the frequency of data collection;
- Follow the data flows from collection, collation and analysis through to the reports received by the stakeholders;
- Assess the data dissemination mechanism;
- Identify main users of data and the use cases;
- Identify who is responsible for managing each system;
- Determine the infrastructure of each database;
- Identify the stakeholders that have access to each database;

- Review the data governance systems in place, i.e. data management policies and data sharing policies;
- Establish the current interoperability between the systems; and
- Assess the technical and analytical resources attributed to each database.

A summary of the information related to the Existing-LIS is set out in Section 2 with a more detailed review in Annexes 1 and 2.

Future-LIS

The vision of an optimal Future-LIS includes an ideal state for all six information system components in an Ethiopian livestock context. The required data needs to be collected with sufficient care and delivered to the system digitally in a timeframe that makes it relevant for its users. The Future-LIS also needs a robust infrastructure and data management function overseeing it and the appropriate data governance rules in place so that the appropriate users are receiving the information. To understand what the Future-LIS might encompass, an information-gathering process was undertaken and this set out to:

- Identify the potential users of the data;
- Detail data collection processes that could be implemented;
- Establish the type of information required by each stakeholder;
- Determine the required level of data integrity for each output;
- Understand the time-criticality of reporting required information;
- Comprehend the type and amount of technical infrastructure required to deliver the users' needs;
- Gain insights into the level of data management needed for the system;
- Ascertain the ideal governance structure to oversee the Future-LIS;
- Prioritize the activities that will lead to an improved livestock information system; and
- Identify complementary actions that while not directly linked to the development of the system, are essential if the system is to operate to its full potential.

A summary of the users and their needs is set out in Section 3 with a more detailed review in Annexes 2 and 3.

Roadmap to reach Future-LIS (Roadmap-LIS)

To recommend the optimal pathway between current state and ideal future state of the livestock information systems in Ethiopia we set out to:

- Engage with key stakeholders in the country to gain their support for the vision;
- Understand any structural, organizational or technical limitations that need to be considered;
- Determine the level of investment and ongoing resource required to build and maintain the system; and
- Minimize the cost and effort of development while still preserving the integrity and robustness of the ideal system.

1.5 Methodology of roadmap information capture

The methodology used in this investigation to identify the data requirements and data gaps of the Ethiopian livestock stakeholders was based on a process of engagement with a wide cast of players in the sector. The information was obtained by LIC and CIAT in collaboration with the MoA Directorates, affiliated organizations and CSA. A detailed overview of the methodology is described below.

- **Systematic Review of government strategy and policy documents and user manuals**
  The main documents considered during the literature review were the LMP (2015), GTP I[4] and II (2010-2020), Precise Documents[5] (2018), Agricultural Extension Strategy of Ethiopia[6], the Ten-Year Strategic Development Plan (2021), Digital Ethiopia 2025 (2020), institutional mandates, directives and proclamations, and technical and user manuals of all the existing livestock databases. This review assisted in the identification of key stakeholders in the sector and provided key information on the Existing-LIS and the Future-LIS.
- **A Vision Workshop with key thought leaders**
  A Vision Workshop with key thought leaders in the Ethiopian agricultural industry was organised at the start of the roadmap development to get high-level understanding of the requirements for an ideal, Future-LIS and to understand where the Existing-LIS is not satisfying user needs. A follow up workshop was held a year later to further validate understanding of the Future-LIS vision.

4. Government of Ethiopia (2010) Growth and Transformation Plan (2010/11 -2014/15). Ministry of Finance and Economic Development.

5. Precise - Bill & Melinda Gates Foundation (BMGF) (2018)

6. Agricultural Extension Strategy of Ethiopia

- **Stakeholder identification**
  Given the breadth of the scope for the Roadmap-LIS it was important to identify the appropriate organizations across the whole livestock sector. This was achieved through the review outlined above, studying the MoA organizational structures, utilizing the extensive networks of the Ethiopian-based team and expanding the sphere of engagement as new stakeholders were identified during interviews, field visits and workshops.
- **Identification of key users within each organization**
  There are often multiple users of information within the same organization and each individual requires different data to carry out his/her job efficiently. It is important to understand the needs of each user. The individuals were identified with the assistance of MoA, CSA, ATA and through workshops.
- **Stakeholder interviews**
  A survey was prepared and administered via interview on the key individuals identified within each organization. Each of the heads (management teams in some cases) of the livestock directorates and associated institutions of the MoA, Consultative Group for International Agricultural Research (CGIAR) centers, as well as the heads of the Regional Livestock Development Bureaus and Agencies were interviewed. Other officials with specific data needs within the institutions were also interviewed. The surveys were designed to map out how the interviewee interacted with data and the other players in the livestock environment, and to obtain the information outlined in Section 1.4.
- **Regional stakeholder survey**
  Insights into the Existing-LIS and Future-LIS were also gained through conducting regional surveys in Amhara, Afar, Oromiya, Southern Nations, Nationalities, and Peoples Region (SNNPR), Sidama, Addis Ababa City Administration, Dire Dawa City Administration, and Somali regions. Surveys were conducted in person with kebele officers, zone officers, regional bureau staff and enumerators. Information was sought around the existing systems, future data needs, human capacity, information technology infrastructure, how the users send and receive information from the Existing-LIS and what the strengths and weaknesses of each system are.
- **User requirement workshop**
  A full day of stakeholder engagement including a half day workshop with a wide range of government and institutional data users was held. This session was introduced by a BMGF representative and included invited speakers from across the Ethiopian livestock sector. The focus of the workshop was to understand user requirements from a diverse cross-section of the industry and to use this information to inform the Future-LIS requirements.
- **Physical infrastructure review**
  In instances where a database was hosted at the organisation where the surveys were conducted, a physical review of the infrastructure was undertaken. The purpose of this was to gain information on how the data are collected and curated. This enabled the architecture team to establish the best way of working with those data in the design of Future-LIS.
- **Regular engagement meetings**
  Regular interactions with a wide range of federal and regional players, as well as BMGF representatives, have produced useful insights and these have guided the development of the Roadmap-LIS. The ongoing engagement has kept stakeholders updated and facilitated the identification of additional stakeholders and related projects. This enabled the team to avoid duplication of efforts.
- **Embedded staff member in MoA**
  To observe how data are used for decision-making within the MoA, a member of the project team, Professor Alemayehu Regassa, was seconded into the Livestock Minister's office. The secondment also allowed the Minister and other officials to be updated regularly on the progress of the Roadmap-LIS and ensure high levels of engagement within the MoA.
- **Information collation into a Landscape Document**
  Feedback from the direct engagement with multiple stakeholders was collated into a Landscape Document (Annexes 1 and 2). This document contains the information from the interviews, surveys and the infrastructure inspections.
- **Governance Steering Committee established**
  A Governance Steering Committee was established to provide the project team with oversight, guidance and direction on the implementation of the project. This ensured that the project's activities are aligned with the broader context of agricultural data systems management and other complementary initiatives implemented by the MoA and its partners.
- **Technical Steering Committee established**
  A Technical Steering Committee was set up to provide guidance and advice on the technical aspects of the project's activities. This is particularly important as the focus of the roadmap is to integrate data management systems and this needs to be consistent with ongoing initiatives within the MoA and affiliated institutions.

1.6 Objectives

The Roadmap-LIS describes a pathway from the Existing-LIS to the optimum Future-LIS. It is envisaged that the Future-LIS will receive data from a variety of sources, collate, validate and securely store data to enable timely, accurate, reliable and useful reports to be generated. This will allow improved monitoring of productivity progress against the objectives of the Ten-Year Strategic Development Plan and better decision-making from the MoA and stakeholders in the agricultural sector.

The high-level objectives for the Future-LIS that will support the Ten-Year Strategic Development Plan are outlined below.

Objective 1
Provide relevant, accurate, timely, digital data to key stakeholders

The Future-LIS will provide accurate and timely information to stakeholders enabling them to make better evidence-based decisions. This will lead to improved outcomes for the livestock sector, such as:

- Progress of the sector can be monitored alongside the objectives outlined in the Ten-Year Strategic Development Plan;
- Animal disease outbreaks will be readily assessed and contained;
- Export of higher value, registered and traced animals will be increased;
- Genetic gain will be accelerated as improved tagging and recording occurs;
- Effect of feed shortages will be mitigated as location of feed and animals is monitored; and
- Real-time livestock market price and volume information will regularly be provided to stakeholders to provide marketing options and early warning of supply and demand issues.

Objective 2
Establish a high level of interoperability between databases

The Future-LIS will have the ability to query information across multiple databases, and combine data sources for targeted analyzes by geography or sub-sector. The improved interoperability will enable stakeholders to collate relevant data from disparate sources and produce reports that have a greater level of insight and will greatly improve users' accessibility to data from various databases.

Objective 3
Support research goals, commercial and industrial activities

The Future-LIS will be a platform where researchers and industry participants can access accurate and timely information enabling them to create additional value for the sector. It will also create an enabling environment for policy makers to provide strategic guidance to the livestock sector.

Objective 4
Establish requirements for data and information collection, validation, storage, and sharing

The Future-LIS will have a robust set of guidelines around the acceptance and storage of data into the system. The system will support:

- The ability for accurate collected data and information to be incorporated into the system;
- Validation of data entering the system;
- Secure storage of data within the system;
- Enable timely information flow to all actors; and
- Access to the system for authorized stakeholders.

Objective 5
Be owned by the MoA and managed using cost-effective local technical expertise and infrastructure

The Future-LIS will be owned and managed by the MoA using local technical expertise. The infrastructure will be developed for Ethiopian needs.

Objective 6
Create strong engagement with data suppliers and data users to use the system

The Future-LIS will only be effective if data collection agencies provide their data in a format that is compatible with the system. The industry needs to ensure that any new data created from any project can be consumed by Future-LIS or Ethiopian livestock industry databases will continue to be fragmented. Similarly, report users need to also engage with the system in order to extract value out of the data. Timely interventions will not possible unless the users have access to the data when they require it.

2.

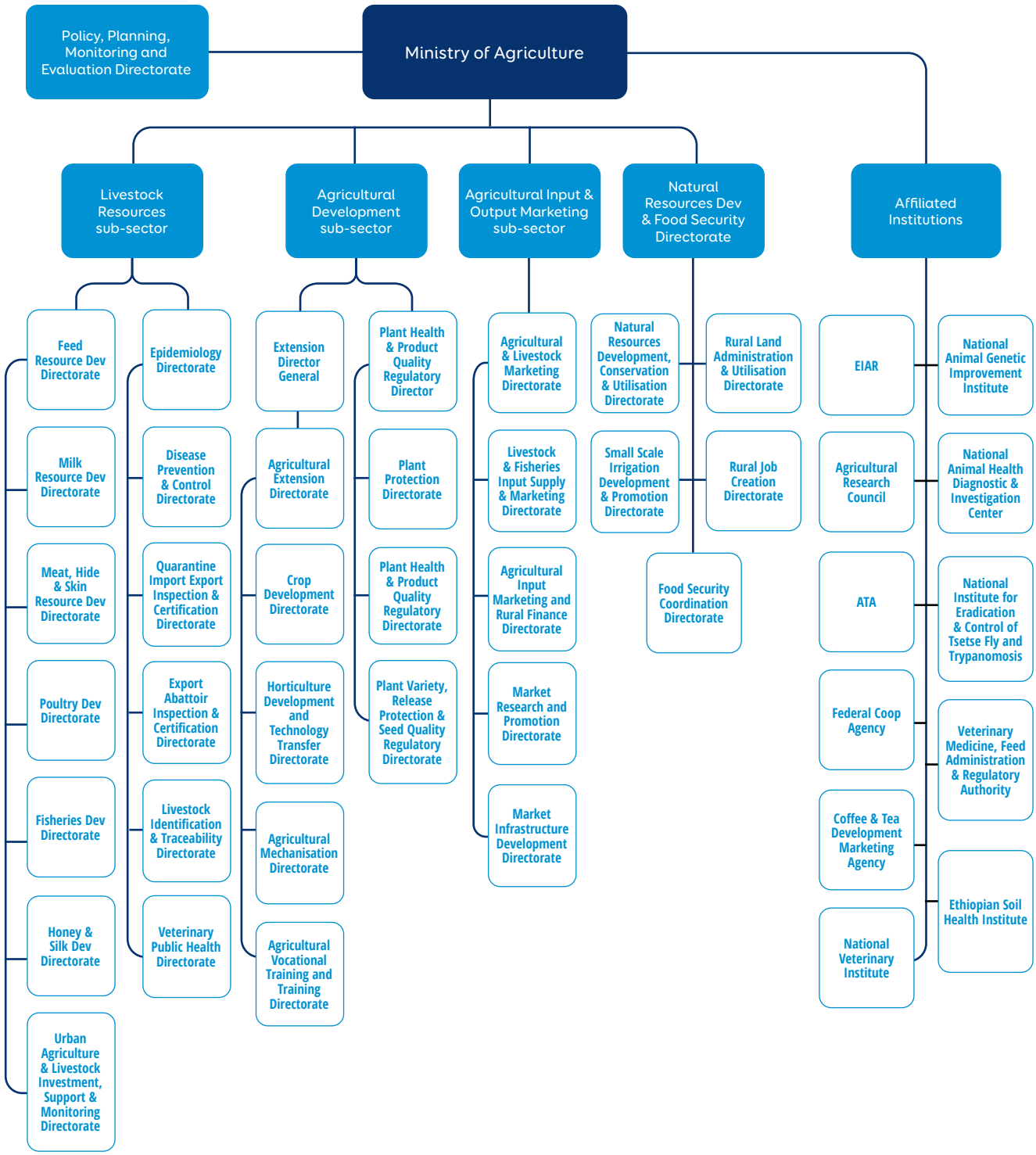
Current state analysis of information systems (Existing-LIS)

This section assesses what livestock information systems are being used in Ethiopia, who is using them and whether users are getting the information they require. The first part (2.1) summarizes the organizational structure of the MoA and looks at the technical capability of the Information Communication Technology (ICT) systems and staff that manage the systems. The following parts to this section provide an overview of the livestock information systems in place. The databases have been aggregated into Health (2.2.1), Population (2.2.2), Trade (2.2.3) and Genetics (2.2.4) information systems. Overall, this section contains information that constitutes the starting point of the Roadmap-LIS.

2.1 Organizational and technical capacity of MoA

The MoA organizational structure is set out in Figure 1 and comprises 33 Directorates under four sub-sectors (Livestock Resources, Agriculture Development, Agriculture Input & Output Marketing and Natural Resources Development & Food Security). There are also a number of affiliated institutions that are key players in the livestock sector, including EIAR, ATA, National Veterinary Institute (NVI), NAGII and National Animal Health Diagnosis and Investigation Center (NAHDIC) (Figure 1).

Figure 1. Ministry of Agriculture organizational structure*



* Correct as at September 2021

The infrastructure for the MoA's ICT has been established at the directorate level and the respective databases are controlled under the Epidemiology and Livestock Identification and Traceability (LIT) Directorates in collaboration with the ICT Directorate. Apart from the National Livestock Market Information System (NLMIS) database which has recently been transferred to MoTIn, the livestock databases are managed entirely by the MoA with the server located in the MoA's compound. The respective livestock directorates and the ICT Directorate have separate roles and technical capacities to implement the system. For example, the ICT Directorate takes the system administrative role while the Epidemiology and LIT Directorates take the system content administrative role for DOVAR2 and ADNIS, and LITS databases, respectively. A range of ICT experts including the network administrator, database administrator, system administrator and software developer, are employed to maintain the systems.

The eight existing databases cover different aspects of the livestock sector including health, markets, development activities, feed and products. There is considerable inconsistency around the robustness of data input, data integrity and interoperability, infrastructure and technical resources between the different information systems. The federal livestock directorates have serious concerns that they are underreporting the performance of the national livestock sector as there is no regular flow of reports from every regional bureau. There appears to be poor visibility around who is in control and this has resulted in fractured communication channels between the federal livestock directorates and their respective units at the regional level.

Key issues pertaining to organizational and technical capacity include:

- Numerous gaps in the ICT infrastructure, expertise and investment at various federal and regional institutions of the MoA;
- Federal experts have not delivered a consistent data collection capacity building scheme to the regional professionals;
- Overlapping mandates among the livestock directorates and other institutions have resulted in a lack of strong structural and functional alignment and poor coordination and collaboration both vertically and horizontally. This has resulted in duplication of collected data, multiple data formats and unstructured dissemination of data.
- No systematic monitoring and evaluation of the sectoral performance beyond requesting reports on an ad hoc basis when needed; and
- Federal livestock directorates do not provide feedback on the reports or performance to regional actors.

Various training of trainers (TOT) on database usage have been delivered to the regional data enumerators and the knowledge was subsequently cascaded down to the animal health personnel of the woredas. Unfortunately, the roll-out of the training programme has been incomplete due to deficiencies in funding. Most of the training and infrastructural support are provided from specific temporary projects leading to a lack of consistency and sustainability. As more funding becomes available these issues will become increasingly mitigated over time as knowledge expands across the sector.

2.2 Information systems

2.2.1 Health information systems

Livestock health is a critical component of Ethiopia's agricultural sector and the MoA has three health information systems currently in use:

- Disease Outbreak Vaccination Reporting System (DOVAR2);
- Animal Disease Notification and Investigation System (ADNIS); and
- Laboratory Information Management System or SILAB for Africa (SILABFA).

The three information systems receive data on notifiable animal diseases via local authorities enabling mitigation plans to be formulated by the MoA. Animal diseases negatively impact society by reducing the quantity and value of livestock and livestock products which leads to a worsening of food security and the national trade balance. Treatment of these diseases also absorbs valuable resources from farmers and the government that could be directed towards more productive purposes.

High level details of the health information systems are outlined below with additional content available in Tables 5-7 in Annex 1. MoA directorates and organizations that use health data are summarized in Annex 2.

Health databases - Data collection and content

For DOVAR2 and ADNIS, the input data comes from a widespread geography within Ethiopia and includes the type of disease, location and numbers of animals affected. The ADNIS information system is used for immediate daily reporting on outbreaks, whereas the DOVAR2 system reporting is a regular monthly update. Data are collected locally by kebele/woreda/district level animal health technicians with varying levels of skill and attention to detail resulting in a lack of consistency and accuracy in the regularly gathered information. Underreporting of disease outbreaks is also an ongoing issue and is particularly problematical in pastoral and agro-pastoral (PAP) settings where the disease reporting systems are constrained by lack of trained data collectors. This results in poor data recording and documentation that leads to unreliable and irregular information flow. This, in turn, presents challenges for the MoA experts to estimate the incidence and prevalence of livestock diseases with accuracy and timeliness.

The data collection issues are exacerbated by poor infrastructure. For the DOVAR2 database, data collectors send their information to Regional Veterinary Laboratories (RVLs) for collation, but this collated data cannot be directly uploaded into the system. These organizations have to send the compiled disease outbreak and vaccination reports of the districts to the MoA via e-mail. This problem appears to stem from weak ICT infrastructure, absence of ICT technical support at the RVLs and the difficulty to upgrade the system. Similarly, although the ADNIS data content is well-designed as it incorporates standardized data collection and has a standard reporting format, the system has not reached the required World Organization for Animal Health (OIE) standard. This failure is predominantly due to poor internet connectivity at woreda or kebele level (particularly in pastoral areas) and a lack of the required functionality of the Open Data Kit (ODK) data collection tool.

The richness of the DOVAR2 data set could also be improved. The DOVAR2 system was initially designed to include data from a wide range of sources, but currently it is only practical to collate data on disease outbreaks and vaccinations. Data from other sources such as diagnostic laboratories, quarantine stations, abattoirs, border posts, wildlife authorities, Non-Governmental Organizations (NGOs) and private practitioners are not incorporated. Accordingly, reports on disease outbreaks and vaccinations cannot be correlated with the clinical and laboratory observations from these key stakeholders.

SILABFA is an animal health information system that is mainly linked to monitoring active disease outbreaks in Ethiopia, but it also has a lesser role in passive surveillance activities. It is a web application used by a laboratory information management system to collect and manage all necessary information on diagnostic samples, tests, and test results. Various institutions send livestock samples to the NAHDIC laboratories, and from there, the system involves entering sample data on arrival, tracking samples through the laboratory, and then collecting the diagnostic test results. Data collected include the type of sample (e.g. serum/blood, meat, milk), location of the animal, lab tests conducted and the test results. These results are checked by experts prior to being disseminated. Once validated, the system automatically generates test reports that can be used to monitor outbreaks through data interrogation functions.

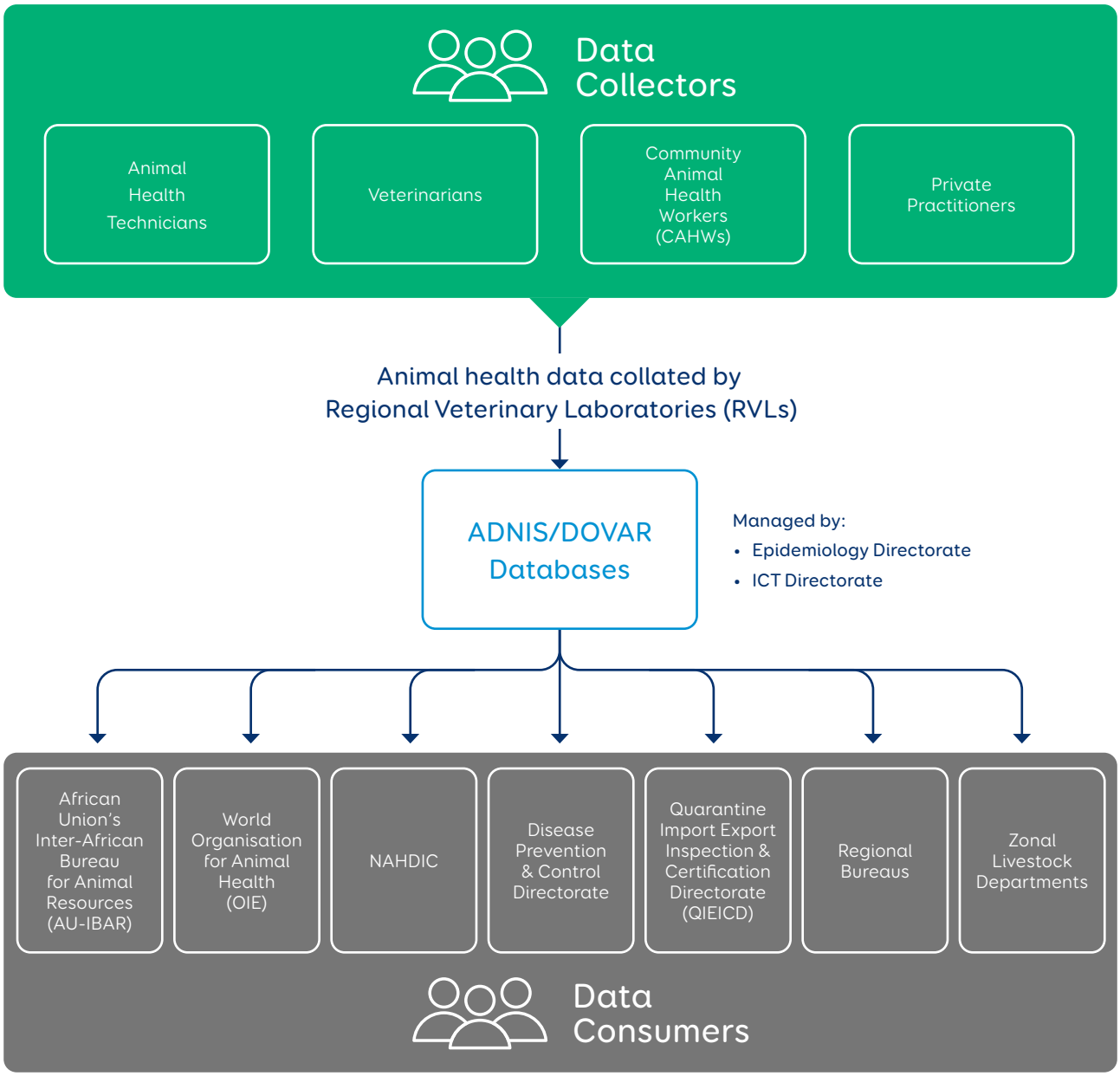
Health systems - Infrastructure, data management and users

The Epidemiology and the ICT Directorates have overall responsibility for the DOVAR2 and ADNIS databases, whereas NAHDIC and its respective ICT unit has responsibility for the SILABFA database. The ICT Directorate takes the system administrative role while the Epidemiology Directorate takes the system content administrative role.

A range of ICT experts including the network administrator, database administrator, system administrator and software developer, are employed to maintain the systems. DOVAR2 and ADNIS are managed entirely by the MoA with the server located in the MoA's compound, whereas NAHDIC hosts the SILABFA database.

Data flow through the DOVAR2 and ADNIS databases is summarized in Figure 2 below and more information on the databases and their users are summarized in Annexes 1 and 2.

Figure 2. Data flow of animal health information through ADNIS/DOVAR2



The Epidemiology Directorate validates incoming data and prepares outputs that can be accessed by different stakeholders. The goal of the stakeholders is to use the information from these databases to monitor and control outbreaks of prioritized diseases to minimize their impacts.

In terms of data accessibility, the data are not readily available online for end users and the notifications are not targeted optimally. The messages are being delivered only to the Epidemiology Directorate of the MoA after which the directorate notifies the respective regional livestock bureaus and laboratories via text message. The message goes to all districts irrespective of whether the outbreak has occurred in that region or not. Ideally, the ADNIS N-alert message notification should be filtered and sent specifically to the regions where actions need to be taken. Direct access to the health systems would enable regional livestock epidemiology units to make quicker decisions around local outbreaks and lead to improved outcomes.

The SILABFA is a well-designed system that provides a consistent historical dataset, uses a simple data collection format and is well-adapted to NAHDIC's laboratory settings thereby enabling data interoperability, test standardization and harmonization. However, one of the drawbacks of this system is that it is only available as a web application form making it difficult to save work offline. Frequent and unpredictable power cuts cause damage to hardware (servers, switches, computers) but also impede the processing functionality.

Tighter collaboration between the Epidemiology Directorate of MoA and the NAHDIC would provide synergies around disease investigation and response. NAHDIC is working on active surveillance, whereas the Epidemiology Directorate is working on passive surveillance, so the combination of the two related datasets should lead to a marked increase in their effectiveness. As such, there is currently a promising initiative to align the SILABFA with the ADNIS system.

2.2.2 Population information systems

The Ethiopian Livestock Identification and Traceability System (ET-LITS) is the main livestock identification and traceability system within Ethiopia. Animal identification is the use of unique identifiers and registration systems to identify animals individually or collectively by their epidemiological units, whereas livestock traceability refers to the ability to follow an animal or group of animals during all stages of life. Systems, such as ET-LITS are being used increasingly to support animal production, trade, and health interventions throughout the world. This section assesses ET-LITS and informs the starting point of the Roadmap-LIS for population information.

Population systems - Data content and collection

For ET-LITS, tagging and recording of animals are carried out by feedlot operators, export abattoirs and pre-quarantine operators. Cattle purchased by these operators carry two ear tags bearing the same unique animal identification number. The animal data are captured on the Animal Movement Permit form at the holding ground. For each animal, ID, age, sex, breed, location and the ID of the seller are recorded in a hardcopy format.

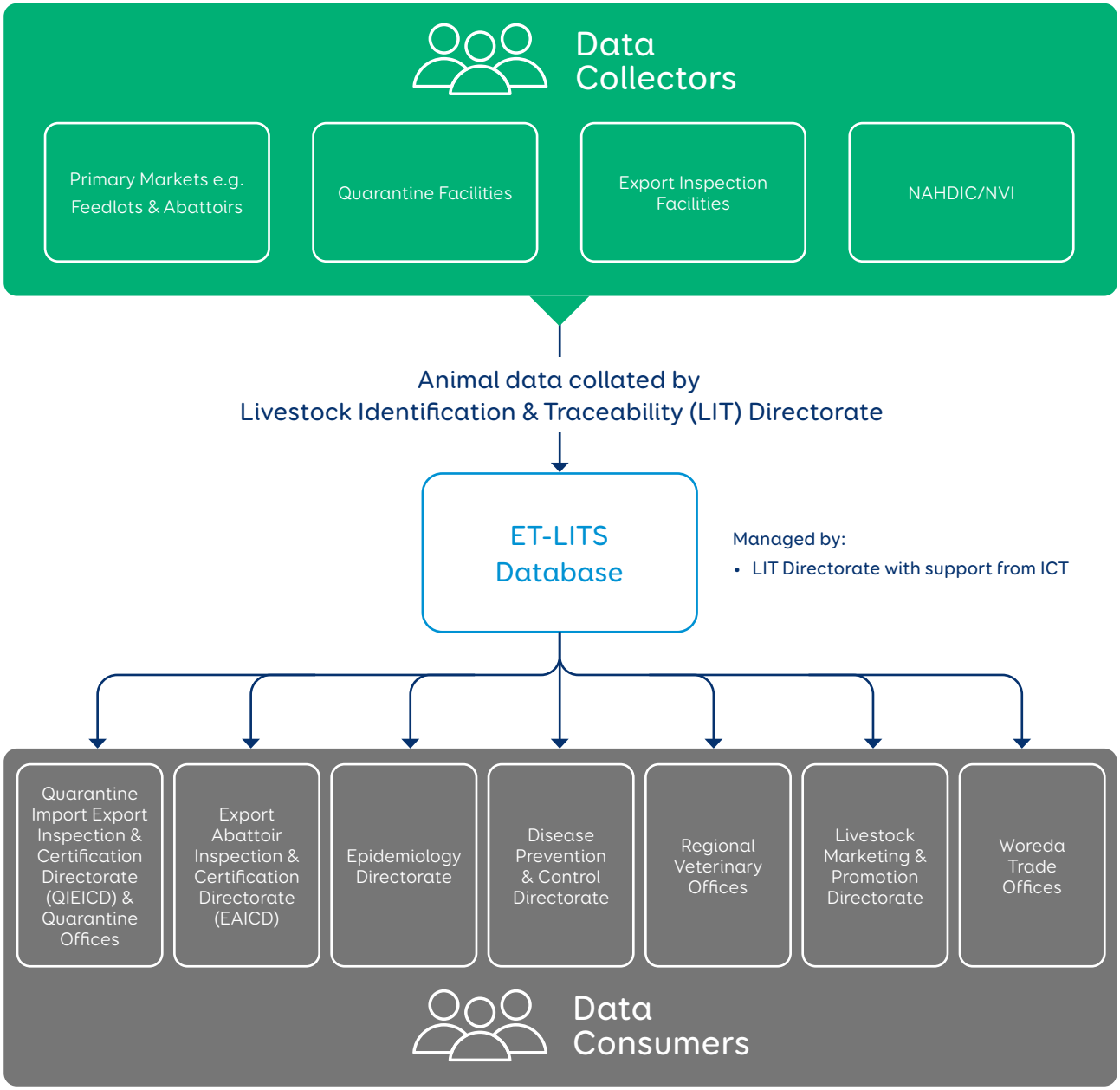
Although there is capacity within the system and placeholders for additional information in ET-LITS, the system is currently limited to those animals that are due to be exported. Given that most animals are not exported (such as dairy cattle and beef cattle destined for the local market), the vast majority of animals are not tagged and recorded in ET-LITS. Data are also collected from only six pilot markets covering a very limited geographical spread. Expansion of the regional coverage along with the numbers and types of animal recorded would significantly improve the power of ET-LITS. Currently approximately 10,000 exported cattle have been tagged and recorded through ET-LITS.

Population systems - Infrastructure, data management and users

The ET-LITS is managed entirely by the MoA under the Livestock Identification and Traceability Directorate in collaboration with the ICT Directorate. The system administrators of ET-LITS enable authorized organizations and businesses to track the lifespan of livestock and their production, processing, distribution, and transport into the broader retail market, as well as to help ensure animal health and food safety. As such, the main users of the information in ET-LITS are those involved in the health and trade sectors. Tagging and recording of animals also acts as a deterrent to cattle theft and can lead to improvements in management and productivity. The system is housed in the MoA ICT data center.

The data flow through ET-LITS is shown in Figure 3 below and more information on the database and its users are summarized in Annexes 1 and 2.

Figure 3. Data flow of animal identification information through ET-LITS



The weak ICT infrastructure and internet connectivity at data sources like feedlots and animal holding grounds, have resulted in intermittent data flow and a low reporting rate. The necessary workstations, enabling hardware and infrastructure are crucial for the continuous use of the system and there are currently gaps in the system that need addressing. Another drawback of the ET-LITS is data accessibility, as access to the system is not readily available for all end users but only for designated users authorized by system administrators. To address the limitations of ET-LITS, the Livestock Identification and Traceability Directorate has a strategy in place to improve the information system. These improvements include:

- Procurement of ICT infrastructure, including computers, internet subscriptions, printer copiers, scanners and uninterruptible power supply (UPS) batteries;
- Collation of geographic information system (GIS)-related information gained via the pilot projects of the system. These data include the identification and recording of markets, holding grounds, feedlots, export abattoirs, quarantine facilities, check posts, veterinary clinics and laboratories;
- Revision of data content to ensure it is in line with current needs, system updates and upgrades to enable translation into local languages;
- Training sessions on database application and tagging for stakeholders wanting to use the ET-LITS (ministry staff, producers, traders, feedlot owners, abattoir operators and vets);
- The development of a guideline for animal identification, tagging, tag ordering, decentralization, replacement and notification; and
- The development of Standard Operating Procedures (SOPs) to ensure compliance for data entry. The SOPs will work across the country and include compliance information from the ear tag application, the pre-purchase inspection, the market inspection, the transportation and handling staff, quarantine facilities, abattoirs, feedlot facilities and border posts.

2.2.3 Trade information systems

The NLMIS is a unified system that helps Ethiopian livestock producers and traders to make better decisions on when to sell their livestock and earn increased income. The NLMIS collects and disseminates reliable and timely livestock market information to producers, traders, processors and consumers to promote greater participation in local and regional markets. It has been designed to allow data collected from primary, secondary, and terminal livestock markets to be entered into the system via short messaging service (SMS) messages from cellular telephones. Pastoralists, livestock traders, and other interested stakeholders can then request the price and volume information for specific markets using SMS. Overall, the NLMIS allows users to bring down the costs of doing business by preventing middlemen from using their market knowledge to exploit smallholders through trading activities. It forms the starting point for Roadmap-LIS with respect to trade information.

Trade systems - Data content and collection

Enumerators submit averaged livestock pricing data from 56 different market centers over six regions and two city administrations. Information from animals such as cattle, sheep, goats and camels include species, breed, age, sex and grade. Animal product volumes such as honey, hides, skins, meat and milk are also collated to enable sellers to identify optimal market conditions for their produce. The information is sent to NLMIS via SMS, email or a web portal and disseminated regularly via means such as text, phone, radio and bulletins.

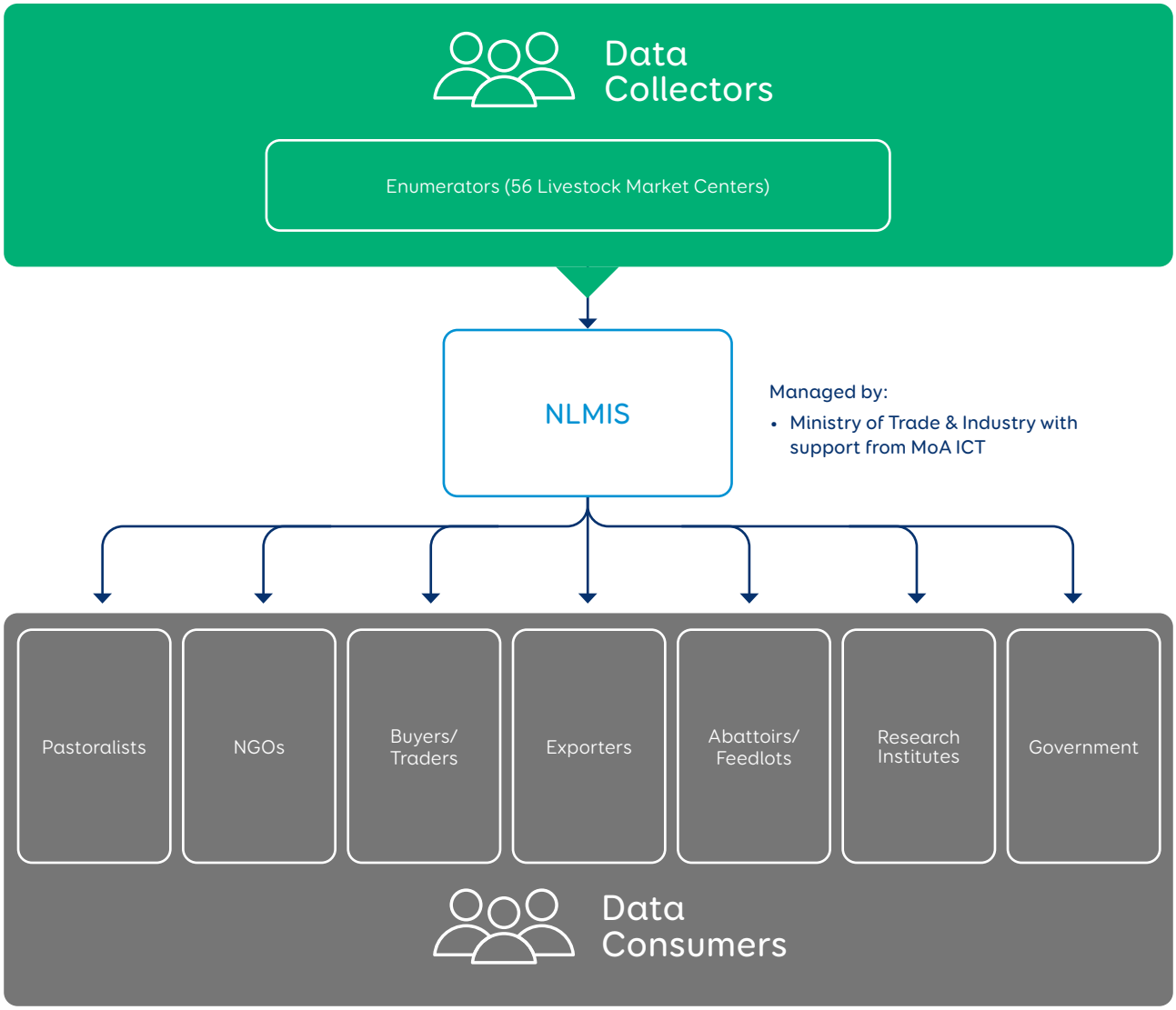
Trade systems - Infrastructure, data management and users

NLMIS is managed by directorates within the MoA and the MoTIn. The server is located within the data center of the ICT Directorate of MoA. This ICT Directorate is responsible for hardware and software maintenance of the system, whereas the Livestock, Hide and Skin Directorate of the MoTIn is responsible for training, data integrity, dissemination of data and access to the system.

The key users of the NLMIS are livestock market participants such as pastoralists who need to decide where and when to sell their livestock and at what price, through to abattoirs/feedlots who need to know how much to pay for the livestock. All parties rely on accurate pricing and market information to optimize their businesses and this transparency makes it more difficult for middlemen to exploit information deficits amongst market participants. Government and research organizations also monitor the market information to get insights into trends and potential issues such as plagues or drought.

The structure and data flow into and out of NLMIS is shown in Figure 4 and more information on the database and its users are summarized in Annexes 1 and 2.

Figure 4. Data flow of animal market information through NLMIS



2.2.4 Genetics information systems

The LUKE database was developed in 2012 as a resource to drive livestock resource improvement in Ethiopia. The database has since been absorbed into the African Dairy Genetic Gains (ADGG) database which is housed in Kenya. The overall goal of the system is to improve the genetic potential of the dairy population which will increase the economic productivity of dairy systems.

The second genetics information system is Dtreo (formerly known as AniCloud) and this is targeted towards recording performance data and genotypic data of small ruminants with the aim of genetic improvement of the local populations.

Together these two databases and the information in them constitutes the Existing-LIS for genetics in Ethiopia.

Genetics systems - Data content and collection

A wide variety of livestock performance data is collated in LUKE/ADGG to enable genetic selection of superior animals. The information collected includes pedigree, production metrics, reproductive performance, health and the genotype of dairy cows from Oromia, Amhara, Tigray, SNNPR and Addis Ababa. The data from each dairy farm are collected by enumerators, entered onto a hard copy Cow Card and then entered into the database by NAGII data encoders.

Dtreo is a cloud based digital genetic database for community-based breeding programs. It is used in Ethiopia for small ruminants and collects a wide range of data on animals involved in breeding programmes. The pedigree and performance data, such as weights, milk yield and genotypes are collected by enumerators that have been recruited for each village. The enumerators use a smartphone/tablet to collect the data which are then submitted when an internet connection is available.

Genetics systems - Infrastructure, data management and users

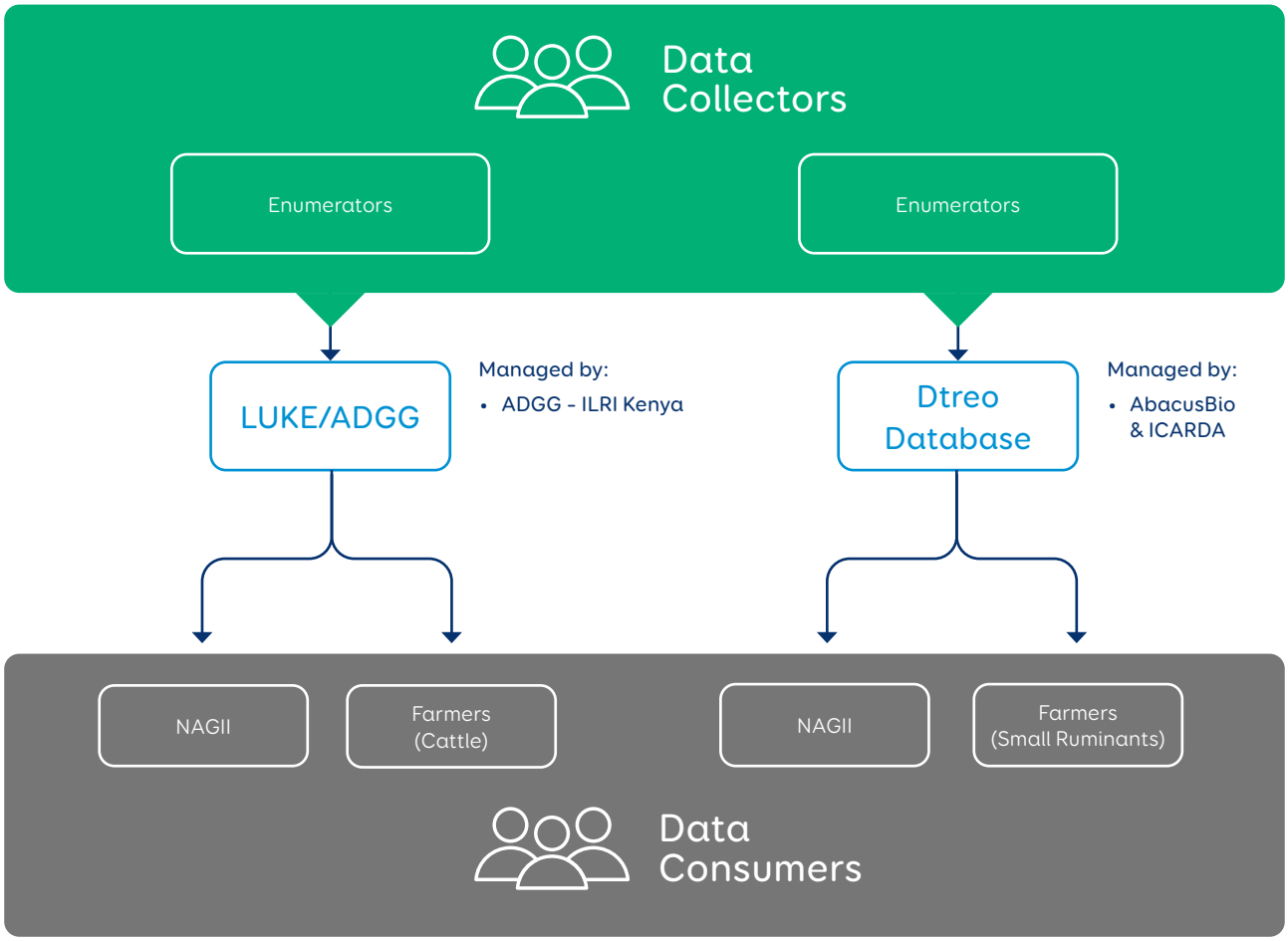
The LUKE database has been absorbed into the African Dairy Genetic Gains (ADGG) database. This database is routinely updated with records of on-farm performance and genetic information on dairy cattle in Ethiopia. The information and the related samples are used to develop genomic prediction algorithms for selecting crossbred bulls and cows of superior genetic merit for artificial insemination and natural mating. The results of this analysis are used by farmers and their professional advisors to inform herd management decisions. The improved genetics of the participants' herds lead to sustainable animal and herd productivity gains which, in turn, generate higher profits for smallholder dairy farmers. The ADGG database is based in Kenya and run by ILRI.

A significant challenge for the small ruminant sector in Ethiopia is low productivity, primarily due to high lamb and kid mortality, low growth rates, and long lambing and kidding interval. The Dtreo platform targets performance data recording, analysis, and reporting in livestock production systems thereby leading to the potential for improved genetic evaluation and selection. Overall, the database is being used to improve the livelihoods of small-holding sheep and goat farmers by implementing sustainable breeding schemes. NAGII is the main institution that uses the information in Dtreo and this is for genetic improvement initiatives.

The Dtreo system is managed by the International Center for Agricultural Research in the Dry Areas (ICARDA), an organization that is responsible for facilitating data capture, storage, analysis and feedback of the system. Technical management is carried out by the AbacusBio team from New Zealand. Dtreo is the only cloud-based database in the Ethiopian livestock sector. It has not been fully institutionalized by the MoA, although there is a possibility that it may be incorporated by NAGII in the future.

A summary of the genetics data flow is shown in Figure 5 and more information on the databases and their users are summarized in Annexes 1 and 2.

Figure 5. Data flow of information through LUKE/ADGG and Dtreo



2.3 Related information systems

This sub-section provides some examples of livestock information systems that are not under the control of the MoA but would be potential data sources for the Future-LIS. The success and uptake of these initiatives has been variable.

Animal Feed Balance Sheet (AFBS)

This is a national feed inventory and feed balance tool that was developed and tested by the Food and Agricultural Organization of the United Nations (FAO). Areas in Ethiopia have been categorized as either forest land, grazing land, or wetland and AFBS makes it possible to identify areas of feed deficit and surplus fodder which is important during times of feed shortages. The tool can support linkage with livestock insurance to purchase animal feed to safeguard livestock early enough before drought decimates livelihoods. Potential community-driven business opportunities could also be available for those engaged in the production of fodder for sale to commercial livestock owners.

Predictive Livestock Early Warning System (PLEWS)

Predictive livestock early warning system (PLEWS) combines field data collection, simulation modelling, and geographic information systems (GIS) to produce regional maps of current and forecast forage availability six months into the future. The Forage Condition Index (FCI) is a resampled index that uses Geo-eye satellite and specialized models to provide accurate palatable monthly forage condition for livestock and can distinguish invasive species such as Prosopsis Juliflora. The PLEWS uses the PHYGROW model which is a point model that contains four integrated sub-models: climate, soil, plant growth and grazing. The model simulates a soil water balance, multi species/functional group plant growth, and livestock grazing on a daily basis. PHYGROW is based on the light use efficiency model concept that simulates plant growth under optimal conditions (water not limiting). The model then discounts plant growth based on the degree of water stress (calculated from the water balance), temperature stress (based on species specific temperature tolerances for growth), and livestock grazing demand.

Famine Early Warning System Network (FEWS NET)

FEWS NET is a leading provider of early warning and analytics on acute food insecurity. Created in 1985 by the United States Agency for International Development (USAID) after devastating famines in East and West Africa, FEWS NET provides objective, evidence-based analysis to help government decision-makers and relief agencies plan for and respond to humanitarian crises. The FEWS NET is focussed on the effect of climate on agriculture and identifies extreme weather events that might affect crop growth causing famines. The outputs from FEWS NET include monthly reports and maps detailing current and predicted food insecurity, alerts on potential crises, along with specialized reports on weather and climate, markets and trade, agricultural production, livelihoods, nutrition, and food assistance. The system also has a Waterpoint viewer that monitors how dry water sources are.

landpotential.org

Since 2015, the US Forest Service (USFS) has been using LandPKS to collect monitoring data in Ethiopia to develop a baseline for rangeland condition, and to evaluate the efficacy of rangeland management treatments in an adaptive management approach. USFS has conducted monitoring work primarily in the Borana, Guji, and Afar regions of Ethiopia, using both the LandPKS, LandInfo and LandCover applications for electronic data collection and online cloud storage. To date, this work has resulted in 149 monitoring plots.

LandPKS (Land Potential Knowledge System)

It is important to understand the potential production capacity of land and to determine its potential resilience. Land potential is determined by the climate, soils, and topography of the land. LandPKS is a system for storing and accessing user data, as well as providing access to knowledge that can inform sustainable land management. The current primary target audiences for LandPKS include those who need (a) information about land potential to make better land use and management decisions, and (b) a simple system for collecting and storing soil and vegetation data. The first group includes land use planners, extension agents, and agricultural consultants and input suppliers. The second group is using LandPKS for inventory, monitoring and evaluation (M&E), and for research including on-farm research.

The LandPKS app includes the following:

- Long-term climate data;
- Soil texture guide;
- Soil color determination;
- Land capability classification results;
- Vegetation monitoring with the LandCover module; and
- Photos and notes.

LandInfo Module
LandInfo Module is a tool for rapid soil (texture, color) characterization, soil identification, and accessing soil and ecological site information. Specifically, it can:

- Predict soil infiltration and plant available water-holding capacity (AWC) at variable soil organic matter (SOM);
- Determine Soil Color using the phone's camera and a standardized reference card;
- Determine Land Capability Class (LCC) for sustainable land use planning and management; and
- Match user inputs to global soil databases to identify the soil (SoilID).

LandCover Module
LandCover Module is a tool for rapid vegetation monitoring (vegetation composition, plant height, and canopy/basal gaps) that is used for rangeland monitoring, natural resource conservation, and crop residue monitoring.

Databases within government and affiliated research organizations

There are information systems outside of the MoA, but within government control that could be connected with the Future-LIS to strengthen both systems. For example, the CSA have systems with livestock information that could be incorporated into Future-LIS and it is envisaged that Future-LIS will contain data that may be useful for the CSA. By maintaining compatible data formats and data standards the two-way flow of information will help all systems to improve the outcomes for their respective users. Similarly, affiliated research organizations such as ILRI and EIAR also create and store a lot of high-quality information that could be incorporated into the Future-LIS. Uploading data from these sources into Future-LIS will benefit a wide range of users and, reciprocally, information from the Future-LIS will provide an enormous data set for research organizations.

2.4 Related projects

PAID - Public Private Partnership for Artificial Insemination Delivery

PAID is a partnership between local government institutions and multinational and local dairy genetics companies to scale-out effective artificial insemination (AI) delivery and heifer multiplication in Ethiopia. The program began in 2015 and has three components to it:

- Support and monitor AI service providers;
- Increase farmer demand for AI services; and
- Enable AI Centers to increase production and distribution of quality frozen semen.

Equip - Strengthening smallholder livestock systems for the future (Feed the Future)

The Equip project (2018-2022) aims to improve the efficiency of growing quality feed in Ethiopia. This will lead to improved incomes, livelihoods and nutrition of smallholder farmers, in part, by increasing livestock productivity. To achieve this aim, Equip will generate feed data that could be used to populate the Future-LIS. In particular, Equip will document the quantities, nutritional qualities, prices, availability and accessibility of feed, together with land use designation.

PRIME - Pastoralist Areas Resilience Improvement and Market Expansion

This USAID-funded project aimed to make lowland farmers more resilient to drought and was focussed on the Oromia, Afar and Somali regions. The PRIME project ran from 2012 to 2017 and had five components: Livestock Productivity, Natural Resource Management, Alternative Livelihoods, Learning and Knowledge and Nutrition. The data generated by the PRIME project included information on live exports, vet networks, dairy production and rangeland mapping.

Lowland Livelihood Resilience Project

The Lowlands Livelihood Resilience Project is an initiative with the aim of improving the resilience of Pastoral and Agro-Pastoral (PAP) Communities in Ethiopia. This project has a range of components that will achieve this objective including supporting the overall management and productivity of rangelands where these production systems operate. The geographical coverage of the project includes PAP areas in six regions: Afar Regional State, Benishangul-Gumuz Region, Gambella Region, Oromia Region, SNNPR and Somali Regional State. Within these six regions, the project will intervene in approximately 100 woredas.

Feed the Future Ethiopia country strategy

This US-funded programme that runs from 2019 to 2023 has three components: Sustainable Production & Market Systems (Productivity and Diversification, Access to Markets, and Natural Resource Management), Business and Entrepreneurship, and Resilience. The project aims to demonstrate to farmers and pastoralists the value of employing improved technologies and better farming and livestock management practices. This will lead to increased productivity and sustainable natural resources such as soil quality and watersheds. In combination with these productivity gains, improved linkages between rural producers, including smallholders and markets, will result in better commercial opportunities for supply chain actors.

BRIDGE - Bridging Rural Income through Inclusive Dairy Growth in Ethiopia

The BRIDGE project (2018-2023) is a Dutch initiative that is being implemented by the not-for-profit international development organisation, SNV, and Wageningen University and Research (WUR). The aim of BRIDGE is to improve the dairy sector performance in Ethiopia and thereby increase incomes and produce safe nutritious food for all consumers. The project targets 120,000 farming households and has four main outcomes:

- Improving milk production;
- Improving collection, processing and marketing;
- Improving connection to consumer markets; and
- Improving the policy environment.

The project has targeted strategies on gender, climate change and youth employment and is focused on developing inclusive dairy value chains through provision of extension services, including breed and cattle nutrition training.

LIVES - Livestock and Irrigation Value Chains for Ethiopian Smallholders

The focus of LIVES was to enhance income and gender equitable wealth creation for smallholders and other value chain actors in Ethiopia through increased and sustained market off-take of high value livestock and irrigated crop commodities. The project finished in 2018 and was based in Oromia, Amhara, Tigray and SNNP. The project team carried out activities in five focus areas: capacity development, knowledge management, promotion, commodity value chain development and documentation. The project was funded by the Department of Foreign Affairs, Trade and Development (DFATD) of Canada and led by the ILRI and the International Water Management Institute (IWMI).

3.

Future-LIS

This section and Section 4 set out the blueprint for the Future-LIS. Section 3 is based on the collation and analysis of data from information-gathering activities carried out with key MoA stakeholders and other key stakeholders on their data requirements and how they use the data. This has resulted in the following high-level objectives:

- Provide relevant, accurate, timely, digital data to key stakeholders;
- Establish a high level of interoperability between databases;
- Support research goals, commercial and industrial activities;
- Establish requirements for data and information collection, validation, storage, and sharing;
- Be owned by the MoA and managed using cost-effective local technical expertise and infrastructure; and
- Create strong engagement with data suppliers and data users.

In Section 3, prospective users of the Future-LIS have been identified and their data requirements ascertained. This section also sets out the importance of interoperability between databases to maximise the power of the data. The relationship between the various segments within the livestock sector is key to understanding this interoperability and a summary of these segments is described in the following sub-Section.

3.1
Segmentation of the livestock sector

The livestock sector is complex and involves a number of segments that can be viewed independently or as an intricate ecosystem with multiple interactions with the other modules.

Figure 6 shows the livestock sector divided into seven segments.

Figure 6. Segmentation of the livestock sector

Population

For decision-making purposes, animal numbers are the foundation of the livestock sector. Without this information it is difficult for the analytics function of the Future-LIS to draw informed insights from any of the segments.

Genetics

The genetics segment refers to breed information as well as the genetic merit of the livestock where this is known. With an improved data capture and sharing mechanism, those mandated to improve the Ethiopian livestock genetics sector will be able to make informed decisions into uses such as planning semen collection and dissemination, artificial insemination training and synchronies at scale.

Production

Production data will provide insights to processors so they can allocate resources to meet production demands. Production is strongly influenced by information housed within the other six segments.

Feed

Possessing ongoing information around the amount of feed available for livestock is important for both farmers and the government. This information can be used for right-sizing the level of stock within a herd or by mobilizing federal or regional resources to reduce the effects of drought and starvation risk.

Health

The health segment contains information on disease prevalence and incidence, disease outbreaks and vaccinations. Using the information within this segment will enable users to take measures to mitigate disease outbreaks, reduce losses due to mortality and morbidity and increase the value of the animals and products in the marketplace.

Trade

Information within the trade segment relates to the prices and volumes of the livestock and livestock products in the local and export markets. Dynamic marketplace data helps supply chain actors to make informed decisions around the sale of their stock. Data from the markets can also inform other users around the supply and demand for specific breeds and provide insights into the animal health status of the Ethiopian livestock population. Additionally, the information can inform policy formulation and provide insights into the food security situation in each region and nationally.

Location

Although there are no specific databases set up exclusively to store location information, these data do play an important role for all of the other segments in the Future-LIS. While some usable location information is being collected, a more comprehensive dataset is essential for making decisions around deployment of services such as disease outbreak mitigation, planned synchronies for artificial inseminations and feed development.

3.2 Future-LIS users

It is expected that a range of different user types with varying needs would benefit from the Future-LIS. The Future-LIS will need to be amenable to people of different backgrounds, expertise and literacy, as well as the plurality of written languages across Ethiopia. The category of potential users of Future-LIS and the types of activities that will be informed by the information within the system were established via workshops and in-depth interviews. A detailed review of potential government and non-government users is summarized in Tables 12-16 in Annex 2, with some specific examples set out below.

Minister of Agriculture and Minister of Trade and Industry

Ministers use data to monitor progress against sectoral objectives such as those set out in the Ten-Year Strategic Development Plan and to make decisions on resource allocation, risk mitigation and investments. Demonstrating the value of data-driven decisions, in conjunction with the associated interventions, assists in securing funding for the sector. The up-to-date information received by the Ministers is likely to be provided by the Directors and analysts within the respective MoA directorates and will include performance metrics, areas of concern and individual business unit funding requirements. Overall, Ministers will be involved in a wide range of activities including:

- Sectoral oversight by monitoring progress on strategic plans and targets;
- Strategic planning by understanding resources, threats and opportunities and developing long-term solutions to sub-sector constraints;
- Coordination and problem solving;
- Resource mobilization and guidance on investment;
- Program and intervention development;
- Capacity building; and
- Analyzing local and global developments and using best practices to inform policy decisions.

MoA directorates

As shown in the organizational structure of the MoA (Figure 1), there are many directorates and each one will have specific needs for data often involving information from more than one of the Future-LIS segments (Figure 6).

For example, the users in the Epidemiology Directorate have a role in reducing the prevalence and effect of animal disease outbreaks. The reason they need timely and accurate information is to enable them to carry out activities such as:

- Addressing critical issues as they arise;
- Designing and monitoring sub-sector interventions and understanding capacity gaps;
- Understanding availability and costs of inputs in raw materials;
- Determining profitability of investments and innovations;
- Designing interventions to mitigate risk and/or further outbreak potential;
- Conducting socio-economic studies on notifiable animal diseases to determine their impacts;
- Undertaking qualitative risk analysis, hazard identification, exposure assessment, risk estimation and setting mitigation measures;
- Coordinating passive surveillance; and
- Reporting on disease occurrence and providing regular feedback to regional livestock bureaus and to international organizations such as OIE and the African Union-Inter African Bureau for Animal Resources (AU-IBAR).

A second example of an MoA directorate user is the Livestock Identification and Traceability (LIT) Directorate. This directorate has a role in establishing and implementing a robust, dependable, and comprehensive livestock identification and traceability system that enables disease surveillance and prevention, maintains food safety standards and strengthens the export market. The activities of the users from this directorate include:

- Identifying and registering individual animals (individual identifier) or epidemiological units or groups of animals (group identifier);
- Piloting a livestock identification and traceability system (LITS);
- Providing ET-LITS information as required for tracing diseases; and
- Preparing guiding documents such as the ET-LITS legal framework.

One further example of a directorate that uses data is the QIEICD. This group of users regulates the import and export of live animals and animal products to ensure that they meet International Standards. They are also responsible for regulating the construction of quarantine centers and animal health posts. Their activities include:

- Inspecting the quality and health status of live animals and their products in feedlots and quarantine stations;
- Providing sanitary certification for different livestock commodities and samples; and
- Issuing Import Permits for imported livestock commodities.

Regional agencies

Regional agencies, such as the Oromia Regional Livestock and Fisheries Resources Development and Promotion Agency, and the Amhara Regional Livestock and Fisheries Resources Development and Promotion Agency, have a role in supporting the generation and adoption of improved livestock technologies to increase the productivity and production of diverse livestock species which leads to improved livelihoods of communities. Central to this role is genetic improvement, health services for disease prevention and control, and provision of quality and standardized production input. The activities of these users include:

- Breed improvement;
- Improving grazing land, and forage development;
- Facilitation and coordination of resources;
- Addressing the water shortage for livestock;
- Delivering advisory services for improving the production and productivity of livestock resources;
- Preparing, implementing and monitoring animal health development;
- Improving clinic and vaccination coverage, and the quality of the treatment;
- Disseminating improved livestock technologies to farmers; and
- Distribution of animal health and production inputs to zones.

Researchers

Research scientists from Universities and Research Institutes have an important part to play in delivering insights and solutions to the Ethiopian livestock sector. Their work is dependent on accurate and relevant data and it is anticipated that the Future-LIS will enable these users to make significant progress towards developing and improving livestock practices in Ethiopia. Researchers' use of data is very diverse but may include:

- Identifying systemic constraints of agricultural development and alleviating these constraints;
- Proving the value of interventions;
- Delivering new modelling solutions;
- Regional analyzes of livestock performance;
- Studies to inform policy decision-making; and
- Research and development into improved practices.

Value chain actors

The value chain actors, such as feed suppliers, farmers, traders and processors, who actually transact a particular product as it moves through the value chain, will benefit from the data in a livestock information system. Each of these users will have different data needs but all will require timely market price information to make informed decisions on where to source or sell their products. Some of the activities of these users include:

- Identifying which market has the highest price for a livestock category;
- Ascertaining whether to sell an animal or not;
- Proving vaccination status of livestock for sale;
- Demonstrating ownership of livestock; and
- Identifying commercial opportunities for salespeople.

3.3 Data requirements

Through the workshops and interviews that were held with potential users (section 3.2 and Annex 2) it was determined that each stakeholder has a range of different data requirements that need to be fulfilled to improve the effectiveness of their roles in the sector. These data requirements are aligned with the high-level objectives of the Future-LIS (sub-section 1.6) and can be segmented into the livestock data segments as shown in sub-section 3.1. This section sets out the data requirements categorised by segment. In some cases there is duplication where a certain data point is important to more than one segment and in these instances the data point has been included in both segments. This illustrates the importance of interoperability between disparate databases and is a theme expanded upon in the following section where specific use cases are described.

3.3.1 Data requirements by livestock data segment

Population data

- Total population
- Animal numbers
- Species
- Category of animal
- Primary use
- Unique animal identifier
- Registration of birth
- Registration of death
- Slaughter
- Cause of death
- Sold
- Location
- Owner details
- Farmer age
- Farmer type
- Farmer gender
- Household

Genetic data

- Breed
- Gender
- Sex
- Age
- Dam
- Sire
- Reproductive status
- Heat date
- Mating date
- Mating type
- Insemination type (AI versus natural)
- Pregnancy diagnosis
- Fetal count
- Expected calving date
- Actual calving date
- Expected calf details (anticipated traits)
- Gestation length
- Calving difficulty
- Year born
- Unique animal identifier
- Location
- AI centers
- AI technicians
- Semen doses collected
- Semen doses available

Production data

- Processor name
- Milk volume
- Meat weight
- Skins and hides
- Protein
- Fat
- Days in milk
- Dry date
- Lactation date

Feed data

- Available feed
- Feed utilization
- Feed type
- Amount of feed purchased
- Growth rate
- Fertilizer used
- Crop treatment
- Residual crop yield
- Crop type
- Crop yield
- Grazing/harvested
- Prosopsis infestation
- Water source availability
- Water point development date

Health data

- Body condition score
- Body condition score date
- Vaccinations
- Vaccines available
- Antibodies present
- Screened for disease
- Diagnosis of disease condition
- Disease category
- Treatment
- Dosage
- Application date
- Fit for export
- Health center
- Resource capacity

Trade data

- Market type
- Market location
- Price
- Volume
- Importing country
- Export revenue
- NLMIS registered
- Rejected animal
- Business type (e.g. feedlot, abattoir)

Location data

- Region
- Zone
- Kebele
- Woreda
- Land use
- Land area

3.3.2 Use cases

Over 200 use cases were identified by the stakeholders during the information-gathering interviews and workshops and these are included in Annex 3.

Use case interoperability scenarios

In order to display the future interoperability of the Future-LIS system, a series of hypothetical scenarios have been developed that display how information from different sources need to interact to deliver the maximum value to the stakeholders. The connections of data located within different segments illustrate the importance of interoperability of Future-LIS. These scenarios also demonstrate how processed data can be cascaded to multiple users who can then combine it with other data to meet their sector-specific objectives.

Scenario One

Disease outbreak in Somali region

There has been an outbreak of an infectious disease in the Somali region which to date has affected 247 animals. There is concern that this fatal disease will spread into neighbouring farming zones and affect multiple animals within each of the zones. The CAHW believes an urgent vaccination drive could help mitigate this pending crisis but needs accurate information quickly.

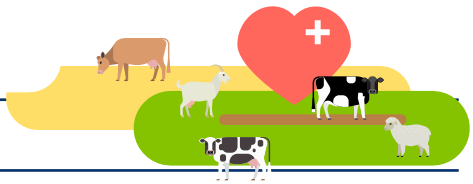
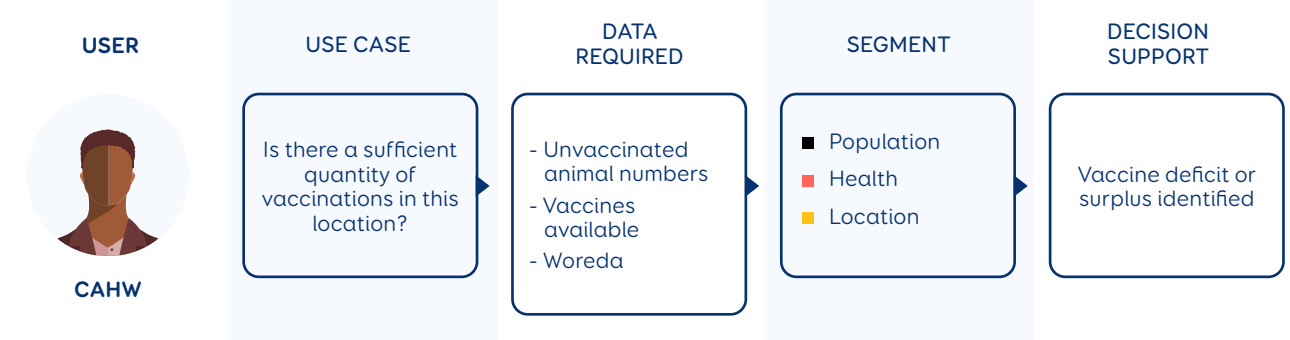


Figure 7. Health use case



Scenario Two

Drought event

An alert has been generated by the PLEWS that there is a potential upcoming drought event in the Oromia region. If this was to occur, there would be wide-ranging consequences to the livestock sector in this region. To mitigate the risk, several directorate heads require information from the Future-LIS, so that they can make informed decisions on what action to take.

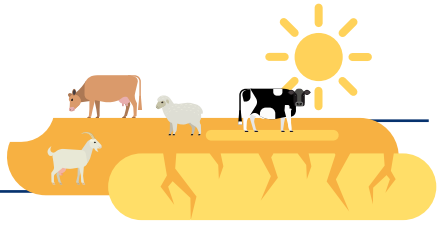
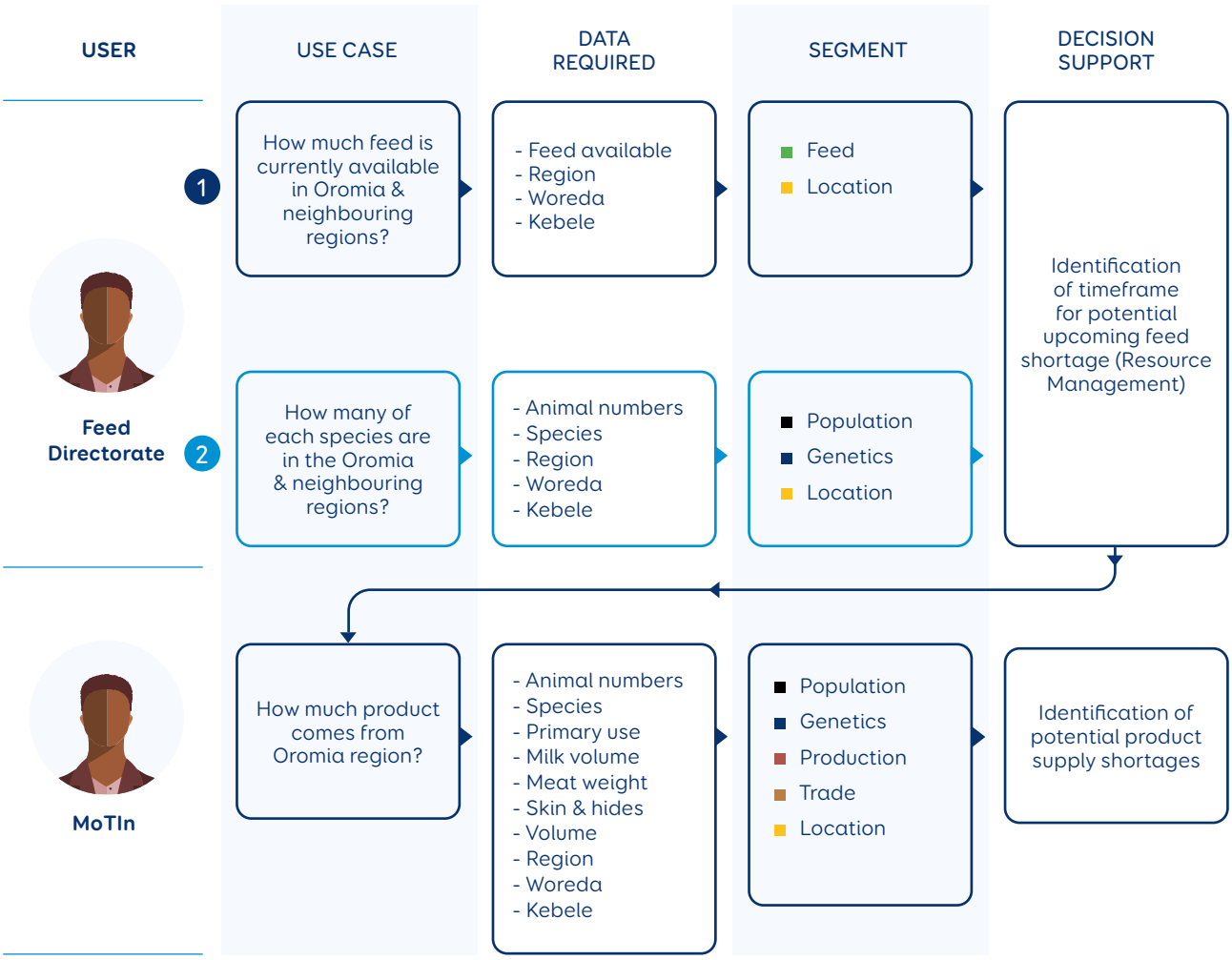


Figure 8. Drought use case



Scenario Three

Genetic improvement

The MoA is considering carrying out a trial into genetic improvement for the Ethiopian dairy herd in the south east Oromia region as it is widely believed that cross-bred genetics will increase productivity in the dairy sector and drive export revenues. To compile a compelling business case for government investment several factors need to be considered.

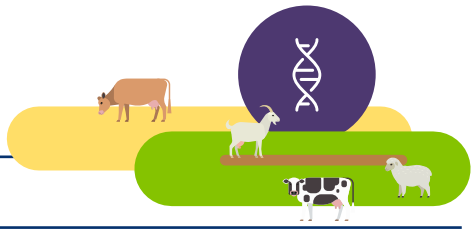


Figure 9. Genetic improvement use case

MoA

USER	USE CASE	DATA REQUIRED	SEGMENT	DECISION SUPPORT
	1 How much extra milk is produced by cross-bred cows?	- Species - Breed - Milk Volume	■ Genetics ■ Production	Total number of cross-bred animals & production from these animals in relation to indigenous breeds within the south east Oromia region
	2 How many cross-bred cows are in the south east Oromia region?	- Animal numbers - Species - Primary use - Gender - Region	■ Population ■ Genetics ■ Location	
	3 What extra revenue would the investment make?	- Milk Price - Milk Volume	■ Trade	Potential return on investment of targeted genetic breeding program

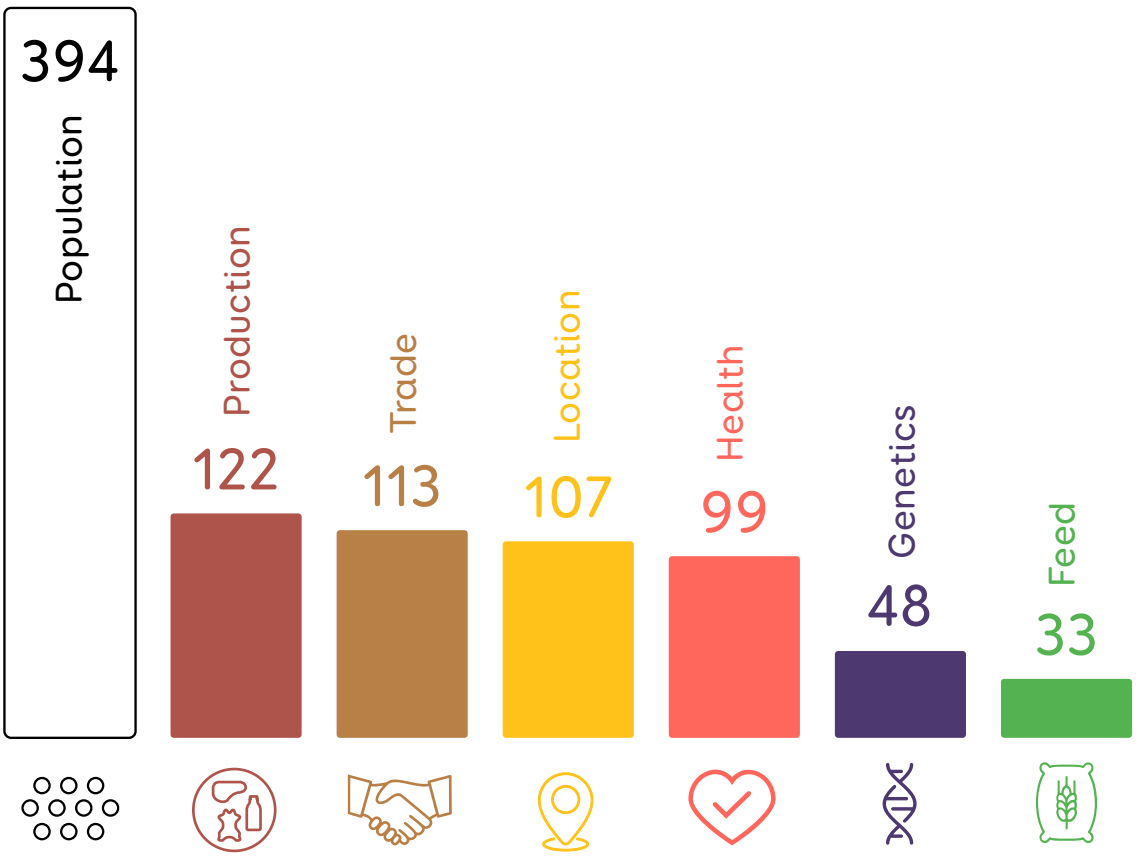
3.3.3 Gap analysis

The information systems operating in Ethiopia today are hampered by variable quality data, poor interoperability between systems, incomplete regional and/or temporal datasets and lack of regulation around data inputs. The resulting data gaps have made it difficult for stakeholders, including the MoA, to make timely, evidence-based decisions. Monitoring progress of the sector is also impacted and it is difficult to know whether agricultural initiatives are having the desired productivity gains.

To assess which are the most important datasets, each of the use cases generated by the Ethiopian livestock sector were analyzed individually and the data points required to address the use cases were identified. The data points were subsequently cataloged into the seven livestock segments to gain an understanding around where data collection efforts could have the biggest impact. The result has been summarized in Figure 10 which shows that the vast majority of use cases involve population data. Having an animal recording system that addresses animal numbers, animal species and location across Ethiopia would form the basis of a strong livestock information system and add value to numerous use cases.

Development of the Future-LIS needs to be done in parallel with improvements in the accuracy, timeliness and prevalence of data collection. There is little benefit in having a first-class livestock information system if the data entering the system is low quality. In many instances, the lack of robust data being collected and transmitted to databases is due to lack of awareness of best practice or not having the right tools.

Figure 10. Prioritized data need by segment and use case



3.3.4 Use case - Targeted training to strengthen NLMIS usage

There is general consensus among stakeholders in the livestock sub-sector that there is lack of and need for price information, particularly in the pastoral areas. Information is critical for decision-making, especially when assessing risk. It is useful for different groups including producers, traders, researchers, and policy makers. While there has been an emergence of organized market information development over time, particularly in relation to prices at terminal markets, there is generally a lack of information on price and volume of livestock at more remote secondary and tertiary markets where pastoralists trade livestock.

The NLMIS works by storing price and volume data at designated markets and conveying it to the NLMIS server in Addis Ababa using SMS enabled cell phones and a data coding system. These data are then made available to all interested parties via an SMS query of the server or through the internet portal (http://www.lmiset.gov.et). Data collectors and supervisors are selected by the regional government and assigned on the NLMIS database by the MoTIn technical team. The frequency of data collection has been standardized across the country. Each market reports once a week based on the livestock species (cattle, camel, goat, sheep, and donkey) using the standard data collection formats. Similarly, the data collectors report price information on livestock products such as milk, meat, hide and skin on a monthly basis. Although the ICT infrastructure is in place to enable the system to function there is irregular data flow across the major markets in Ethiopia.

To demonstrate the impact of targeted training to build the human capacity to support NLMIS usage, a team of experts collaborated with the MoTIn to strengthen their capacity to collect, compile, analyze and disseminate livestock market information. The capacity building was undertaken in two phases:

Training of Trainers (TOT):

- Advanced training for institutional users (MoTIn Livestock Hide & Skin Directorate, Information Technology Directorate, MoA Livestock Directorates, regional bureau heads) to create user accounts, analyze data and generate reports; and
- Enable trainers to train data collectors in techniques for livestock grading, market price and volume data collection and use of SMS for data input.

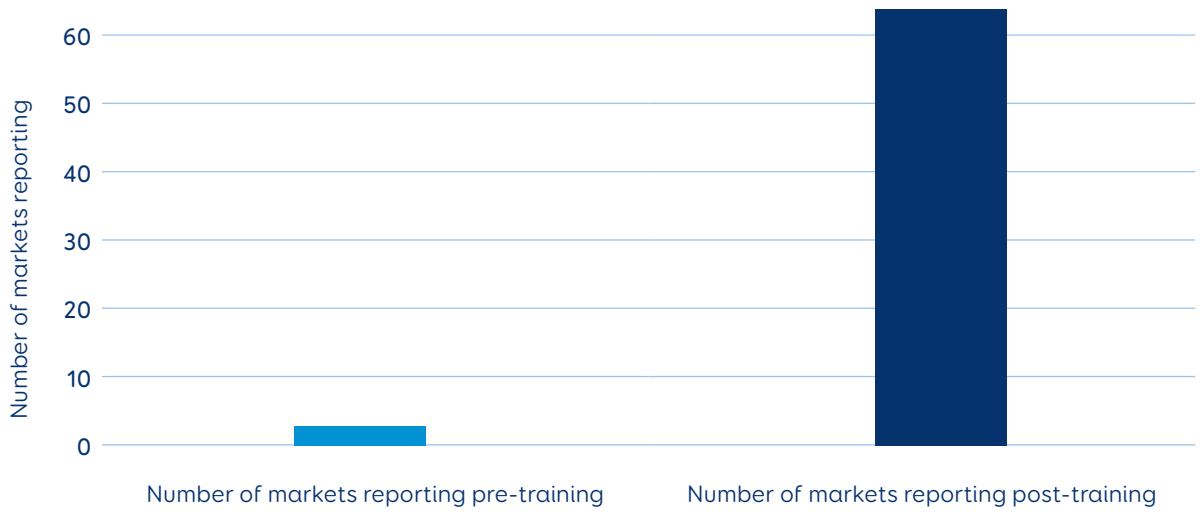
Direct training for data collectors:

- In the regions of Afar, Amhara, Dire Dawa, Addis Ababa, Oromia, SNNPR and Somali.

Project team members conducting NLMIS training session

A total of 157 participants comprising team leaders, marketing and livestock experts, leaders of the woreda trade and market development officers, public relations officers, regional bureau directors, program officers and others were trained on NLMIS using a workshop format. Prior to the training sessions only three markets were routinely providing data into NLMIS, even though 47 markets had provided data at some time in the past. After the training sessions, the number of markets routinely reporting data increased from three to 56, and included nine markets that had never previously reported (Figure 11).

Figure 11. Increase in number of livestock markets reporting data after training sessions



The significant increase in markets providing a steady flow of timely, regular and reliable livestock market information to a central NLMIS database demonstrates the effectiveness of the targeted training outlined above. The four-month long initiative, carried out as a collaboration between the MoTIn and a small team of experts, transformed the NLMIS from an underutilized resource to a valuable tool in the livestock supply chain. Furthermore, the MoTIn has established a department that works with regional governments and oversees the entire NLMIS activities enabling the dissemination of the livestock market data through local languages on a weekly basis.

3.3.5 Use case - Development of New Zealand's livestock information system (MINDA)

Dairy is an extremely important sector to New Zealand. In the year to March 2020, New Zealand exported NZ$19.7 billion of dairy products which constituted over 30% of the country's total export trade. Even though New Zealand accounts for only 3% of the world's milk production, it is the global leader in exported dairy products with over 95% of its production sold internationally mainly as dried milk powder. New Zealand milk production has increased by 288% over the past 35 years primarily driven by the increased use and availability of data.

New Zealand's first livestock information system began through commercial herd testing being introduced to the New Zealand dairy sector in 1909. Herd testing allowed farmers to identify the best and worst performing animals in their herd thereby enabling them to make informed decisions around which animals to cull and which animals to breed from. The data reference point was the measure of milk fat produced as this was the determining factor on how much income the farmer received.

In the 1950's the types of decisions based on herd test data were more complex. Not only did farmers want to identify their best and worst cows, but it was recognized that the data could also be used to identify elite cows and therefore elite bulls. This led to the introduction of a Sire Proving Scheme that would prove the genetic merit of the sires based on the desired characteristics of the milk. Breeding from the elite bulls had a direct effect on the herd's production as milk from the improved cows was able to be measured and valued based on its characteristics.

At this time, the animal records were kept largely decentralised and disaggregated. During the mid-1980's LIC established the MINDA animal software that fed into the national database. Information was captured on carbon copy paper and sent to LIC to input into the database. In return for their herd's records, subscribed cooperative members received an annual herd record book that allowed them to review their historical breeding decisions and estimate the impacts of these decisions on their performance retrospectively. Based on this information, farmers could then plan their breeding and herd management decisions that would lead to improved production the following year. So, although farmers were still using herd testing for herd management decisions around which animals to keep, the data from these herd tests was forming an ever-expanding data set that could assist LIC in identifying elite cows and bulls. This information was then used in the Sire Proving Scheme to confirm the performance of the elite bulls, at which time the cooperative members could buy this elite bull semen and benefit from subsequent production gains.

With the advancement of technology through the 1990's and into the 2000's farmers were provided tools by LIC that allowed them to record and analyze their own information with a desk-based version of MINDA. This system synchronized to a centralised national database to deliver information to LIC with little human intervention. The MINDA information system continues to evolve and the most recent version is cloud-based with visualizations of analytics being presented to the end users. In-situ data input and analysis can be performed through a mobile application that is available in an online/offline capacity in the field.

This flow of data into the National Animal database has connected dairy processors, industry good partners and genetics companies who compile and aggregate information for their own use cases. The information is further used to compile the annual New Zealand dairy statistics report that enables the New Zealand Government's Ministry of Primary Industries to make policy and planning decisions based on robust, accurate data.

The progressive development of the livestock information system, MINDA, coupled with New Zealand's rapid development as a leading dairy exporting nation, illustrates how data can contribute meaningfully to drive productivity. The impact of the collection of accurate, timely data has accelerated genetic improvement, production metrics and improved decision-making abilities at all levels throughout the value chain and in to government for policy and planning.

Lessons learned

1. Legacy software

Developing software is considerably easier and more efficient when it is built from a clean starting point. Adaptation of legacy software in order to create a new product that fills a need is expensive to develop and often requires bespoke integrations to be created. This makes the process slow, cumbersome, expensive to execute and expensive to maintain as it requires software engineers with historical knowledge of the system and sometimes knowledge of old programming tools.

2. Cloud

Earlier movement away from legacy systems with complicated inter-connections towards cloud computing would have been of benefit for many reasons, including:

- Ability to share data more efficiently;
- Minimization of on-premise servers that require significant investments and management; and
- Connection with partners and businesses could have been facilitated sooner.

3. Data volume and accuracy

Transitioning from carbon copy to digital format had a significant impact on user experience by reducing call numbers into the LIC contact center, increasing the volume of data input into the system, removing human transcription error and improving the quality and timeliness of outputs to the New Zealand dairy farmer.

4. Early agreement of national data standards

Stakeholders in the New Zealand dairy sector worked independently over a period of time resulting in various data standards being adopted. If a national set of data standards was agreed at an earlier stage in the MINDA development lifecycle, integration of data from multiple sources would have been easier. This would have facilitated an even better user experience and enabled data analysis to occur using accurate data from multiple contributors.

5. Cooperative structure

LIC is a national cooperative which means that the farmers who use the services are also shareholders of the company. Being a cooperative significantly improves the engagement of farmers as the information that they contribute to MINDA is used to directly benefit them through better herd management decisions and improved genetics.

6. National organization

LIC is recognized as a premium company in the New Zealand dairy sector and this provides a level of trust and security with the user's data and their personal information. The company has a national reach with approximately 93% of dairy farmers receiving some service from LIC. Accordingly, the datasets are representative across the regions of New Zealand, and since LIC also carries out most of the dairy herd testing and diagnostics in New Zealand, the data are generally consistent, timely and accurate. Outputs from MINDA to government, research institutions and private companies such as sale yards are held in high regard for their accuracy and completeness.

7. Bespoke system development

Developing bespoke systems is a limiting factor as it creates specialists and pockets of knowledge around the system itself. Adoption of "off the shelf" software at an earlier date would have accelerated the rate of improvement at a lower cost with included maintenance schedules and service level agreements.

4.

Technical Requirements

This section defines the high level technical and system capabilities and architectures required to successfully implement the data and analytics platform of the Future-LIS. The foundational components outlined will define the core data, reporting and analytics capabilities required to meet the strategic objectives of the MoA and empower the wider Ethiopian regional and national livestock sector to improve productivity.

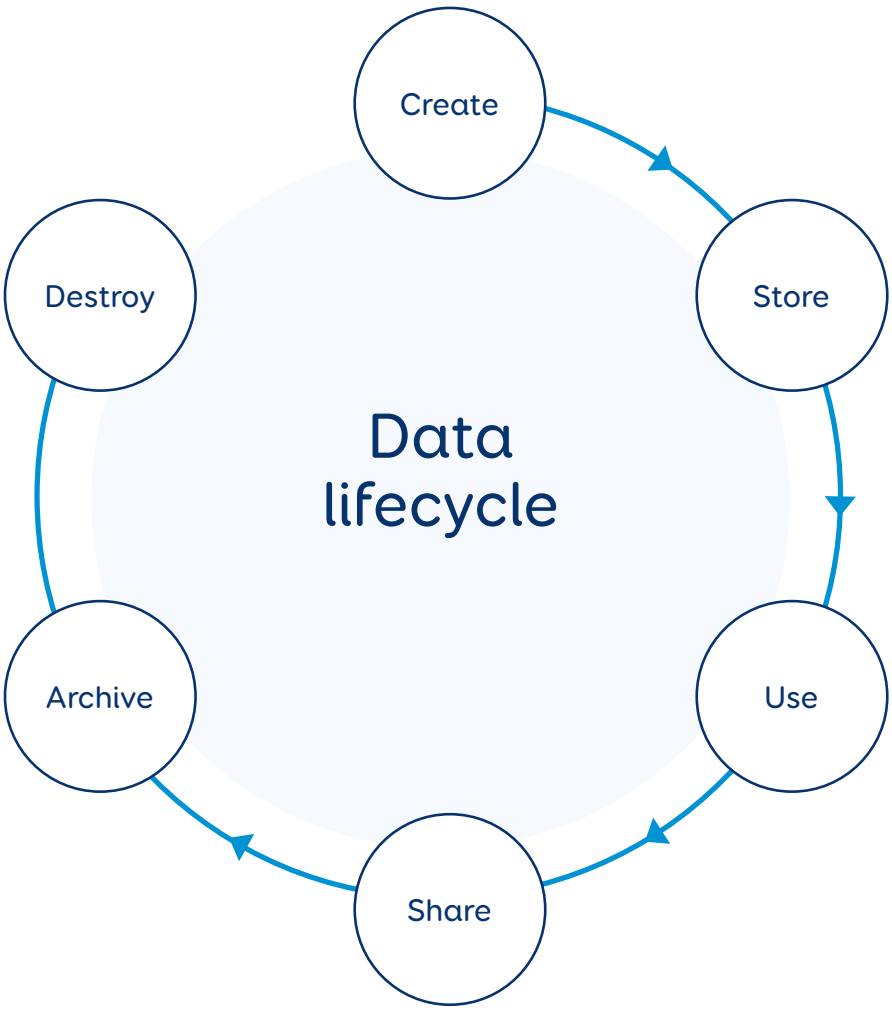
This section is partitioned into three sub-sections:

- Data lifecycle;
- Architecture; and
- Non-functional considerations.

4.1
Data lifecycle

To design an effective architecture for the Future-LIS, the data lifecycle needs to be considered. The data lifecycle is the sequence of stages that a particular unit of data flows through from its initial creation to its eventual archiving and/or deletion at the end of its useful life. The six distinct stages of data lifecycle are summarized in Figure 12.

Figure 12. Data lifecycle



Data creation

The data lifecycle begins with data acquisition and capture whereby an organization obtains new and validated information. This can occur via internally generated data creation, purchase of third-party data, and/or the collection of data as it streams from apps. There are a multitude of different formats that data can be created in including documents, spreadsheets, PDFs, emails, texts or images.

Data storage

Data storage refers to any number of ways that physical media can be used to retain digital information so it can be readily retrieved when users need it. Stored data needs to be maintained securely and accessible only to approved users.

Data use

Data usage is the process whereby the data can be viewed, processed, modified and saved to support the activities of the approved user.

Data sharing

Data sharing is the fourth stage of the data lifecycle. Data Sharing means the exchanging or disclosing of information by one organization with one or more other organizations. Open sharing of information from the system and the release of information via relevant agreement must be balanced against the need to restrict the availability of confidential and sensitive information.

Data archiving

Data that are no longer required on a regular basis undergo an archival process that ensures redundancy. Since these data are not considered active, they can be stored on drives that aren't on the network but can be retrieved for ad hoc reporting and analytics.

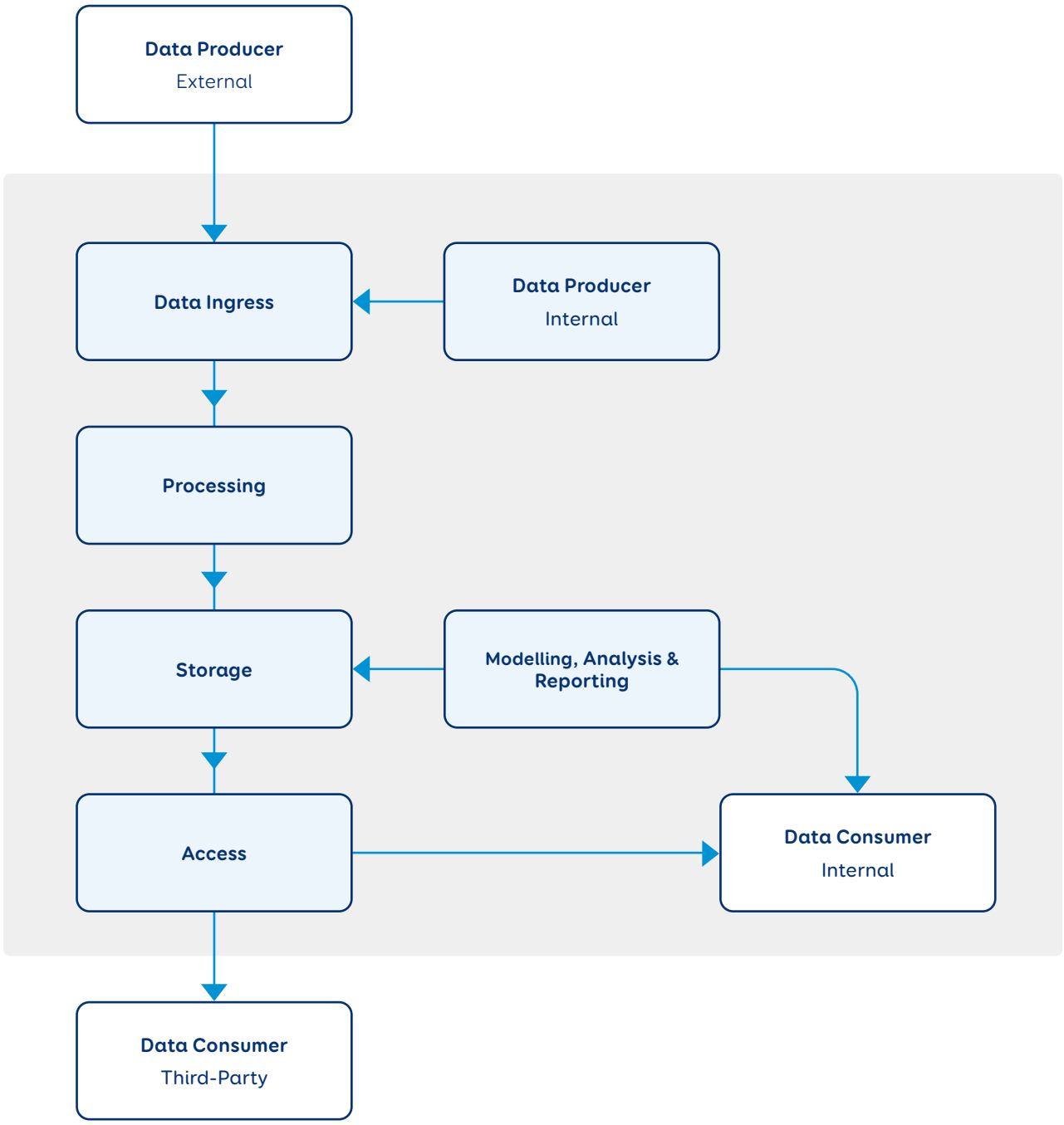
Data destruction

Data destruction or purging is the removal of every copy of a data item from an organization.

The Future-LIS data and analytics platform will need to be capable of supporting all stages of the data lifecycle to enable users to address a very broad range of use cases and requirements (Section 3). Given the complexity of working across the entire livestock sector, the technical requirements and associated data architectural components outlined in this section will focus on the underlying platform capabilities that satisfy a range of users, activities and processes across the Ethiopian livestock value chain, rather than a more limited range of specific information services or use cases. The data flow diagram (Figure 13) is a simplified view of how information flows within a typical livestock information system. Each of the core technical themes illustrated in the figure will be addressed in the following sections.

The data lifecycle is managed within the data governance framework of the information system. Data governance is a collection of processes, procedures, policies, standards and metrics that enable information to be used effectively by approved users. It ensures the quality and security of the data used and defines who is authorized to use what data, in what situations, and using what methods. The administrators of the information system need to engage with internal and external stakeholders to ascertain access rights as well as the service levels expected. In many cases, service-level agreements (SLAs) are entered into where the qualities of the service are specified. Such qualities could include attributes such as uptime, speed of response, timeliness of data, etc. Governance also covers aspects of the system where there are interactions with multiple parties and there are expectations around system operation and performance. With the growing popularity of cloud scaled architectures, data governance also needs to address data sovereignty and geolocation of data processing and storage of cloud-based data centers.

Figure 13. Data flow of the Future-LIS



4.2 Architecture

The following section outlines how the system architecture has been designed so that it meets the Roadmap-LIS objectives. It will address the following:

1. Defining the principles and key design decisions influencing the architecture;
2. Describing the best fit architecture to meet short-term and long-term objectives; and
3. Outlining the architecture from high-level to system level components.

4.2.1 Architecture principles

To provide some architectural structure themes, a set of high-level principles were developed. These are based on the widely adopted Open Group architecture principles and provide guidance as to the appropriate architectural capabilities and design that will be required to meet the objectives of the Future-LIS.

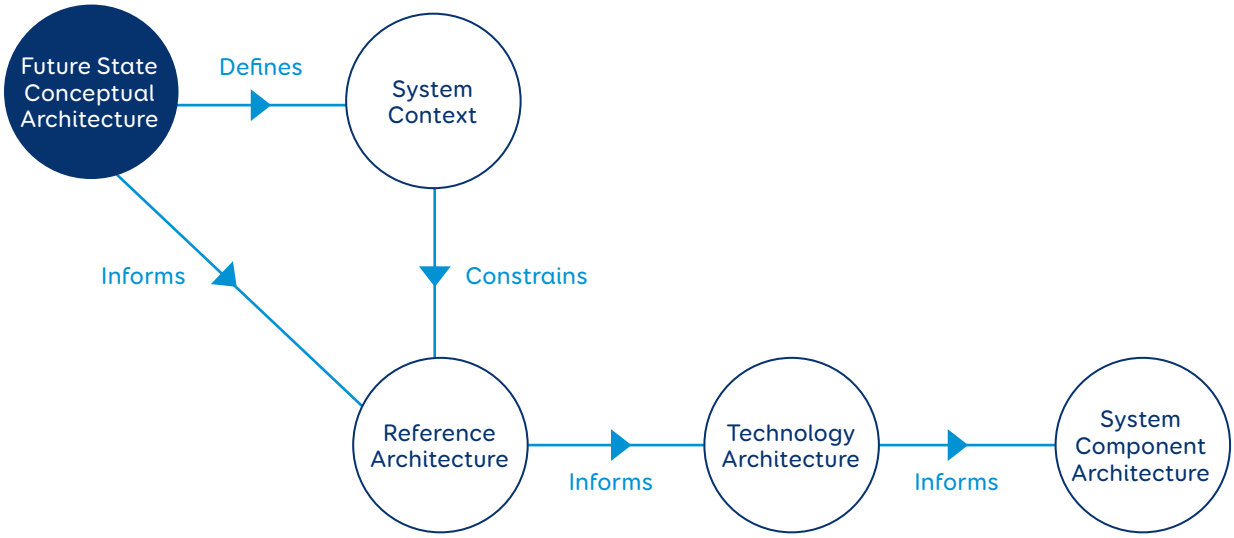
Table 1. Architectural principles

PRINCIPLE	DESCRIPTION	GUIDANCE
Principle 1 DATA ARE AN ASSET	Data are an asset that have commercial value to the MoA and wider livestock stakeholders. Data will be managed accordingly.	• Data stewards of livestock data at farm, kebele, woreda and ministry levels all have a key role in ensuring data are accurate and timely. Data stewards must be enabled and have authority to correctly manage the data that they are accountable for. • Systems must be implemented to reduce human error and encourage reusable and predictable data capture, processing and reporting processes.
Principle 2 DATA ARE SHARED	Users must have access to the data necessary to perform their functions and duties. Therefore, data must be available across organizations and regions.	• Standardized tooling, processes and systems across the MoA and wider data collectors and consumer entities. • Implement highly available, fault tolerant technology so data are available as required.
Principle 3 DATA SECURITY	Data are protected from unauthorized use and disclosure. In addition to the traditional aspects of national security classification, this includes protection of pre-decisional, sensitive, and proprietary information.	• The system needs to remain operational at all times and not be vulnerable to external malicious threats. • Data privacy is essential and the system needs to prevent unauthorized users from accessing certain data.
Principle 4 TECHNOLOGY INDEPENDENCE	Applications are independent of specific technology choices and can operate on a variety of technology platforms.	• Architecture to support change so the MoA is not dependent on specific vendor technology. • Business-aligned services to provide fault tolerant architecture that allows the MoA to change components while minimizing the cost of change.
Principle 5 INTEROPERABILITY	Software and hardware should conform to defined standards that promote interoperability for data, applications and technology.	• Architecture will adopt a series of standards that allow for interoperability.
Principle 6 VALUE FOR MONEY, ADAPTABLE INFRASTRUCTURE	Low cost, scalable infrastructure options required to meet Ethiopian livestock sector needs.	• Minimizing upfront infrastructure costs will maximize the ongoing value of capital investment into the system to meet the demand and ensure sufficient resources are available for system maintenance.

4.2.2 Approach to developing the architecture for the Future-LIS

The design of the Future-LIS architecture will provide the constraints for the transitional state architectures that will occur during the development of this optimized livestock information system. The steps taken to develop the data and analytics platform architecture are illustrated in Figure 14.

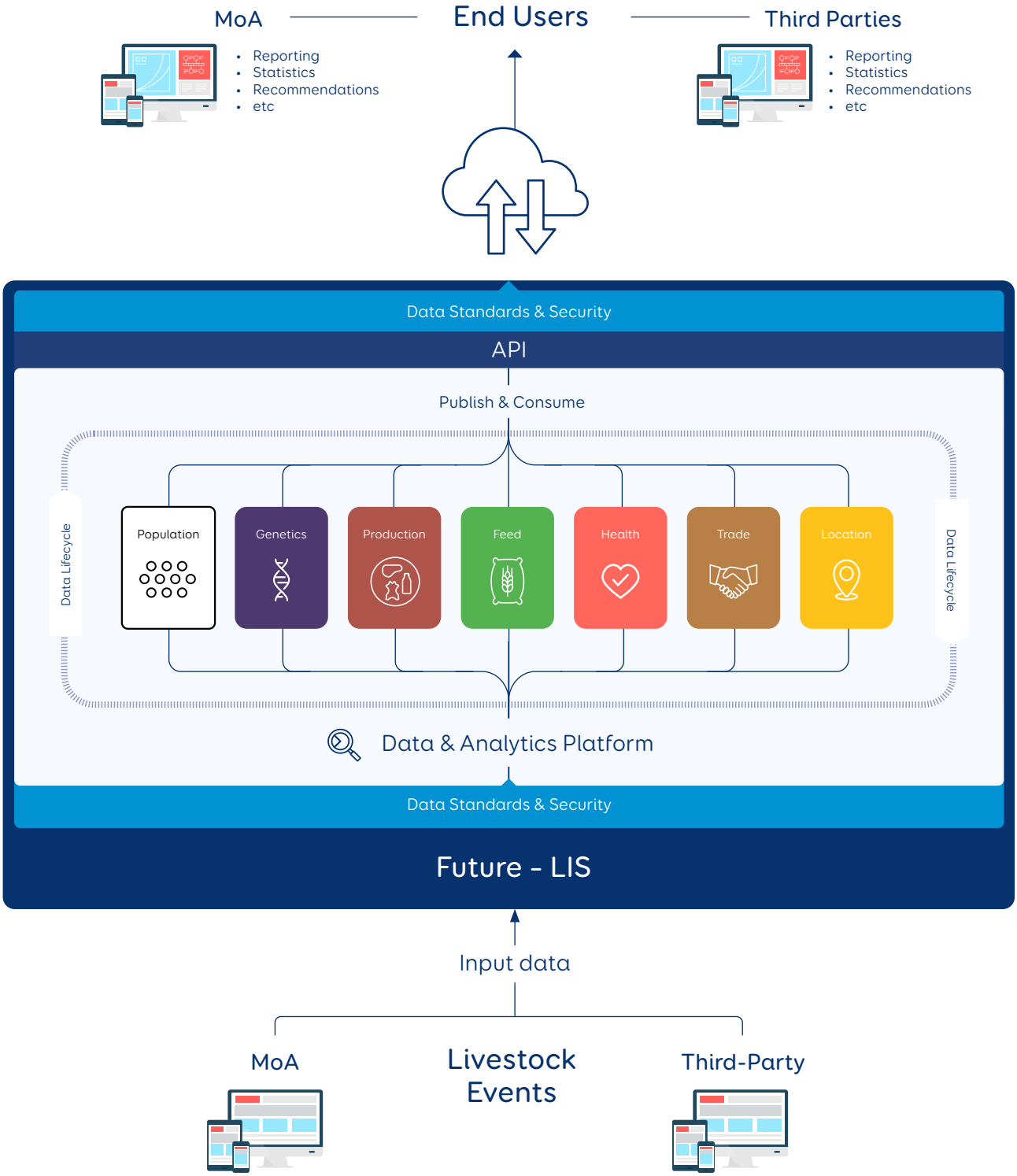
Figure 14. Architecture development



4.2.3 High-level Future-LIS architecture

The proposed Future-LIS architecture is shown in Figure 15. The Future-LIS is a platform-based event-driven architecture based on the Service Orientated Architecture (SOA) style. This style of architecture embraces the principles outlined in Table 1 as it is based around services that are aligned with business capabilities that are stable and slow changing. The underlying technology however can be changed and configured without impacting other areas of the Ethiopian livestock sector.

Figure 15. Future-LIS high-level architecture



API layer

The Application Programming Interface (API) layer is the key enabler to reliably and securely connect the Future-LIS with a wide range of third-party entities. It will provide a platform for livestock data producers and consumers to transact and innovate. The API layer will support open, common standardized protocols such as RESTful webservices to encourage widespread adoption throughout the Ethiopian livestock sector and position the Future-LIS as an important player in the wider data economy. Service where applicable will expose lightweight contracts or APIs that allow third-party integration or strategic MoA initiatives to consume and configure livestock data to meet changing stakeholder demands.

Independent services

The Future-LIS is designed to have independent services and this is illustrated in Figure 15 by the seven livestock sector segments. All systems and data associated with each of the segments are grouped behind service boundaries. Interactions between services are based on the event driven architecture style where services publish and consume events.

Event driven architecture

The Future-LIS architecture is organized as a collection of services (seven livestock segments) that communicate with each other through lightweight events. Events are defined as changes in an individual service's state. For example, when a user enters a new, tagged animal into the Population service underlying database (ET-LITS) the service will reflect this change in population state by publishing a lightweight event that a new animal has been tagged. Other services (Genetics, Health, etc) that use this information for other purposes will 'subscribe' to this Population service event and respond accordingly. The Future-LIS livestock events will be based on the event structures defined in the International Committee for Animal Recording (ICAR) data exchange specification as described below.

The advantage of event driven architecture is that it reduces tight coupling between services. In the past, software system architecture integrated different applications through bespoke point-to-point mechanisms such as writing custom code to access another application's database tables and views. Point-to-point integrations create dependencies between systems that morph over time into complex, tightly coupled monolithic architectures. The complex nature of monolith architecture results in high cost of change and slow response to rapidly changing stakeholder demands. The event driven architecture of Future-LIS means that the complexity of the system is reduced and this will result in overall lower cost of change.

Data & analytics platform

The data and analytics platform architecture provides the recommended patterns, structures and integration of software products and services for the data and analytics platform of the Future-LIS product. The reference architecture is based on industry best practice and provides the optimal delivery approach and methods for specific technologies.

Network and storage - Cloud computing

The network and storage functions of the Future-LIS will be carried out using the cloud. Cloud computing is the on-demand use of computer system resources, such as data storage and computing power, without active management by the user. Cloud computing often has functions distributed over multiple data centers in various locations and are available to many users over the internet. The advantage of using the cloud for Future-LIS is that it minimizes up-front ICT infrastructure costs and allows enterprises to get their applications operational more quickly, with improved manageability and less maintenance. The Future-LIS architecture will be implemented as cloud native systems so that it can be rapidly scaled to meet fluctuating and unpredictable demand.

Interoperability

The architecture of Future-LIS is composed of reusable and interoperable software components that interact with each other via stable contracts or interfaces. In this context, software systems, processes and data are grouped into services. These services can only interact with one another via events or API calls.

Data standards

The data and analytics platform of the Future-LIS purposes full adoption of the livestock data exchange standards and specifications published by the ICAR. The ICAR specification is the result of a collaborative approach by several leading international livestock organizations to standardize common data concepts and facilitate interoperability between different systems within the wider livestock value chain (https://github.com/adewg/ICAR/wiki/About-ICAR-and-ADE). The ICAR specification defines the collections, enumerations, resources, types and url-schema definitions that are aligned with the key animal production determinants such as health, reproduction and feed. At the system level, the ICAR specification implements standards in JavaScript Object Notation (JSON) key value format and aligns to the Open API 3 specification (https://github.com/adewg/ICAR; json.org/json-en.html; https://en.wikipedia.org/wiki/OpenAPI_Specification). The Open API 3 specification defines machine-readable interfaces that describe how to produce, consume and visualize RestFUL web services.

The ICAR data exchange specification provides a comprehensive catalog of all of the animal events, concepts and entities that are created, consumed and published by various roles, activities, processes and systems within the livestock value chain. At the data system and integration level, the Ethiopian livestock sector shares the same foundational capabilities that are found in countries such as New Zealand and Australia. By leveraging and adopting the ICAR standards, the datasets in Future-LIS will be interoperable with datasets generated locally and internationally.

Security and privacy

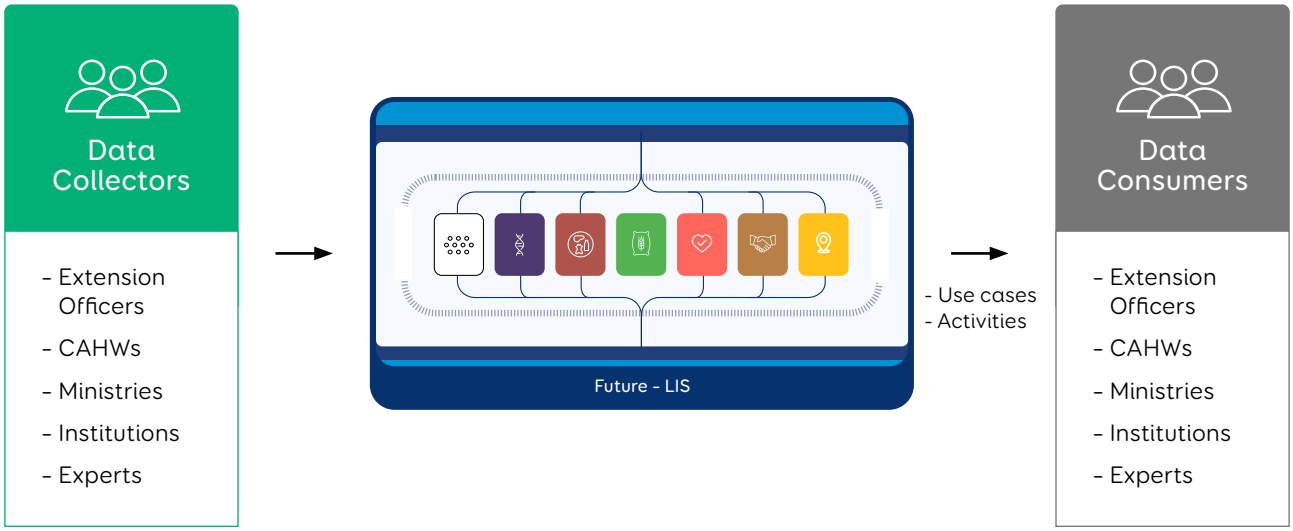
Data security is of paramount importance in the Future-LIS and is a key component of the data and analytics platform architecture. A cloud risk assessment (CRA) was undertaken in collaboration with the Technical Committee of the MoA to mitigate security and privacy concerns around the use of cloud computing for storage processing of MoA datasets. The CRA defined a comprehensive list of security concerns at the regulatory and policy, organizational and system levels that the data and analytics platform architecture needs to consider and overcome. Adopting a Secure by Design approach, where security is built into the system at each stage of the software development, is recommended for the Future-LIS. Security architectural design decisions provide solutions for enforcing the necessary requirements such as authentication, access, privacy, data integrity, monitoring and logging, even when the information system is under attack.

Security requirements are defined at a high level in the reference architecture and described at an interaction level in the system and component architecture. Livestock systems typically contain many components, all requiring different interactions and communication pathways.

4.2.4 System context

The system context describes the architecture of a software system by defining the environment of the system in terms of its external dependencies. For the Future-LIS, the system context provides a business viewpoint outlining the key roles, relationships and information flows that help constrain. Figure 16 shows how data are imported into the APIs of the Future-LIS via data collectors using different formats such as spreadsheets, emails, applications and texts. The data are then processed by the Future-LIS analytics platform architecture which has been designed to support and operationalize a comprehensive catalog of Ethiopian livestock use case services. These use cases provide the scope and boundaries for the reference and lower level architectures. After data processing has occurred, information and reports are disseminated to authorized users also via the API platform for specific use cases, activities and functions as required.

Figure 16. Data flow through the Future-LIS



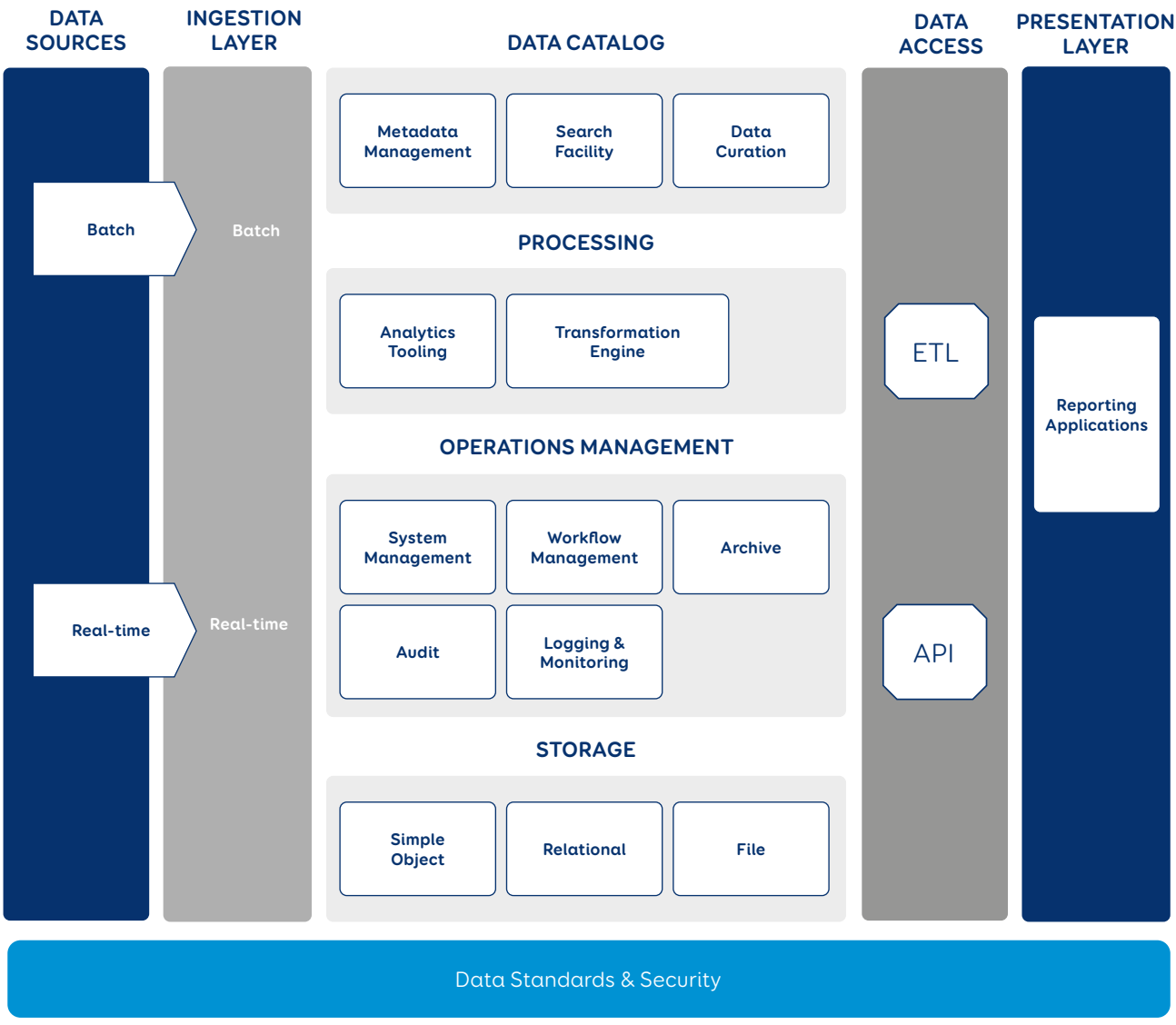
4.2.5 Capabilities within the data & analytics platform

The data and analytics platform is an important component of the Future-LIS that enables data ingestion, analytical processing and publishing of standardized datasets. For Future-LIS, the data and analytics platform consists of data lake reference architecture (Section 4.2.5.1) and additional enterprise architecture patterns (Section 4.2.5.2).

4.2.5.1 Data lake reference architecture

The data lake reference architecture contains multiple capabilities that each require different interactions and communication pathways. Figure 17 illustrates the conceptual view of the data lake reference architecture with required components and their interactions. Although details will vary across system implementations, this diagram captures the common functions that need to exist across systems. This section is targeted at technical experts and provides a description for each capability in the data lake reference architecture.

Figure 17. Future-LIS data lake reference architecture



Data sources

The data lake reference architecture will be designed to support on-premise, external (kebele, woreda, region) and third-party data sources. Initially, given the existing infrastructure and systems within the Ethiopian livestock sector, external data is most likely to be ingressed into on-premise, relational databases such as ADNIS, ET-LITS, NLMIS and DOVAR2. As usage of Future-LIS increases, semi-structured and unstructured formats will also be included as data sources e.g. sensor data, system log files.

Ingestion layer

Data ingestion is the process of enabling data flows so data can migrate from their origin to one or more data stores within the data lake. The primary features of the data ingestion component are to collect and aggregate data from multiple sources, filter, and then route the dataset to one or more destinations. The ingestion layer needs to be resilient and available as per use case criticality requirements. The two primary methods for ingesting data are batch and streaming.

Batch processing

The batch processing model will be the primary ingestion model for the initial stage of the Future-LIS. Batch processing is a method where data are collected and periodically aggregated as defined by user requirements. The batch ingestion process operates in a segmented compute and storage space where livestock data assets are transformed from raw to interoperable models based on ICAR standards. As MoA data assets and reporting tools are typically scheduled on fortnightly and monthly reporting timeframes, the ingestion component will model and configure ingestion processing on the same cadence.

Real-time processing

Real-time processing deals with streams of data that are captured and then processed almost instantaneously to generate real-time (or near-real-time) outputs. There are not many cases in the Ethiopian livestock sector where real-time processing is required as most events occur annually and this creates a static information status. Accordingly, planning for this form of processing has been deprioritized, at least during the initial stage of the Future-LIS development.

Data catalog

The data catalog is the collection of tools, processes and features required to make data searchable and accessible. The data catalog makes extensive use of metadata to provide a queryable interface into the data lake. The data catalog requires three core capabilities to fulfil its function within the data lake and these are described below.

Metadata management

Metadata management provides the tooling and capability to capture, organise and aggregate metadata and is a core capability in providing assurance around data quality and data lineage. This capability ensures that the metadata are complete, current and correct at any given time resulting in users having access to high quality reporting and dashboards.

Search facility

The search facility is the user interface to the data lake. This facility provides a human readable query interface that will query the metadata management as to the location of data sources and return results to the user. The search facility will enable analysts to locate the data they require for their reporting function.

Data curation

The data curation capability will interact with the metadata management and search facility capabilities to organize and integrate differing datasets according to the user's requirements.

Data curation also provides the data assurance functionality as determined by the proposed MoA Governance Group. The data curation function will be carried out by a configurable software component that will profile, standardize, geo code, link and monitor ingested livestock data assets.

Processing

The processing capability is concerned with transforming and cleansing data, as well as providing advanced analytical modelling and sandboxing tools and processes.

Analytics tooling

The goal of any livestock analytics tool is to analyze data and extract actionable and relevant information that can be used to increase productivity or performance. The architecture in the Future-LIS provides a high-level framework and baseline technical analytics tooling that can be further configured at a later stage to provide additional insights.

Transformation engine

- **Processing data in different formats**
  The transformation engine has a pivotal role in processing data in different formats from various sources. This is especially important in the context of batch or real-time ingestion of data. Typically, data may come in via the File Transfer Protocol (FTP) or web services (push), or via external web sites, or another agency's web services (pull). The MoA relies heavily on batch transfer of data via email or FTP. The file format should be standardized as much as possible to avoid the development of many translators. Common formats include CSV, JSON and XML (standards-based). The transformation and load component consists of a transformation of the structure of the incoming data to that of the target system. Data are then transferred to an integration stage with a standardized message queue capability in a standardized structure. The transformation engine will apply the ICAR data exchange standards to all ingested datasets. The transformation engine will also address data validation and classification functions to ensure all published datasets are fit for consumption.

- **Validation**
  The data validation component will check the accuracy and quality of ingested livestock data against a number of rules or constraints. The data validation component ensures data are complete (no blank or null values), unique (contains distinct values that are not duplicated), and the range of values is consistent with MoA rules and industry data standards.

- **Data classification**
  This component of the transformation engine provides vital data auditing, traceability and transparency pertaining to what data are stored on the data lake platform and the storage location. Data classification will adhere to governmental information management policies.

Operations management

The operations management capability provides data lake system maintenance, security, logging, audit and data archiving. These are typical day-to-day tools involving manual and automated processes that ensure the data lake meets its operational and non-functional objectives in terms of regulatory information management, system availability and data lake security. The operations management functionality is comprised of five capabilities as described below.

System management

The system management capability provides system administrators with a centralized portal to organize and administer the distributed system components that operationalize the data lake component of the data and analytics platform. This includes the central administration of logging, auditing and monitoring of system parameters according to the ICT Directorate operational policy and metrics.

Workflow management

Workflow management provides the infrastructure to automate the sequencing of data work flows through the data lake from ingestion through to publishing. This includes the performance and monitoring of workflow services and automation tasks/jobs that perform the majority of the moving, processing and storing of the livestock data throughout the data lake.

Archive

The archive is part of the wider information management capability and provides the tools to tag, process and move archive data in accordance with ICT Directorate policy and procedures.

Audit

The audit function provides the centralized mechanisms for governance processes. The audit capability works in conjunction with the monitoring and logging function to capture system level events that are of interest should the data lake be required to provide a full audit trail of user, system and data activities.

Monitoring and logging

The monitoring and logging capability will provide administrative functionality related to the tracking and logging of the data lifecycle, storage, user activity, security events and system performance. Alerts are configured to notify administrators of service level agreement or operational breaches.

Storage

Data storage is the collection and retention of digital information and is a central component of big data. Future-LIS is designed to use cloud storage and, in particular, cloud native storage formats such as simple object, relational and file storage as outlined below.

Simple object

Simple object storage is a cheap and effective system to store unstructured and structured data. Simple object storage will provide the storage mechanism for all ingested livestock data assets such as documents, images, sound files, historical data and archived files.

Relational

A relational database is a type of database that stores and provides access to data points that are related to one another. For the Future-LIS, the data lake will provide relational database storage facilities that will include backup and transactional logs where required.

File

As part of the data source processing and Extract, Transform, and Load (ETL) publishing, New Technology File System (NTFS) file allocation will be required as part of storage requirements.

Data access

API (Application Programming Interface)

APIs provide internal and external organizational programmatic access to the Future-LIS data assets. APIs are widely used internationally and although they are a well-proven integration method, their application has not yet been adopted by the MoA. The API platform will further unlock value in the Ethiopian livestock data by enabling new opportunities for innovative solutions and markets to be explored.

ETL

Traditional ETL facilities will be required for large batch datasets that are published for reporting and analytics users.

Presentation layer

The presentation layer will display data in customized packages that can be consumed by any reporting application.

Reporting applications

The reporting applications are the local reporting applications that are favoured by stakeholders in the Ethiopian livestock sector.

4.2.5.2 Additional enterprise architecture patterns

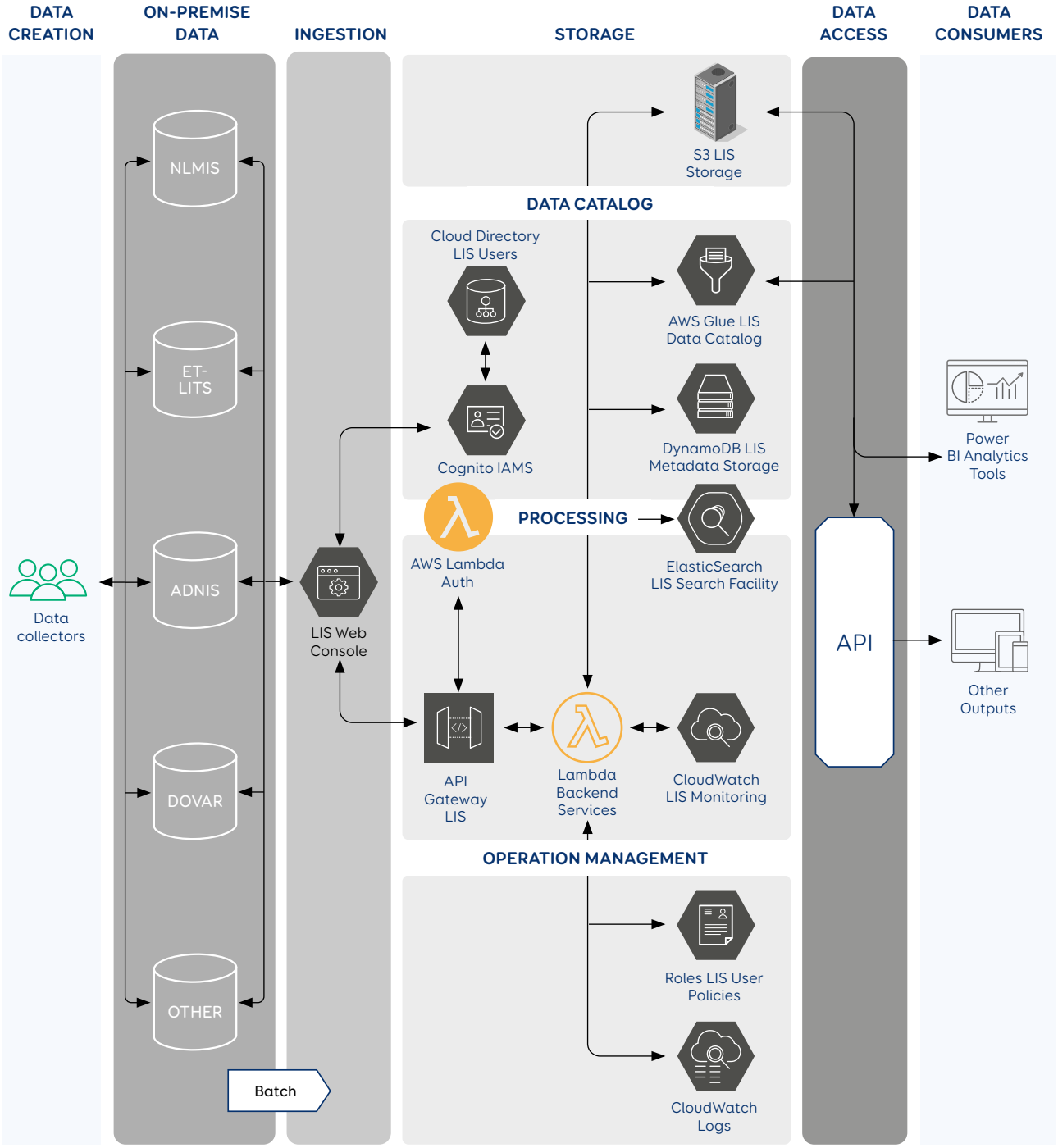
The additional enterprise architecture patterns are standard frameworks that enable interoperability between different systems. These will reduce complexity of integrations between systems and allow faster and more cost-effective responses to changing stakeholder demands and priorities. The Future-LIS will use standard enterprise architecture patterns such as:

- Messaging;
- Asynchronous versus synchronous communication; and
- API gateway.

4.2.6 System component model

The system component model provides the run time design components such as SaaS services, software packages and products required to satisfy the reference architecture. Each of these components may be implemented by different software packages and these may be commercially-available, open-source or custom-built. Sometimes a single piece of software will provide more than one of the functions shown in the data lake reference model, or two systems may provide one functional component. Software components that can fulfil multiple functions will be defined in this section. It is also worth noting that some of these components are designed to be implemented on MoA hosted data centers, whereas other components may be implemented on cloud vendor compute and storage facilities.

Figure 18. Future-LIS system component model



4.2.6.1 Technology selection

Cloud computing is aligned well with the 2025 Ethiopia Digital Strategy and serves to provide a key technological building block that will enable digital transformation throughout the country. Following consultation with the MoA Technical Committee, the Amazon Web Services (AWS) platform is recommended as the most appropriate system for cloud computing (Figure 18). The pros and cons of the AWS system are summarized in Table 2.

Table 2. AWS pros and cons matrix

AWS Pros	AWS Cons
• Geo located data centers on every continent	• Future system designs will need to consider the impacts of storing data in geo located data centers
• Low cost commodity compute, network and storage enables systems to scale easily	• Organizational change e.g. in ICT procurement processes
• Predefined solutions, marketplace and services are available through GitHub awslabs. Deploy solutions in minutes rather than months	• Less control over the system components
• Pay as you go model. The MoA will only pay for the ICT assets it uses instead of wasted expenditure on ICT assets sitting idle in the on-premise data center	• Changing ICT cost centers from Capex to Opex will require change management processes for the MoA
• Rapid deployment of a secure data lake solution in minutes rather than months	• Internet coverage and availability is not guaranteed. During internet outages MoA ICT Directorate will not be able to access cloud based ICT assets
• Reusable infrastructure code and solution building blocks in GitHub	• There will be training costs to upskill staff

4.2.6.2 Solution architecture

The solution architecture provides the technical level of detail that will enable project managers to sequence and prioritize work packages and development activities to deliver the Future-LIS. The solution architecture also describes the products, services, high-level integrations and data flows for the project delivery team. The data lake solution architecture presented will serve as a blueprint that is informed by higher level architectures such as the reference architecture and the system context architecture.

The data lake solution component architecture (Figure 18) describes the flow of information from data collection to data sources housed on MoA on-premise data centers. Data are ingested into the data lake via a web console which implements parts of the ingestion, data catalog, system operation and data access capabilities. The web console implements these capabilities on backend microservices that are accessed via the API gateway.

Ingestion involves tagging and applying metadata policies set by the MoA Data Governance Committee against datasets that have been extracted out of databases such as NLMIS, ET-LITS, DOVAR2 and ADNIS. Once ingested datasets are compliant with data governance standards and polices, the datasets are moved to the processing layer which consists of an S3 bucket. AWS glue services and crawlers scan through ingested and standardized datasets extracting metadata information that is stored in Dynamo DB. ElasticSearch provides the data lake search functionality to data lake users. CloudWatch Monitoring and CloudWatch Logs provide monitoring and logging tooling to manage performance, security and auditing. Any component failures will be surfaced through support dashboards. Data lake security for this implementation is native, with AWS Cognito providing IAM (Identity and Access Management) capability to data lake users and backend services. Each AWS product and service in the solution architecture component is described in more detail below.

4.2.6.3 Solution architecture component description

The following section provides a brief overview of the key AWS products and services that are recommended for Future-LIS.

AWS Key Management Service (KMS) Key
The data lake AWS KMS key is created to provide encryption of all dataset objects that the solution owns and stores in Amazon S3. Additionally, the AWS KMS key is used to encrypt the secret access key in each user's Amazon Cognito user pool record for API access to the data lake.

Amazon CloudFront
The solution configures an Amazon CloudFront distribution to serve HTTPS requests for the data lake console.

Amazon S3
The data lake uses a default Amazon S3 bucket to store datasets and manifest files associated with packages that users upload to the data lake. Additionally, the bucket stores the manifest files generated for a user when they check out their cart (collection of packages). All access to this bucket (get and put actions from the package and manifest microservices) is controlled via signed Uniform Resource Locators (URLs). All objects stored in this bucket are encrypted using the data lake AWS KMS key.

A second Amazon S3 bucket hosts the data lake console. This console is a static website that uses Amazon Cognito for user authentication. End users do not have direct access to the S3 endpoint. All access is done via the Amazon CloudFront distribution.

Amazon Athena with AWS Glue
This solution automatically configures an AWS Glue crawler within each data package and schedules a daily scan to keep track of the changes. The crawlers crawl through the datasets and inspect portions of them to infer a data schema and persist the output as one or more metadata tables that are defined in an AWS Glue Data Catalog.

Amazon Cognito user pool
The data lake console is secured for user access with Amazon Cognito and provides an administrative interface for managing data lake users through integration with Amazon Cognito user pools. Only administrators can create users and groups.

Data Lake API and Microservices
The data lake API receives requests via HTTPS. When an API request is made, Amazon API Gateway leverages a custom authorizer (AWS Lambda function) to ensure that all requests are authorized.

The data lake microservices are a series of AWS Lambda functions that provide the business logic and data access layer for all data lake operations. Each AWS Lambda function assumes an AWS IAM role with least privilege access (minimum permissions necessary) to perform its designated functions.

Amazon DynamoDB tables
The data lake solution uses Amazon DynamoDB tables to persist metadata for the data packages, settings and user cart items.

4.3 Non-functional considerations

Non-functional requirements specify the quality attribute of a software system. The data lake architecture will support the following non-functional characteristics:

- Availability;
- Reliability;
- Resilience;
- Scalability; and
- Fault isolation.

AWS supports 95% uptime on basic and free tier plans. Once the Data Governance Committee has set guidance on acceptable performance criteria, the MoA may need to consider allowing for subscription costs that align with the above non-functional requirements.

5.

Proof of Concept

To demonstrate the simplicity, effectiveness and potential of the Future-LIS design, an end-to-end proof of concept was carried out. The purpose of the prototype was to demonstrate a working model of an analytical platform broken down into domain specific component parts, i.e. data collection, data storage, and data analysis. The data capture tool was designed to enable information collection for the National Animal Genetic Improvement Institute (NAGII). The application is capable of capturing animal data in the field in an online/offline capacity, thereby minimizing issues arising with internet connectivity across the nation.

Design considerations:

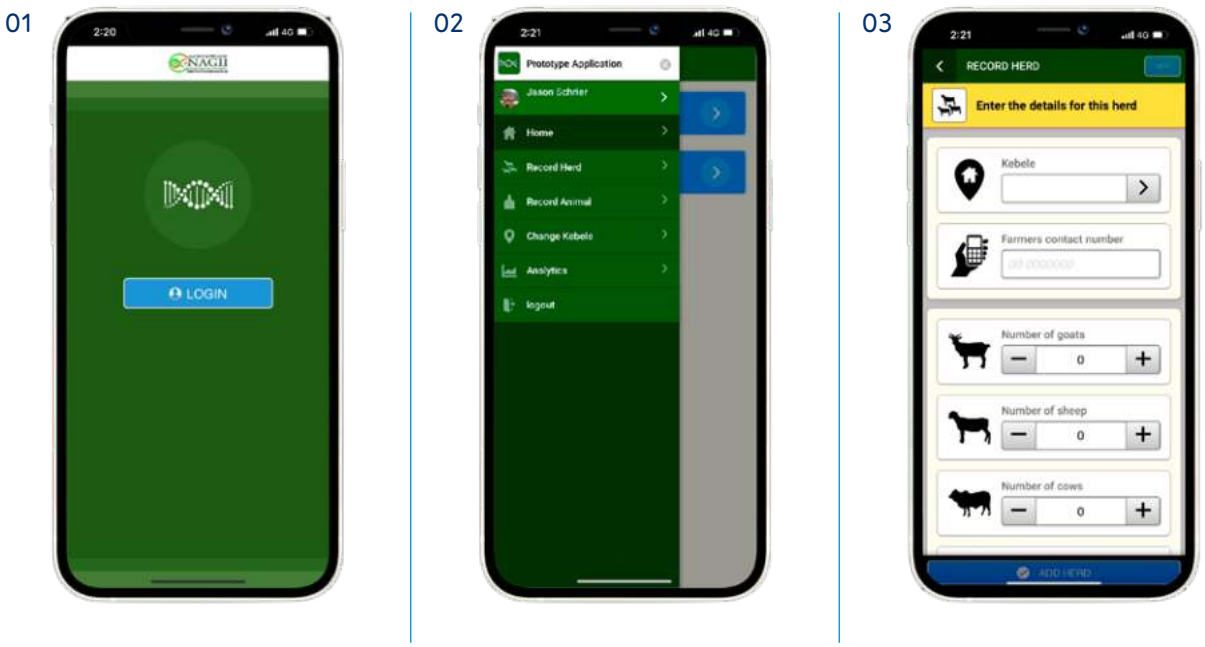
- Online/offline capability;
- Progressive design that scales to device;
- Cloud technology;
- Components mirror those of overall architectural design;
- Ability to share data with Future-LIS data lake and for the data collected to be shared with other interested parties via API;
- Iconography utilized for navigation of application to mitigate literacy concerns;
- Multi-species compatibility;
- Multiple languages supported
  - English
  - Oromiffa
  - Amharic;
- Security of data and validation of user;
- Scalability; and
- Geo-referencing of location of users.

Specific objectives include testing the following items:

- Show that a solution could be constructed with industry standard, low cost technologies;
- Prove the use of a "Progressive Web App" (PWA);
- Use the OAuth security standard for authentication and authorization;
- Identify enumerators by their mobile device IMEI number;
- Demonstrate multilingual support;
- Explore the use of pictographic iconography to assist multilingual and literacy issues;
- Demonstrate vendor analytical platforms;
- Prove the use of a data lake as a storage solution;
- Use local storage and delayed uploading of survey data;
- Prove the cloud service platform;
- Show ease of data entry;
- Share data with NAGII (LUKE database);
- Generate meaningful analytics; and
- Utilize geo-referencing.

This Proof of Concept mirrors the Future-LIS roadmap architecture (Figure 19). The information is collected and created via a device and submitted to a data lake that was designed for the purposes of this Proof of Concept. Data are ingested via the AWS data ingestion endpoint where they are validated by a token. The data are then submitted to the S3 data lake bucket where data crawlers create metadata and store them in DynamoDB. The ElasticSearch component transforms the data into a format that is able to be queried for display within the PowerBI analytics tooling. The rapid development of the data lake demonstrated the simplicity and cost-effectiveness of operating and supporting this solution as a key technology enabler to drive the data and analytics platform part of the Future-LIS.

Figure 19. Mobile application screenshots



6.

Roadmap-LIS Development

Over time, numerous information systems that cannot interact with each other have been created within and across organizations in order to collect, process and report on data for specific purposes. This has resulted in a proliferation of various technology platforms, data standards and authorization procedures making it difficult to compile datasets and make informed decisions. The MoA and the Digital Ethiopia 2025 strategy document have both highlighted the importance of a strong overarching livestock information system in Ethiopia in driving productivity within the sector. The absence of such a system will hamper growth and the sector will not reach its full potential.

The previous two sections of this document have outlined the current status of the Ethiopian livestock information systems (Existing-LIS) and set out a proposed future state (Future-LIS). To transition between the two states will require investment in technology infrastructure, system maintenance and organizational agreement on common data standards, formats and classifications. There also needs to be institutional and organizational accountability for data collection, processing, analytics and data sharing to authorized users to maximize the value of the investment.

The roadmap below constitutes a series of steps over an estimated two-year period that are on a pathway towards developing the final Future-LIS that has been outlined in Section 4. The roadmap also sets out the technological steps as well as the governance steps required to make the Future-LIS interoperable at multiple levels, and provides a timeline and costing to achieve the final outcome.

6.1 Stage 1 of Future-LIS - Interoperability of six existing databases

The first stage in the development of the Future-LIS is to link together six existing databases so that these systems are interoperable and reports can be generated from information pulled from each database. Completion of this stage of work will demonstrate the value of the Future-LIS and ensure ongoing engagement from stakeholders to further develop the system.

6.1.1 Pre-development and non-technical tasks

Prior to developing the infrastructure for Stage 1 of the Future-LIS, it will be important to engage with the MoA and other key stakeholders to make some important strategic decisions and to put an operational framework in place. One key early step is to agree on an appropriate set of data standards that will be adopted across the entire livestock sector. In this report, the ICAR standards have been recommended as they are an internationally accepted set of standards that will make Ethiopian datasets compatible with datasets from other countries.

The MoA has a key responsibility in managing and utilizing the system. For example, subject matter experts and the lead analyst will be required to understand how the data in Stage 1 of the Future-LIS can be used and what reports can be delivered to benefit the sector. These experts will also have a role in engaging with stakeholders to ensure that the reports are providing insights that can inform decision-making. MoA ICT support staff will monitor the operation of the system to ensure that it's operating to its full potential. Training in the use of cloud technology and system maintenance will be essential for the new staff members.

A number of agreements will need to be negotiated. For example, a Service Agreement between the cloud provider and the MoA will need to be put in place once the non-functional considerations are established. Other licensing agreements will be required depending on what software solutions the MoA selects. For example, in this report, PowerBI is recommended and this will require a licence to enable use of the software. Data sharing arrangements may also be required between relevant ministries to use or collect the data.

As demonstrated in this report, training of data collectors in each region leads to a sharp increase in the amount of data flowing into the system. It is recommended that regular training activities continue for the data collectors that contribute data into the Future-LIS. The ingress of high-quality data from multiple regions is essential for the Future-LIS to reach its potential.

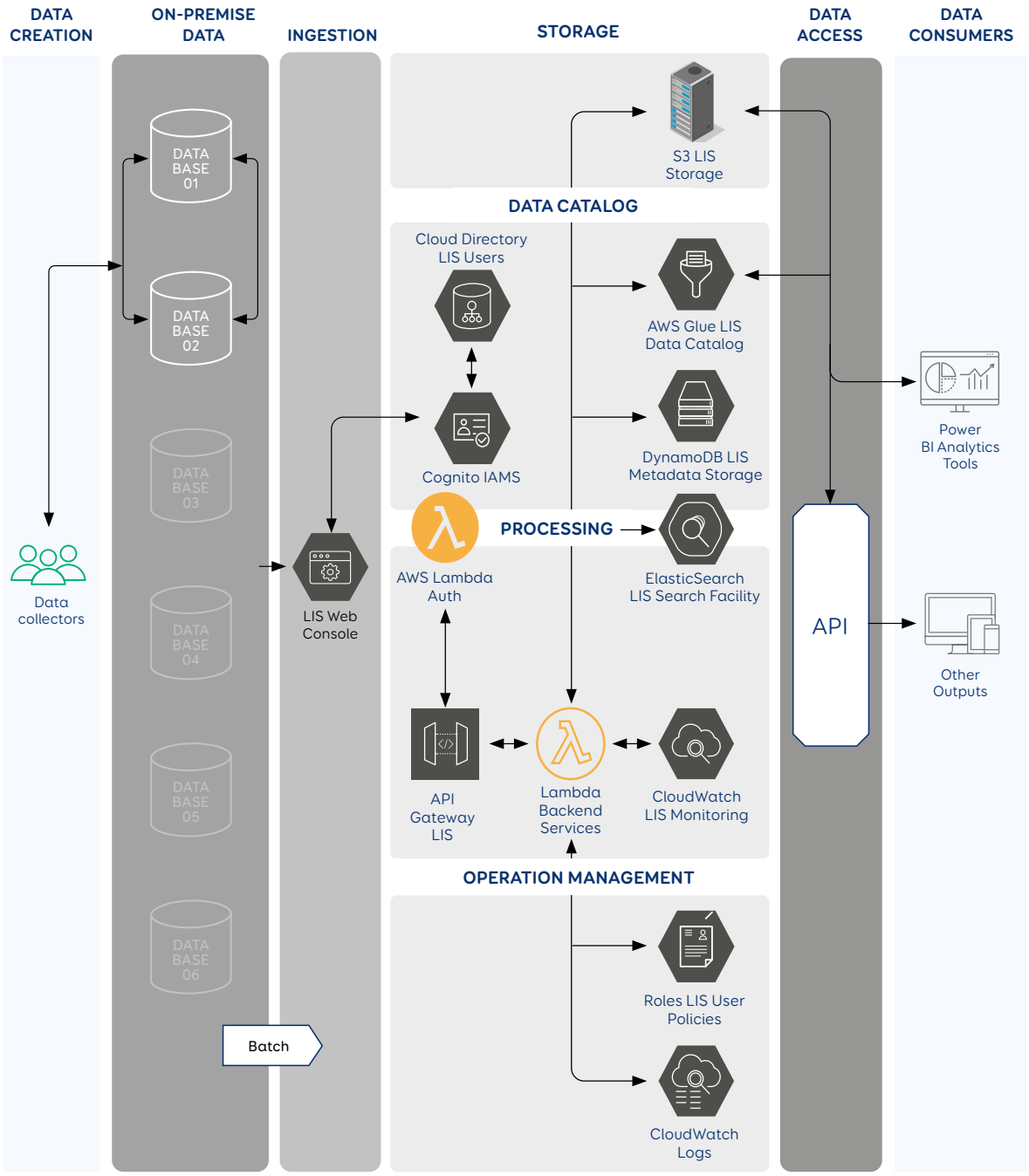
6.1.2 Technical development of Stage 1 of the Future-LIS

Stage 1 of the Future-LIS has been split into two parts to simplify ICT infrastructure development and mitigate risks. Part 1, over an estimated one-year timeframe, involves establishing the core livestock information system infrastructure and combining two existing databases. Part 2, over an additional one-year period, involves the addition of four more databases into the Future-LIS and builds upon the core infrastructure established in Part 1.

6.1.2.1 Part 1 of Future-LIS - Establishment of infrastructure and linking two databases

Part 1 represents a minimum viable Future-LIS that has the information system infrastructure set up with two databases inputting data into the system (Figure 20). The building of the infrastructure has been described in detail in Section 4 of this report. There will be some data normalization required to ensure compatibility of these data systems with the MoA-mandated data standards. The PowerBI consultant will liaise with key stakeholders and continue to validate use cases to develop new reports based on the information from the two databases that are incorporated into this system.

Figure 20. Part 1 of the Future-LIS

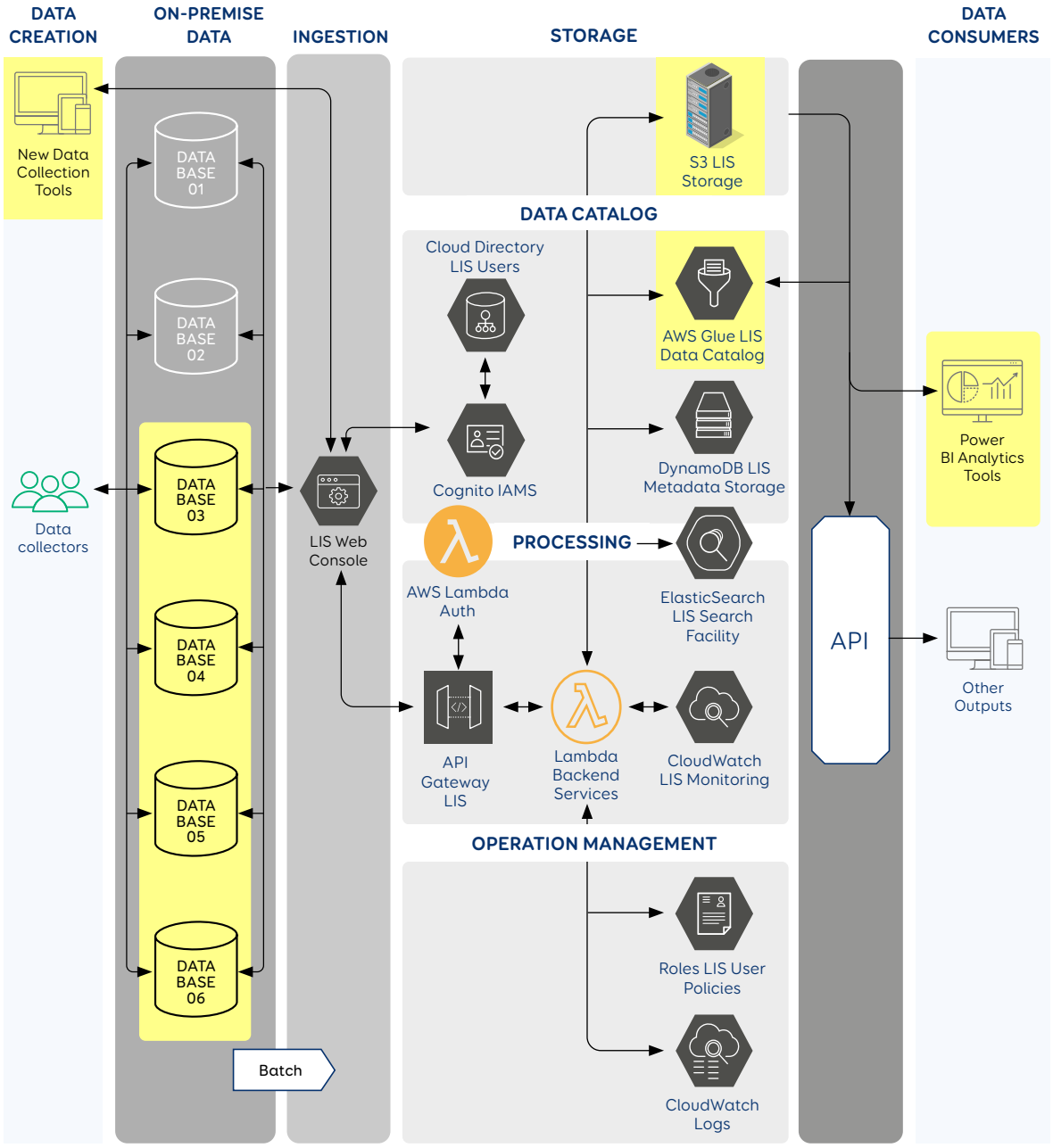


6.1.2.2 Part 2 - Six databases interacting in the Future-LIS

Part 2 will have six of the existing core databases incorporated and will have the same infrastructure as Part 1. Some of the components, such as the S3 Storage and the AWS Glue Data Catalog, will have increased capacity and updated configuration (Figure 21). Potentially Part 2 will also have new data collection tools ingressing data into the system. The increased number of databases linked within the information system will lead to richer data sets for improved analytical modelling, insights and reports. Part 2 of the Future-LIS will be a pure ingestion pipeline that takes data and stores it. Users of this system will need to interact with the system to generate reports, i.e. it will not be triggered by real-time events.

Figure 21. Part 2 of the Future-LIS

Yellow boxes indicate where increased capacity has been implemented.

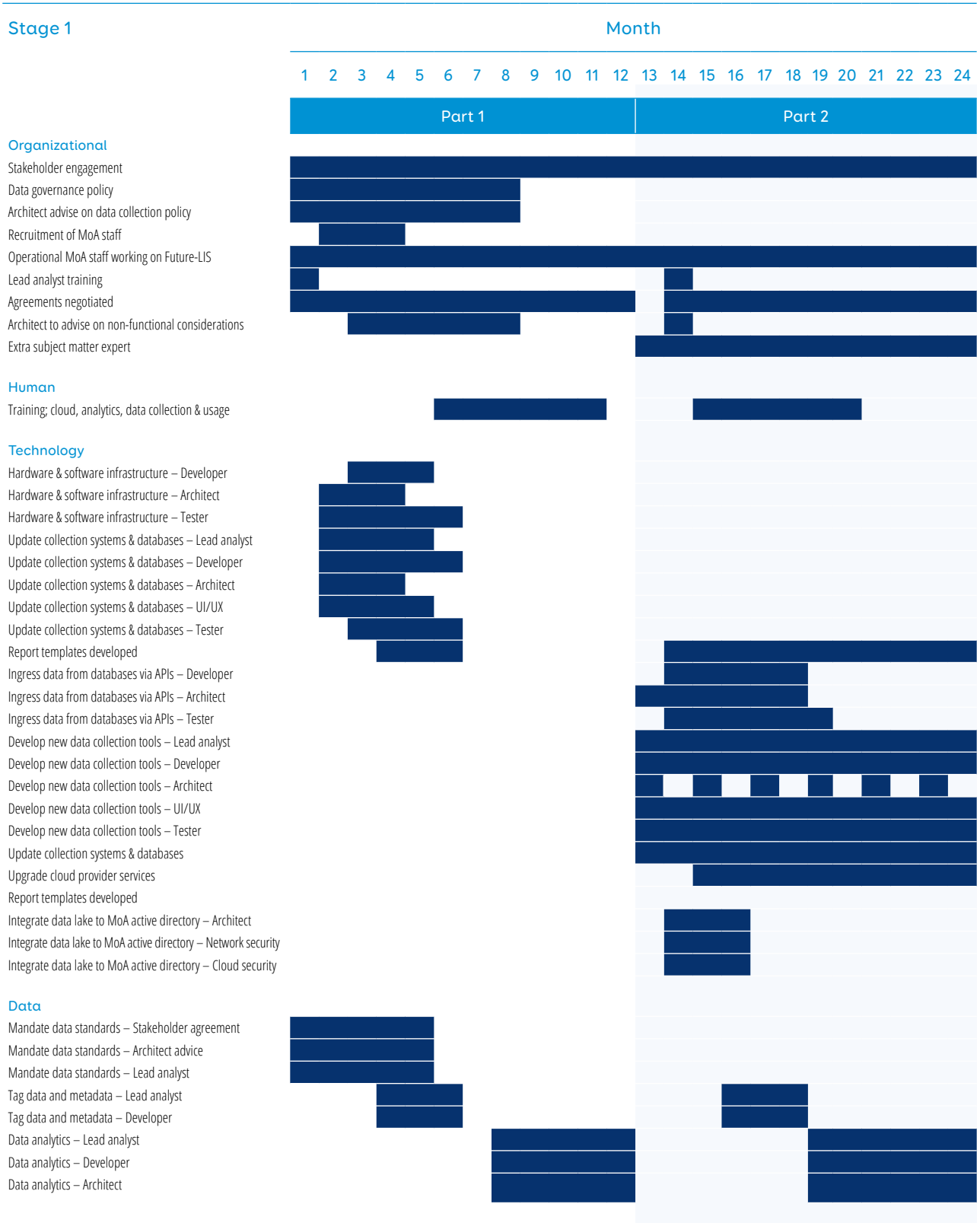


6.1.2.3 Stage 1 costing and timeline

It is anticipated that the implementation of the Future Livestock Information System (Future-LIS) will be led by the Ethiopian Ministry of Agriculture utilizing both ministry staff and external expertise. In year one the technology build will be completed largely internationally with a transition to Ethiopia in year two. This will mean that on completion ministry staff will be familiar with the system and in a position to manage its ongoing development, support and use. The cost of development, implementation, project management and training of MoA staff and data collectors nationally is estimated to be USD 3.725m and is expected to take approximately two years.

A more detailed breakdown of the costs is available on request.

Table 4. Proposed timeline for setting up Stage 1 of the Future-LIS



6.2 Stage 2 - Final stage of the Future-LIS roadmap

As Stage 1 of the Future-LIS becomes increasingly used and embedded into the MoA's operational activities, the data flows will grow and stakeholders will come to rely on the system more for decision-making. Once Stage 1 of the Future-LIS has proven its value, the MoA may need to move to Stage 2 of the Future-LIS development (Figure 22).

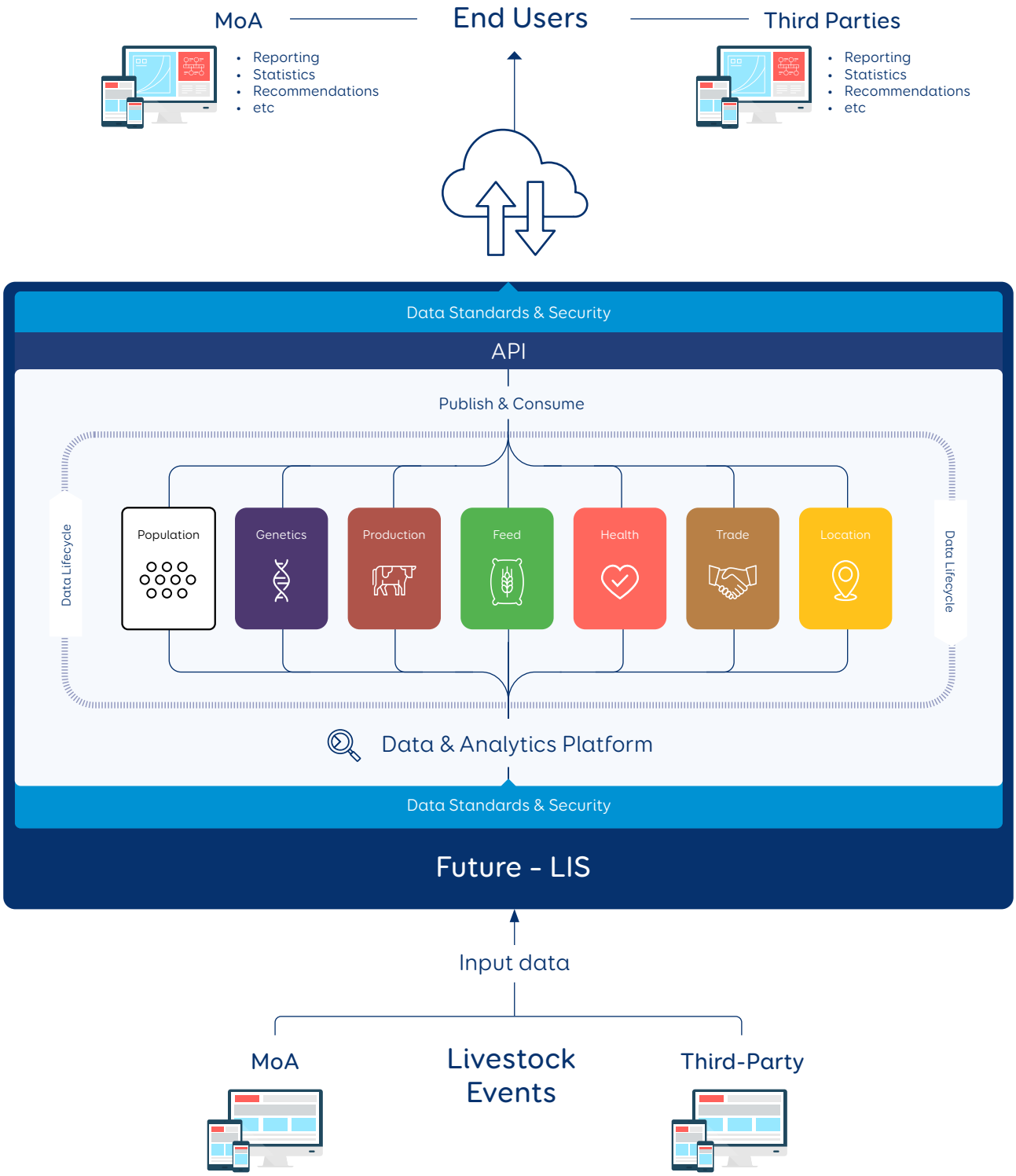
In Stage 2, it is envisaged that the Future-LIS will ingest further MoA and third-party databases depending on the requirements of the growing livestock information ecosystem and the availability of data through open source and other third-party systems. Allowances for this to occur have been taken into account through the architectural design of the system. Stage 2 will also provide an additional level of robustness and functionality to deal with the ongoing high usage. Under Stage 2 there will be a scaling up and use of microservices. Data, systems and processes will be segregated into business services or segments thereby minimizing the performance impact of outages in any single segment.

The Future-LIS incorporates an event bus which consumes and publishes data from each of the segments. From a big data and analytics perspective, this will enable real-time analytics capabilities such as complex event processing (CEP). This allows real-time generation of reports, insights and analytical modelling. It will also notify users of events as data and events are processed throughout the system.

As part of Stage 2, the development of a suite of APIs that expose data to third-party consumers will encourage start-up companies and well-established enterprises to innovate and provide operational solutions for the sector. The development transition from Stage 1 to Stage 2 will also require uplift and configuration of the infrastructure to be significantly upgraded to accommodate the increase in scale.

The costs associated with Stage 2 will be dependent on the speed of adoption of Stage 1 and the increased requirements for decision-making data.

Figure 22. Stage 2 of the Future-LIS



6.3 Action plan to develop the Future-LIS

Roadmap-LIS comprises a series of actions as set out below with additional details provided in Annex 4.

6.3.1 Pre-development tasks

- Establish a Future-LIS Governance Group and a Technical Committee;
- Identify and establish development team;
- Agree on data standards with MoA directorates, other relevant government ministries, institutions, universities and Rural Economic Development and Food Security (REDFS);
- Determine and document minimum service levels (SLAs);
- Establish partnerships with other stakeholder organizations; and
- Engage cloud service provider e.g. AWS.

6.3.2 Stage 1 of the Future-LIS

6.3.2.1 User interface

The user interface is the visual part of an information system through which a user can interact with the system. It determines how commands are given to the computer or the program and how data are displayed on the screen.

- Develop reports user interface (i.e. Future-LIS Web Console and PowerBI components);
- Select Future-LIS data search facility (e.g. AWS ElasticSearch and DynamoDB);
- Select Future-LIS data visualization tooling (e.g. PowerBI);
- Select Future-LIS data capture facility (e.g. Future-LIS Web Console);
- Select Future-LIS data collaboration tooling (e.g. PowerBI); and
- Develop Future-LIS advanced analytical modelling environment (e.g. PowerBI).

6.3.2.2 Technology enabler deliverables

Technology enablers will provide the back end heavy lifting capabilities to drive the Future-LIS data platform and analytics functionality.

- Develop Identity Access Management Security (IAMS) - federated data access;
- Develop Future-LIS data quality management facilities;
- Develop Future-LIS data lake - structured and unstructured data;
- Develop data discovery engine;
- Develop ETL - processing;
- Develop data stream processing engine;
- Develop analytics engine; and
- Develop AI services.

6.3.2.3 Metadata

The metadata layer relates to the metadata management capability which forms the cornerstone component of the Future-LIS data and analytics platform. Metadata management creates the connective relationships that bind everything together, and it is the key component through which all the other components interact with each other. The metadata management capability and tooling interact with all the components of the Future-LIS data and analytics platform. Conceptually, it consists of two tightly-coupled dimensions of metadata - data dictionary tooling and business domain tooling.

- Establish data dictionary tooling; and
- Establish business domain tooling.

6.3.2.4 Implementation tasks

Once the Future-LIS is developed, a number of actions will be launched to ensure that is functional and delivering value to users.

- Perform user acceptance testing and bug identification;
- Appoint Technical Officer to manage the Future-LIS post-development;
- Develop a monitoring and evaluation plan;
- Train subject matter experts on Power BI;
- Schedule regular training by subject matter experts for data consumers on Power BI report generation;
- Conduct regular training and development for cloud provider support and management; and
- Develop manuals for the Future-LIS.

6.3.2.5 Data collection tasks

- Develop and complete data collection applications;
- Conduct training for trainers on data collection tooling across Ethiopia; and
- Conduct training for data collectors across Ethiopia.

ANNEXES

ANNEX 1:

Existing livestock databases in Ethiopia

TABLE 5. DISEASE OUTBREAK VACCINATION REPORTING SYSTEM (DOVAR2)

Profile of database

Profile	Purpose	Scope	Management	Technical Information
YEAR OF INCEPTION: 2019 **CURRENT STATUS:** Functional (partially) **SYSTEM OWNERSHIP:** MoA (Epidemiology Directorate) **SYSTEM DEVELOPED:** By MoA through financial support of FAO **LANGUAGE IN USE:** English **LAST UPGRADE OF THE SYSTEM:** Jul 2019 **PORTAL INFO:** http://196.188.40.68/dovar/Account/Logon?ReturnUrl=%2fdovar	To conduct national passive surveillance through the collection of animal disease outbreak and vaccination data on a monthly basis.	Collection of disease outbreak and vaccination reports from all districts of the country through the 15 Regional Veterinary Laboratories (RVLs). Thus, the system covers the 9 regions (Afar, Amara, Benishangul-Gumuz, Gambella, Harari, Oromia, Somalia, SNNP and Tigray) and the two city administrations (Addis Ababa and Dire Dawa).	The ICT Directorate of MoA manages the technical system administration while the Epidemiology Directorate administers the system from the user perspective. **Roles & Responsibilities:** **The ICT Directorate is responsible for:** · Delivering the infrastructure for housing and personnel for maintaining the DOVAR2 server and website. · Providing hardware maintenance, antivirus updates, modem and network configurations and connectivity. · Providing software maintenance and installation support including upgrades, data maintenance and back-ups. · Providing oversight and feedback for all aspects of quality control for the system and network. **The Epidemiology Directorate is responsible for:** · Compiling, analyzing, interpreting and reporting on a monthly basis any national disease outbreak to key stakeholders. · Training regional personnel on DOVAR2 data collection procedures in collaboration with the regions. · Monitoring the enumerators, supervisors and RVL professionals to ensure data collection is of high quality. · Partnering with relevant stakeholders to maximize the coverage and dissemination of the information.	**Languages:** · C# and JavaScript (SQL Server) database programming languages. **Location of server:** · Data center of ICT Directorate of the MoA. **Structure and data format:** · Five main modules i.e., the data entry and retrieval module, the administration module, the report management module, the laboratory investigation module, and the municipal abattoir module. · Standardized data collection format adopted at the national level. · Reports come with several filtering criteria, and can be imported to formats such as PDF, CSV, Microsoft Excel, etc. **Manuals:** · Data administrative, data administration, and user manuals have been developed for users at Federal and Regional level. · Provide information on the system including steps on how to use the system to collect and report the required data. **Accounts** · Three types of users: Users, administrator, and Epidemiology Directorate administrator. · User accounts are overseen and managed by the ICT administrators. · Functionalities within the system are accessed based on the roles and privileges provided to the user accounts.

ANNEX 1:

TABLE 5. DISEASE OUTBREAK VACCINATION REPORTING SYSTEM (DOVAR2) – Cont

Data input and dissemination

Data Type	Data source	Data Accessibility	Data collection method, format and frequency	Data Compiling System	Data Dissemination Mechanism	Main Data Users and Purpose
For each outbreak: · Disease name and/or serotype of the agent. · Animal species, sex and age group affected. · Number of new outbreaks per month. · Number of cases, deaths & slaughtered per month. · Population at risk. · Number of animals vaccinated. · Geo-reference data. · Date of report. · Date of first clinical case. · Type of farming system (mixed farming, pastoral, dairy, feedlot, ranch). The data content is comprised of both qualitative and quantitative data.	The kebele/woreda-based animal health assistant or veterinarian records detailed information about the occurrence of the outbreak.	DOVAR2 can be opened with all types of operating systems. The web-based application can be accessed via (http://196.188.40.68/dovar/Account/Logon?ReturnUrl=%2fdovar). Data saved in the application can be seen using any major web browser. Once a user account including username and password is created by the system administrator, DOVAR2 can be accessed immediately without any further configuration.	**Format** Based on standard OIE formats which are used nationwide by the animal health services. **Method** Animal health assistants (technicians), veterinarians, Community-based Animal Health Workers (CAHWs), or private practitioners at kebele or woreda level collect the required information and submit the filled hardcopy format to the respective Regional Veterinary Laboratory (RVL). The RVLs then compile and verify the data that comes from woreda or zonal level. Currently, there are 15 regional veterinary laboratories (RVLs) across the country which are responsible for investigating the suspected outbreak reports. Where possible, the RVLs are expected to rapidly confirm a reported outbreak and cross-check laboratory results with the district's report through the recorded reference number. Finally, the RVLs submit the aggregated data of the respective districts, to the Epidemiology Directorate at MoA for further validation and approval. **Frequency** Monthly	The focal person at each RVL compiles the disease occurrence reports which are submitted from districts as an email attachment (excel document) and then submitted to the Epidemiology Directorate of the MoA. The Epidemiology Directorate then compiles all the reports in another excel document.	The Epidemiology Directorate analyzes and interprets the compiled RVL data and generates various types of reports to disseminate to: 1. Regional livestock bureaus, every 6 months via hard or soft copy, so that they can: · Understand the level of reporting from their respective regional laboratories. · Monitor the status of disease outbreaks in their regions. · Execute national mitigation actions to control disease. · Summarize the zonal status and disseminate to each zone. 2. OIE every six months via email as per the requirements. 3. AU-IBAR every month via email.	**Users** Disease Prevention and Control Directorate, MoA. · Quarantine Import Export Inspection and Certification Directorate · Regional livestock bureaus · Zonal livestock departments · OIE · AU-IBAR · NAHDIC **Purpose** To know the national monthly disease status and consequently to take control actions.

ANNEX 1:

TABLE 6. ANIMAL DISEASE NOTIFICATION AND INVESTIGATION SYSTEM (ADNIS)

Profile of database

Profile	Purpose	Scope	Management	Technical Information
YEAR OF INCEPTION: 2016 **CURRENT STATUS:** Functional (partially) **SYSTEM OWNERSHIP:** MoA (Epidemiology Directorate) **SYSTEM DEVELOPED:** By consultants with the source code delivered to MoA **LANGUAGE IN USE:** English **LAST UPGRADE OF THE SYSTEM:** Jul 2019 **PORTAL INFO:** http://197.156.88.141/#/login	To notify disease occurrences from selected sites or villages on a daily basis through capturing and reporting field data. Notification of a case or cluster of disease evokes a rapid response from the responsible actors including control measures and emergency preparedness plans. Absence of disease in a defined group of animals at a given location (e.g. a market, feedlot, quarantine facility, watering point, communal grazing area, ranch, etc) is also monitored – a zero report.	Approximately 900 sites are monitored from Afar, Amhara, Oromia, Somalia, Tigray, Gambella and SNNPR regions. ADNIS covers 21 OIE priority diseases including: Foot and Mouth Disease (FMD), Rinderpest (RP), Contagious Bovine Pleuropneumonia (CBPP), Haemorrhagic Septicaemia (HS), Lumpy Skin Disease (LSD), Rift Valley Fever (RVF), Rabies, Bluetongue (BT), Peste des Petits Ruminants (PPR), Sheep and Goat Pox (SGP), Camel Pox (CP), Newcastle Disease (ND), Highly Pathogenic Avian Influenza (HPAI), Marek's Disease (MD), Infectious Bursal Disease (IBD), African Swine Fever (ASF), African Horse Sickness (AHS), Unknown Camel Disease (UCD), Bovine Spongiform Encephalopathy (BSE) and East Coast Fever (ECF).	ADNIS is managed entirely by the MoA under the Epidemiology and ICT Directorates. Both Directorates have a separate role and technical capacities to implement the system. **The ICT Directorate is responsible for:** - Delivering the infrastructure for housing and personnel for maintaining the ADNIS server and website. – Providing hardware maintenance, antivirus updates, modem and network configurations and connectivity. – Providing software maintenance and installation support including upgrades, data maintenance and back-ups. – Providing oversight and feedback for all aspects of quality control for the system and network. **The Epidemiology Directorate is responsible for:** – Keeping the notifiable disease list current and relevant. – Identifying the list of users to whom an alert should be forwarded and assigning the user account accordingly. -Training regional focal personnel on ADNIS data collection procedures in collaboration with the regions. – Monitoring the enumerators to ensure data collection is of high quality. – Partnering with relevant stakeholders to maximize the coverage and dissemination of the information. – Ensuring that personnel and resources are in place for maintaining the data collection network for the ADNIS.	**Languages:** · JavaScript, Node.js and Angular database programming languages. **Location of server:** · Data center of ICT Directorate of the MoA. **Structure and data format:** · ADNIS uses the Open Data Kit (ODK), a free software or mobile application, for data collection and entry. · Data is transferred to the central server via the GSM mobile network, or when there is no network coverage, data is stored offline until network coverage is resumed. Where network coverage is not available, a Short Message Service (SMS) short code, 6423, can be used to send data. · The system generates reports and visual maps that support geospatial map data indicating where the disease outbreaks occurred. · ADNIS also sends SMS notification to registered users based on disease occurrence. · Reports can be generated in formats such as CSV and Microsoft Excel. **Manuals:** · The system manuals are for Epidemiology Administration and ICT and are used to upgrade the system and resolve technical issues. · The end user's manual supports the field animal health professionals or any data enumerators to capture and submit information about a suspected outbreak of a target disease.

ANNEX 1:

TABLE 6. ANIMAL DISEASE NOTIFICATION AND INVESTIGATION SYSTEM (ADNIS) – Cont

Data input and dissemination

Data Type	Data source	Data Accessibility	Data collection method, format and frequency	Data Compiling System	Data Dissemination Mechanism	Main Data Users and Purpose
Animal health data related to nationally targeted and prioritized diseases at woreda or kebele level. It specifically includes: · Disease. · Number of animals affected. · Species of animals affected. · Clinical signs. · Possible causes. · Mortality and morbidity rate. · Number of vaccinated animals versus susceptible animals. · Location of disease occurrence. · Type of farming system. The data content is comprised of both qualitative and quantitative data.	Villages, kebeles or woredas where the disease outbreak occurred. The outbreak can be reported from various locations including markets, feedlots, quarantine facilities, watering points, communal grazing areas, or ranches.	Users with the requisite permission can log in to the ADNIS site http://197.156.88.141 and request maps, reports and tables for a given disease (amongst the prioritized 21 diseases) including species, timeframe, and location.	**Format** Uses a standardized data collection template that is integrated into the N-Collect component of the system where any suspected outbreak data are captured. This data collection template is installed into the android smartphone of data enumerators for collecting and encoding the data directly to the system. **Method** Field-based participants (woreda veterinarians and animal health assistants, kebele-level animal health technicians, private service providers and their staff) collect, record and submit data using ADNIS N-collect, N-server and N-web components, respectively, when a notifiable disease is suspected. Details of the incident are entered via an ADNIS-dedicated template installed on a smart phone or tablet (N-Collect component) and submitted directly over the ETC network to the ADNIS server for storage (N-server component). After this data analysis, processing and reporting take place on the N-web (N-Web component) to generate the packages of data that are promptly sent to different stakeholders (N-Alert component). The administrator can download notifications and archive for later 'data mining'. When there are no positive cases, a zero report is submitted. **Frequency** Daily	All the incoming disease outbreak data from the kebele or woreda are permanently stored on the N-server component, i.e., the ADNIS server. The daily report of disease occurrence is compiled as an excel document by the Epidemiology Directorate.	The Epidemiology Directorate generates summary reports to disseminate to: 1. Regional livestock bureaus – Daily disease outbreak alerts to the respective bureaus through text message so that the bureaus can deal with any outbreak. – Weekly disease outbreak summary. – Monthly summary including the spatial distribution of the outbreak so that they can understand the status and location of the issue and take part in any national mitigation measures. 2. FAO weekly summary of disease outbreaks as per the requirements.	**Users** · Disease Prevention and Control Directorate, MoA. · Quarantine Import Export Inspection and Certification Directorate · Regional livestock bureaus · Zonal livestock departments · OIE · AU-IBAR · NAHDIC **Purpose** To get information on the occurrence of the prioritized diseases to facilitate immediate actions for control.

ANNEX 1:

TABLE 7. LABORATORY INFORMATION MANAGEMENT SYSTEM OR SILAB FOR AFRICA (SILABFA)

Profile of database

Profile	Purpose	Scope	Management	Technical Information
YEAR OF INCEPTION: 2017 **CURRENT STATUS:** Functional. Started implementing since January 2019 **SYSTEM OWNERSHIP:** NAHDIC **SYSTEM DEVELOPED:** By Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise (IZSAM), Italian company for the Veterinary Laboratories of the African Countries **LANGUAGE IN USE:** English **LAST UPGRADE OF THE SYSTEM:** 2020 **PORTAL INFO:** Not available	The system is designed to enable management and organization of laboratory data and allows users to retrieve, analyze, and generate a timely report that enables decision makers to give timely, informed decisions. The system automates and makes traceable every laboratory process starting from sample reception until test result reporting. The system helps to improve the laboratory operational efficiency and increases the responsiveness of laboratories towards the requirements of their customers. Animal health data are stored in SILABFA which makes investigations operationally efficient to execute. SILABFA could potentially be integrated with regional laboratories of other countries.	To date, training sessions have been provided to four regional labs Asela, Kombolcha, Semera and Hirna, to link them with the SILABFA database. SILABFA can be connected to the livestock traceability systems in use in the national veterinary services. Currently, NAHDIC is integrating this system with ADNIS using the AIP interface.	Managed by the ICT and laboratory system management experts. **The ICT department is responsible for:** · Providing hardware maintenance, antivirus updates, daily back-ups, modem and network configurations, connectivity and end user support. **The Epidemiology unit is responsible for:** · Receiving and registering information on the samples in the database. After the samples are registered, access to the information is only given to Analysts/Signatories working in each respective testing section. The Analysts/ Signatories /Lab Technologists analyze the data and register the results in the database. The Head and Deputy Head of the testing sections check each test result entry and approve the result of each sample or group sample.	**Language:** · Oracle 11g database language, an open-source software and freeware only. · Apache Tomcat web server using Java 2 Enterprise Edition (J2EE) technology platform. · The Relational Database Management System (RDBMS) used is Oracle 10g Express. This free source product requires a server with a CPU, 1 Gb of RAM and 4 Gb hard disk. **Location of server:** · Hosted on a local server at NAHDIC. · Structure and data format: Web application accessible via any computer connected to LAN or the Internet. · Web application is code oriented i.e. internal codifications used are linked to descriptions. All codes and relevant descriptions are entered into domain tables; for example, all species of interest are codified so that in the data tables only codes are reported, while in domain tables, codes are linked to the relevant description and additional information. · Access is subject to user authentication by username and password. Security developments almost complete and implementation of encrypted passwords, a firewall and the 3A and CIA model is underway. · Reports are generated with Jasper Report, an open-source reporting tool enabling writing, display, and printing to a printer and to PDF, HTML, Microsoft Excel, RTF, ODT, CSV and XML file. **Manuals:** · A technical user manual and SILABFA's inventory module have been developed.

ANNEX 1:

TABLE 7. LABORATORY INFORMATION MANAGEMENT SYSTEM OR SILAB FOR AFRICA (SILABFA) – Cont

Data input and dissemination

Data Type	Data source	Data Accessibility	Data collection method, format and frequency	Data Compiling System	Data Dissemination Mechanism	Main Data Users and Purpose
Data related to veterinary laboratory information, such as: · Type of sample (serum/ blood, meat, milk, etc.). · Origin of sample (location). Animal breed, age, sex, etc. · Disease · Lab tests conducted. · Lab results. If the case is linked to an outbreak, the system may also collect: · Number of diseased animals. · Deaths or slaughters. · Number of humans infected. The data are collected in the quantitative and qualitative format.	There is a wide range of parties that require lab tests, such as: · Universities · Regional labs · Government · NGOs · International institutions. NAHDIC also directly collects field data for active surveillance at the national level.	The system provides laboratory investigation data for all authenticated users with username and password. The level of access is controlled by the system administrator. The data can be available in excel, PDF and CSV format. Laboratory test findings for specific clients are sent via email, fax or by direct collection of a printout at the NAHDIC office.	**Format:** Data from various sources are checked and verified by labs experts to ensure the data quality meets the NAHDIC data collection standard. There is a standardized data collection format for the planned active surveillance. **Method:** Samples are collected and submitted to NAHDIC for laboratory diagnosis by various institutions. NAHDIC also directly collects data from different regions using different standardized data collection formats based on disease of interest. **Frequency:** Daily, weekly, monthly, and annual frequency depending on the type of samples submitted and the nature of the lab analysis. Data collection is tightly linked to sample submission. For disease outbreak investigations, the frequency of data collection varies with the requests from different regional laboratories or regional bureaus or federal offices as well.	The initial data is collected in hardcopy format which is kept at the sample reception of the laboratory. After samples are tested, the results are validated and entered into the system by the Head or Deputy Head of the testing section. Finally, the test reports are sent to the client of NAHDIC as per their request of delivery. These data are stored in the system making it is possible to trace or retrieve the data at any time.	The data are disseminated through the website portal for specifically designated users who are given access to use the system. The system is easy to administer as every lab is independent of others, has its own data content administrator (not necessary an ICT person). Every database table can be modified by the administrator (e.g. it is possible to add a new test or method, or species). For other clients of NAHDIC (Regional labs, universities, etc.) the data are disseminated through email, Fax, or hard copy format.	**Users:** · NAHDIC (laboratory staff, Head of Department, administrators, epidemiologists, and vets). – Universities – Regional labs – Government – NGOs **Purpose:** · Improve the veterinary laboratory investigation and reporting system. · Improve laboratory data management and organization. · Facilitate decision-making. – Research

ANNEX 1:

TABLE 8. ETHIOPIAN LIVESTOCK IDENTIFICATION AND TRACEABILITY SYSTEM (ET-LITS)

Profile of database

Profile

YEAR OF INCEPTION:
2015

CURRENT STATUS:
Not functional. Currently it's under preparation for piloting the system across selected livestock value chains

SYSTEM OWNERSHIP:
MoA

SYSTEM DEVELOPED:
By Unternehmensberatung (GmbH) and ADT Project GmbH with funding support from USAID

LANGUAGE IN USE:
English

LAST UPGRADE OF THE SYSTEM:
2017

PORTAL INFO:
http://197.156.117.172/ or www.etlits.gov.et

Purpose

ET-LITS uses ear tags to record information on animal registration, treatments, vaccine details and issued movement documents. Animals are traced from their origins through to the livestock markets, holding grounds, feedlots and abattoirs. Information is collected until the animal is exported live or slaughtered.

Overall, the aim of ET-LITS is to provide reliable identification and traceability information to meet international meat and live animal export industry requirements (OIE standards). This trustworthy traceability system supports the export sector of the economy and increases market access.

ET-LITS also assists with risk mitigation by tracking back previous and current incidents.

Identification and traceability of livestock is expected to improve cattle management and productivity, and enhance meat quality.

Scope

The Livestock Identitfication and Traceability (LIT) Directorate scope of work extends from primary markets to border posts for live animals and international airports for meat.

There are five pathways for livestock:
1. Primary markets – feedlots – quarantine – export
2. Primary markets – abattoir – export
3. Secondary markets – quarantine – export
4. Primary markets – feedlots – abattoir – export
5. Secondary markets – abattoir – export.

The border posts are Togo wochale (Berbera port) at Somaliland and Galafi port at Djibouti.

The pilot phase of ET-LITS covers the pastoralist and mixed crop-livestock production systems. These areas include Borena pastoral areas (Guji/Bale), representing the pastoralist production system, and Abergele market shades, representing the mixed crop-livestock production system.

There are six markets identified as a pilot area including Yavelo (Haro Bake), Elwoya, Dublek (Mega), Moyale (Oromia and Somalia), Negele Borena, Genir (Melka Oda). There are epidemiological units or woredas that are found approximately 150-300km away that are supporting these markets.

Management

The ET-LITS is managed entirely by the MoA under the LIT Directorate with support from the ICT Directorate.

The ICT Directorate is responsible for:
– System administration including the provision of hardware maintenance, antivirus updates, modem and network configurations, connectivity and back-ups.

The system is not fully managed by ICT Directorate so there are some gaps in delivering tasks.

The LIT Directorate is responsible for:
- Leading the management of the ET-LITS system.
- Developing the required legal frameworks to enrol the system.
- Allowing other stakeholders along the value chain to build the required capacity to run the day-to-day tagging and recording of movements of animals.
- Validating the data entered by stakeholders into the system.

Technical Information

Languages:
- PostgreSQL, an open-source object-relational database system. The DBMS MySQL is used as persistence for the ActiveVOS BPM Engine, since ActiveVOS is not certified for PostgreSQL DBMS.
- Web-based system designed to run on any web browser, with Firefox being recommended.

Location of server:
- Data center of ICT Directorate of the MoA.
  Data storage was designed to be linked with cloud 9.

Structure and data format:
- Administrative unit (ET-LITS Unit and regional office) grants user access to the web interface by providing username (email address) and password.
- The system provides an Administrative account to manage user accounts.
- Functionalities within the system are accessed based on the roles and privileges provided to the user accounts.
- Activities are logged in the system alongside username and timestamp.
- OIE, importing countries, feedlot owners and abattoirs can access data in the system.
- Business Intelligence and Reporting Tool (BIRT) is used to generate customized and interactive reports with parameterization, graphic and conditional display.
  – Data can be exported in XLS, PDF, CSV, Image, Power Point, Word etc formats.

Manuals:
User manual for data administrators covering the system's functional and non-functional requirements.

- User manual for database administrators covering technical implementation, troubleshooting, upgrading of data content and how to use/run the system.
- Manual used to train end users on how to use the system in data collection and reporting.

ANNEX 1:

TABLE 8. ETHIOPIAN LIVESTOCK IDENTIFICATION AND TRACEABILITY SYSTEM (ET-LITS) – Cont

Data input and dissemination

Data Type	Data source	Data Accessibility	Data collection method, format and frequency	Data Compiling System	Data Dissemination Mechanism	Main Data Users and Purpose
Animal data including: · Animal identification. · Movement records. · Health status of the animal and animal products destined for export. · Ear tag registration. · Location information for primary and secondary markets. · Vaccination history. · Laboratory test results. · Ante- and post-mortem findings. · Animal owner or seller information. The data content incorporates both qualitative and quantitative data.	Government and private institutions such as the quarantine facilities, export inspection facilities, export abattoirs, Adama livestock quarantine station office, Bole quarantine inspection center, Regional quarantine stations, primary livestock markets, NAHDIC & NVI.	Can be accessed by the web application http://www.etlits.gov.et	**Format:** There are 20 standardized data collection formats adopted across piloting areas, some of which are generated from the system. Ten Standard Operating Procedures (SOPs) were developed for generating organized data on-line by all services or main stakeholders that provide the data into the database. **Method:** All beef cattle intended for export are identified at the primary market. To achieve this, feedlot operators, export abattoirs and pre-quarantine operators tag cattle they have purchased with two ear tags bearing the same unique animal identification number. The animal data are captured on the Animal Movement Permit form at the holding ground. For each animal, ID, age, sex (default male), breed (default Boran) and the ID of the seller are recorded on a hardcopy format. Once the animals are at the feedlot/abattoir/pre-quarantine, the animal data are entered into the database via the web application. The system saves the animal data as registered on the holding ground and then generates a move-off from the holding ground and a move-on to the compound. If an animal is rejected from entering the compound due to health problems, the operator enters a move-off of the animal out of the system. With this, the animal leaves the scope of the ET-LITS. Vets placed along the value chain submit data of tagged cattle to the ET-LITS database electronically. **Frequency:** Varies depending on the frequency and volume of export of livestock.	LIT Directorate takes the lead to verify and compile the data that are entered into the system. The directorate uses the SOPs format to monitor the data entered into the system. The data quality control and assurance are undertaken using these operating procedures to verify the data quality and reliability.	The data are disseminated through the website portal for specifically designated users who are given access to use the system. These are: · Quarantine IEICD · Export Abattoir ICD · Epidemiology Directorate · Disease Prevention and Control Directorate · Regional veterinary offices · Livestock Marketing and Promotion Directorate · Quarantine Offices · Woreda trade office · Internal check points	**Users** · Livestock producers (pastoralists) · Live animal traders both domestic and exporter · Abattoirs · Quarantine facilities · Quarantine IEICD · Export Abattoir ICD · Epidemiology Directorate · Disease Prevention and Control Directorate · Regional veterinary offices · Livestock Marketing and Promotion Directorate · Quarantine offices · Woreda trade office · Internal check points

ANNEX 1:

TABLE 9. NATIONAL LIVESTOCK MARKET INFORMATION SYSTEM (NLMIS)

Profile of database

Profile	Purpose	Scope	Management	Technical Information
YEAR OF INCEPTION: 2005 **CURRENT STATUS:** Functional **SYSTEM OWNERSHIP:** MoTIn **SYSTEM DEVELOPED:** By Texas A&M University **LANGUAGE IN USE:** English **LAST UPGRADE OF THE SYSTEM:** 2019 **PORTAL INFO:** www.lmiset.gov.et	NLMIS provides real-time livestock price and volume information on livestock and animal products from across selected markets throughout Ethiopia. This information helps different stakeholders, particularly pastoralists, traders, government agencies and non-governmental organizations, to make informed and timely decisions. The rapid transfer of digital data using the system improves market opportunities, reduces risk, and expands the analytical, reporting, and geographical relevance of the data.	The system collates the market data from 55 major livestock market centers across the 6 regions (Afar, Somalia, Oromia, SNNP, Amara and Tigray) and two city administrations (Addis Ababa and Dire Dawa). The system has the capacity to include more market spots as required. NLMIS mainly incorporates data on major livestock types i.e., cattle, camel, sheep and goats and animal products such as meat, milk, skin and hide, and their real-time prices. Additional types of livestock can also be incorporated into the system.	Managed by the MoA and MoTIn. The Market Research and Promotion and ICT Directorates have a separate role and technical capacities to implement the NLMIS. **The ICT Directorate is responsible for:** · Delivering the infrastructure for housing and personnel for maintaining the NLMIS server and website. · Providing hardware maintenance, antivirus updates, modem and network configurations and connectivity. · Providing software maintenance and installation support including upgrades, data maintenance and back-ups. · Providing oversight and feedback for all aspects of quality control for the system and network. **The Market Research and Promotion Directorate is responsible for:** · Training of Market Monitors and regional personnel on NLMIS data collection procedures in collaboration with the regions. · Examining NLMIS data for anomalies, erroneous SMS and data errors. · Correcting errors and keeping logs of changes made to data in the database server. · Adding markets, deactivating, and assigning users. · Monitoring the enumerators and supervisors to ensure data collection is of high quality. · Partnering with relevant stakeholders and using all national media channels to maximize the coverage and dissemination of the livestock price and volume data. · Ensuring that personnel and resources are in place for maintaining the data collection network for the NLMIS. · Raising awareness of the system.	**Languages:** · NET platform, which is an open-source Apache Tomcat platform. · Apache Tomcat is an open-source software implementation of the Java Servlet and JavaServer Pages technologies that allow cross platform (Windows, Linux, Unix) implementations. · Web-based system run on the Windows platform requiring the Java Runtime Environment (JRE) and Tomcat to be installed. · Uses POSTGRES Database server (version 8.0 or higher) as backend database. **Location of server:** · Data center of ICT Directorate of the MoA. **Structure and data format:** · Web-based enabled system allows users to access the data online and perform rapid assessment and time series analysis. · Latest system is integrated with Google Maps, with enhanced functions added to improve graphing and produce interactive graphs. · Other features included i.e., volume mapping of transactions, and a picture gallery of animals. **Manuals:** · Three system technical manuals developed for data administrators, database administrators and users. · Manuals developed to support data content development, updating the system and providing information on how to use and run the system.

ANNEX 1:

TABLE 9. NATIONAL LIVESTOCK MARKET INFORMATION SYSTEM (NLMIS) – Cont

Data input and dissemination

Data Type	Data source	Data Accessibility	Data collection method, format and frequency	Data Compiling System	Data Dissemination Mechanism	Main Data Users and Purpose
Data related to live animal and animal products markets: · Livestock type and breed · Age · Sex · Grade · Market prices Animals monitored include: · Cattle · Camels · Goats · Sheep · Donkeys Animal products include: · Milk · Meat · Hides · Honey The data is collected is both quantitative and qualitative.	From the primary and secondary livestock markets. Currently, 47 major livestock market centers from 6 regions and two city administrations provide data into NLMIS. Market centers were chosen based on the volume of animals supplied and relevance to domestic and export markets.	**SMS** The price and volume information for specific markets can be accessed by SMS through using an abbreviated set of codes. **Internet** A market information portal (http://www.lmiset.gov.et) allows the public and any designated users to view trends in market data over time. It also supports the downloading of data into excel, PDF and CSV formats. **Reports** Reports can be generated for different markets and products as per the required region, animal type and product and timeframe.	**Format:** There is a national standardized data collection format for livestock and livestock products. The data enumerators and supervisors are trained on how to use the format. **Method:** Data are collected by enumerators stationed in each of the 47 regional livestock markets. When a sale or purchase is made, the trader and/or buyer is interviewed on the livestock price through a standardized data collection format in hardcopy. Five separate prices are aggregated by animal type, breed, age, sex, and grade, and then they are averaged. If five animals are not available, mixed class designations are used. Volume data are determined by the number of animals supplied to the markets. Livestock products such as meat, milk, skin and hide are collected from the respective markets. SMS methodology is used to enter the livestock data using coding schemes. **Frequency:** Weekly for livestock, and usually during the peak-time of the market day. Actual reporting dates vary from market to market due to local market variation or supervisor/ enumerator preference. Bi-weekly for livestock products.	The collected data are submitted to the server using SMS, email and, on the web-portal. The data is compiled at MoTIn in the form of monthly market bulletins.	Dissemination of data occurs through communication channels such as: · SMS · Radio · Bulletins · Website · Phone · Email subscription · Television broadcasts The information has been disseminated in several different languages to reach the end-users, particularly those in pastoral communities (Amharic, Somali, Afan Oromifa).	**Users:** There is a wide range of users, including: · Pastoralists · Middlemen · Buyers/traders · Exporters · Abattoirs and feedlots · Research institutes · Universities · Government · NGOs **Purpose:** To allow informed market decision-making for all parties when buying or selling live animal or animal products in different markets. The data provide insights for buyers to decide where to sell, how to price their goods, whether to sell now or wait later. Policy makers can monitor the trend of the livestock market prices to make informed decisions around developing plans and strategies related to the livestock sector. Governments can also use the data as an early warning to respond to any disasters (drought, flood, etc.).

ANNEX 1:

TABLE 10. LUKE
Profile of database

Profile	Purpose	Scope	Management	Technical Information
YEAR OF INCEPTION: 2012 **CURRENT STATUS:** Not functional **SYSTEM OWNERSHIP:** NAGII / MoA **SYSTEM DEVELOPED:** By ProAgria-Finland **LANGUAGE IN USE:** English **LAST UPGRADE OF THE SYSTEM:** 2015 **PORTAL INFO:** Not available: The database runs internally within the firewall.	To identify animals with superior germplasm and enable selection of bulls that have the best performance. Well-managed data and analytics are very important for bull selection, development of policies and strategy, research projects, etc and will play an enormous role in the livestock resource development in Ethiopia. The information will be used to deliver advisory services or feedback for farms to improve their cattle or herd management practices. The goal of the system is to improve the genetic potential of the dairy population to achieve a sustainable increase in milk production and increase the economic efficiency of a dairy production system.	The LUKE database contains herd performance records in a well-organized central system. The information is collected from smallholder dairy farms, state farms, and commercial dairy farms found across Addis Ababa, Oromia, Amhara, and Tigray regions. The LUKE database incorporates an animal identification system that monitors information on region, breed, sex and herd with assigned traceability numbers.	**The NAGII ICT Directorate is responsible for:** · Managing the database. · Providing hardware maintenance, antivirus updates and network configurations. · Providing infrastructure for housing the server. · Providing oversight and feedback for all aspects of quality control for the system.	**Languages:** · MySQL and PHP platforms (open-source software) **Location of server:** · Hosted in the NAGII. **Structure and data format:** · The interface design for data entry into LUKE is a web-based system that can be accessed locally or directly from the server or remotely from client computers that are connected in the network. · The system uses the English language for data collection and dissemination. · The data are exported in XLS and CSV formats. · Users can register and access the data within a firewall, but the system is not accessible outside of the firewall. **Manuals:** · A technical manual exists that enables the ICT team to provide backstopping to run the system.

ANNEX 1:

TABLE 10. LUKE – Cont

Data input and dissemination

Data Type	Data source	Data Accessibility	Data collection method, format and frequency	Data Compiling System	Data Dissemination Mechanism	Main Data Users and Purpose
Livestock performance data such as: · Pedigree and breed · Production · Reproductive performance · Health · Herd · Farm location (GPS). · Genotype data. Individual cow performance data includes: · Milk yield. · Reproductive data such as services and pregnancy diagnosis. · Calving data. · Health records. · Monthly growth data. · Culling date and reason. The data are collected in the quantitative and qualitative format.	Smallholder dairy farms, state farms and commercial dairy farms. Data are sourced from Oromia, Amhara, and Tigray regions and Addis Ababa.	Data are only accessible for designated users at NAGII within the institution compound. Other users such as farmers or traders will get the result of the data in hardcopy feedback report format.	**Format:** A standardized data collection format, known as the Cow Card, has been developed and adopted nationally to collect the required dairy performance records. **Method:** The herd performance data are collected in hardcopy format by enumerators from each dairy farm. The collected data are entered into the system by data encoders at NAGII. **Frequency:** Typically 4-weekly.	The initial data are collected in hardcopy format. Data are compiled into the system by encoders.	In the past, LUKE data was disseminated via quarterly and yearly reports to inform users. LUKE has been absorbed into the ADGG database. This database disseminates information via reports, email and short message service (SMS) to registered dairy farms. The ADGG database also provides feedback including dairy management practices via SMS.	**Users:** · Commercial dairy farms · Researchers · Government experts · NGOs including ILRI. **Purpose**: · National herd performance recording for genetic improvement. · Breed selection. · Ranking best animals. · Data for extension advisory on dairy management. · Undertaking supervision and monitoring. · Developing policy and strategy related to cattle breeding.

ANNEX 1:

TABLE 11. DTREO (FORMERLY KNOWN AS ANICLOUD)

Profile of database

Profile	Purpose	Scope	Management	Technical Information
YEAR OF INCEPTION: 2019 **CURRENT STATUS:** Functional **SYSTEM OWNERSHIP:** ICARDA and AbacusBio **SYSTEM DEVELOPED:** ICARDA in collaboration with AbacusBio **LANGUAGE IN USE:** English and Amharic **LAST UPGRADE OF THE SYSTEM:** **PORTAL INFO:**	To enhance data capture, analysis, and feedback system in small ruminant breeding programs.	National database system which helps to run and enhance small ruminant community-based breeding programs sustainably.	Managed by ICARDA although AniCloud may get transferred to the NAGII in the future. **The ICARDA is responsible for:** · Facilitating data capture, storage, analysis and feedback of the system. Scientists at ICARDA and researchers at respective research centers carry out data management, analysis, and interpretation. The AbacusBio team are responsible for technical management of the system in collaboration with ICARDA.	**Language:** **Location:** · Hosted in New Zealand. **Structure and data format** · Data can be export to CSV, XLS, PDF. · The end user can create an account to access the data. **Manuals** · The system has a small video guide available online.

ANNEX 1:

TABLE 11. DTREO (FORMERLY KNOWN AS ANICLOUD) – Cont

Data input and dissemination

Data Type	Data source	Data Accessibility	Data collection method, format and frequency	Data Compiling System	Data Dissemination Mechanism	Main Data Users and Purpose
Data on livestock performance, such as: · Birth weight. · Weaning weight. · Six month weight. · Yearling weight. · Milk yield. · Disposal (death or sale). · Pedigree. · Location and household. The data are collected mostly in the quantitative format.	Farmers that are participating in the breeding program.	The cloud has a platform to create reports and access the data for further analysis. Researchers access the data, do analysis, and send feedback to the community for decision-making purposes.	**Format:** Has standard format across regions. **Method:** Data (pedigree and performance) are collected by enumerators that have been recruited for each village. The enumerators use a smartphone/tablet to collect the data which are then submitted when an internet connection is available. Researchers validate the data before sending them to the cloud where they are stored. **Frequency:** Daily	Compiled online i.e., the data collected by enumerators are finally checked, approved, and stored on the cloud by researchers.	Summarized reports can be accessed by anyone from the dashboard. Data are owned by the farmer and can only be accessed for research purposes on request.	**Users** National research centers and institutions such as NAGII. **Purpose** For animal ranking/ selection decisions and research purposes.

ANNEX 2:

MoA directorates and affiliated organizations

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES

Institution	Mandate	Activities	Database and Status	Institutional Data Need	Reporting System	Mandate Overlap
Epidemiology Directorate	Undertake risk analysis and active and passive surveillance.	**Conduct** socio-economic studies on notifiable animal diseases to determine their impacts. **Undertake** qualitative risk analysis, hazard identification, exposure assessment, risk estimation and setting mitigation measures. **Coordinate** passive surveillance. **Prepare** the summary of disease occurrence and provide regular feedback to regional livestock bureaus and to international organizations such as OIE and AU-IBAR. **Design** disease control and prevention mechanisms. **Deliver** capacity building training on DOVAR2 and ADNIS systems and on risk analysis for regional experts.	**DOVAR2:** Functional but not comprehensive as it is limited to field disease status. **ADNIS:** Functional but the notification is not limited to disease outbreak area.	Abattoir data: – anti-mortem & post-mortem findings – detailed data on the major causes of carcass condemnation and rejection rate Universities, research institutes and animal clinics, data: – research priority thematic areas – research findings / outputs/ on disease occurrences Private commercial farms data: – farm purpose, location, sources of animal, markets, disease occurrence – livestock population by species, breed	**DOVAR2:** Weekly, monthly, and quarterly report to Livestock State Minister. **ADNIS:** Report to OIE twice a year and for AU-IBAR monthly.	There is no solid coordination and collaboration between the Epidemiology Directorate and NAHDIC resulting in no regular information flow from NAHDIC to the directorate about the active surveillance and from the directorate to NAHDIC regarding the passive surveillance. The directorate rarely undertakes planned active epidemiological surveillance activities to determine the disease status in different parts of the country.

ANNEX 2:

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES – Cont

Institution	Mandate	Activities	Database and Status	Institutional Data Need	Reporting System	Mandate Overlap
Livestock Identification and Traceability Directorate	Establish and implement a robust, dependable, and comprehensive livestock identification and traceability system that enables disease surveillance and prevention, maintains food safety standards and strengthens the export market.	**Identify and register** individual animals (individual identifier) or epidemiological units or groups of animals (group identifier). Each identifier has ET country code as prefix, followed by one to nine digits. **Pilot** livestock identification and traceability system (ET-LITS) across the proposed two production systems: Borena pastoral area (six markets selected – Haro Bake, Dubeluke, Mega, etc.) and crop-livestock mixed farming area (Abergele market shade). **Provide** ET-LITS information as required for tracing diseases. **Prepare** different guiding documents such as the ET-LITS legal framework, training manuals, Standard Operating Procedures (SOPs), animal health and welfare proclamation, etc. **Deliver** training on database application and tagging for the stakeholders that are intended to use ET-LITS (producers, traders, feedlot owners, abattoirs, and vets).	**ET-LITS:** Customized and ready to be implemented focusing on cattle initially.	Data on exported animals including breed, age, sex, origin, route, destination, animal movement data, tag status Data on health status of the animals found in each district, zone and region including any type of disease, number of vaccinated and treated animals, number of slaughtered animals at each abattoir Requirements of destination countries with regular and timely updates Geographical information of primary markets, feedlots, veterinary clinics, export abattoirs, laboratories, quarantine facilities and border posts, etc.	**Weekly report** to the State Minister – via email **Monthly report** upon request **Quarterly, six month and annua**l reports for the State Minister and PPMED.	None

ANNEX 2:

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES – Cont

Institution	Mandate	Activities	Database and Status	Institutional Data Need	Reporting System	Mandate Overlap
Quarantine, Import Export Inspection and Certification Directorate	Regulate the import and export of live animals, animal products and samples for researchers to meet international standards. Also responsible for regulating the construction of quarantine centers and animal health posts, preparing and implementing the residue monitoring plan and developing policies and strategies.	**Regulate** feedlots and quarantine stations. This includes inspecting the quality and health status of live animals and their products. Currently, private feedlots are mainly serving as quarantine station. **Provide** sanitary certification for different livestock commodities and samples in line with the guidelines. The Ethiopian Biodiversity Institute gives genetic certification prior to sanitary certification by this directorate. For non-EU countries, animal product certification is issued by the Ethiopian Conformity Assessment Enterprise, **Give** import permit for imported livestock commodities, based on the findings of risk analysis by the Epidemiology Directorate.	None	List of export and import commodities. **Feedlot data:** · Number of feedlots, capacity of each. · Number, type and origin of animals entering each feedlot, duration of stay and tally of animals each day, week, month and/or year. · Medication and vaccination history of animals and information related to disease situations at the areas of their origins. **Abattoir data:** Ante-mortem and post-mortem findings of the animals for export.	**Weekly** communication with quarantine stations and offices. **Monthly, bi-annual, and quarterly** report to the State Minister.	The import of all types of food items (including food of animal origin) are being inspected by the Food and Drug Authority, but there is doubt surrounding the robustness of this process.

ANNEX 2:

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES – Cont

Institution	Mandate	Activities	Database and Status	Institutional Data Need	Reporting System	Mandate Overlap
Disease Prevention and Control Directorate	Prevent and control diseases prioritized by OIE. Efforts are mainly focused on trans-boundary animal diseases (TADs) at the national and regional level, although some non-TADs are considered. Prepare prevention and control strategy for the identified diseases and also develop long- and short-term national animal health action plans to guide disease prevention and control measures.	**Identifies & prioritizes** animal diseases using international standards & local assessment based on the information from the Epidemiology Directorate (DOVAR2 & ADNIS). **Collaborates** with the respective regions by taking immediate mitigation measures to control disease outbreaks through mapping of the disease's occurrence. It also closely works with NVI and the regions discuss supply and utilization of vaccines. The Directorate coordinates the payment for vaccines against list A diseases while any other vaccine costs are handled directly by the regions. **Follows-up** whether the international and continental disease control and prevention agreements are being implemented nationally. **Works toward** reducing the number of disease outbreaks and minimizing young stock mortality through increasing the veterinary service coverage and particularly via supporting the para-professional service providers and Community-based Animal Health Workers (CAHWs). **Prepares** disease prevention and control manuals and guidelines for the identified diseases and implements risk-based disease prevention and control measures at federal and regional level.	None but use DOVAR2 and ADNIS.	Veterinary vaccine and drug supply and utilization. Regional vaccine demand on regular basis. **Data on disease outbreaks:** · Type of disease, location and coverage of outbreak. · Number of animals affected and at risk. · Mitigation measures taken.	**Quarterly reports** sent from regions and submitted to the State Minister.	There is considerable overlap in the mandate and activities carried out by Epidemiology and Disease Prevention and Control Directorates.

ANNEX 2:

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES – Cont

Institution	Mandate	Activities	Database and Status	Institutional Data Need	Reporting System	Mandate Overlap
Veterinary Public Health Directorate	Prevent and control zoonotic diseases. Regulate safety and hygiene of food items including animal products. Establish One Health platform with the respective human health institutions starting from federal and cascading its implementation to regional level. Build capacity for veterinary public health workers across regions.	**Develop** disease specific strategies, guidelines, and standard operating procedures (SOPs) for various diseases, especially those having zoonotic importance such as rabies and anthrax. **Create** public awareness on different aspects of zoonotic diseases and food safety consequences by disseminating information through print media, TV, radio, and physical campaigns at schools. **Conduct** practical activities such as vaccination campaigns for rabies in different areas. **Support** regions on zoonotic disease prevention and control activities and the dangers of food safety related complications. Also, support the implementation of strategies and guidelines through refresher trainings for regional animal health experts on different topics. **Design and establish** standard domestic abattoir designs (A, B, C, D level) in collaboration with other different stakeholders, and monitor proper implementation of the abattoirs at regions and cities administrative. **Work** on One Health approach implementation through establishing various task forces starting from national, regional to the district level.	None	**Zoonotic disease data:** · Occurrence at all levels from kebele to federal. · Early notifications and reports on outbreaks from each region (village to federal level). · Response to vaccination. · Causalities/number of deaths and illness. **Abattoir data:** · Anti-mortem and post-mortem findings from domestic abattoirs including major causes of carcass condemnation and its rejection rates. · Number of abattoirs and their location and capacity per region. · Number and educational level of experts in each abattoirs. Number and type of farms in the country.	**Weekly** brief work summary of the directorate communicated via email to the State Minister. **Quarterly** formal report to State Minister office and PPMED.	Ethiopian Public Health Institute (EPHI) is currently working with the mandate of combating zoonotic diseases and there is also zoonotic research team at EPHI that comprises veterinarians with no linkage and participation of the veterinary public health. The Food and Drug Authority is mandated to deliver food safety including food of animal origin so there is overlap in this area.

ANNEX 2:

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES – Cont

Institution	Mandate	Activities	Database and Status	Institutional Data Need	Reporting System	Mandate Overlap
Export Abattoir Inspection and Certification Directorate	Regulate and control the export abattoirs and inspection of the abattoir's hygiene and sanitation. Inspect the health of animal products and provide safety assurance and certification. Regulate food safety assurance.	**Inspection and follow-up** along the line, i.e., starting from the animals' reception centers, holding pens, lairage, right through to pre-slaughter anti-mortem inspection. Activities in these areas include assessing the health and wellbeing of the live animals. **Conduct** series of inspections starting from slaughtering, post-mortem inspection and carcass transportation and certification for export. The hygiene of the carcass and offal (main product and by-products) are inspected and certified. **Regulate** cold chain system along the process (at abattoir, vehicle, and airport) and facilitate loading and off-loading of the product. **Ensure** the personal hygiene and health status of professionals. **Collaborate** with city administrations and Environmental Protection Agency on the waste disposal system of the abattoirs to avoid environmental contamination. **Provide** international product certificate along with administrative documents.	None	**Abattoir data:** · Number of slaughtered animals at regular intervals (i.e. daily, weekly, monthly, yearly). · Origin and route of animals, including health status from origin. · Antemortem and postmortem inspection data. · Detailed data on the major causes of carcass condemnation and rejection rate. · Production flow for each animal. · Infrastructure details.	**Weekly** by text and monthly by hardcopy to the directorate. **Quarterly, monthly, and sometimes weekly** to the State Minister. **On request** to other directorates either by email or hardcopy.	The mandate of inspecting animal food items during export by the Food and Drug Authority overlaps with the Export Abattoir Inspection and Certification Directorate, as well as EMDIDI.

ANNEX 2:

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES – Cont

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
Dairy Development Directorate (part of Livestock Resources sub-sector)	Organize and lead the development of policy and strategy related to the dairy sector, e.g. the breeding policy and the establishment of the new dairy board. Prepare national dairy development packages. Provide competence assurance certificate to dairy investors. Update foreign investors' residential licenses after validation of their contribution for technology transfer and job creation. Approve feed formulation standard.	**Build Capacity**: Provides TOT for all regions based on demand, training for AI-technicians, farmers (including urban dairy farmers), development agents and milk collection center technicians. **Provide technical, logistic, and budget support** for regions and the stakeholders. This includes supporting AI services such as providing synchronization hormones, semen production processing advice, AI efficiency assessment by pregnancy testing and campaigning. **Procure and distribute** important equipment like lactometers, milk chillers, milk filters/sieves, milk churners, cream separators, cold truck, etc. and support the installation of milk chillers at the milk collection centers. **Promote** dairy technology transfer & adoption with dairy extension services and scale-up best practices to regions and partners. **Develop** national dairy development strategy and design dairy related policies & guidelines. **Review** curriculum for TVET to incorporate dairy related subjects and prepare COC exams for TVET Agency. **Support** partner organizations by organizing platforms to address common challenges. **Follow up** ongoing nutrition related interventions in selected woredas under the Sekota declaration.	None	**Farmer data:** · Dairy husbandry practices. · Dairy management practices (feeding, watering, housing, etc). **Health data:** · Data on disease outbreaks. · Type of disease, location and coverage of outbreak. · Number of animals affected and at risk. · Vaccination history and frequency. **Farm data:** · Number and size of dairy farms. · Animals on each farm stratified by breeds (Zebu, cross between local and exotic, and exotic) and, where cross-bred, the percentage blood level of each breed. **Production and collection data:** · Milk yield per animal per day or year. · Length of lactation for each breed. · Number and capacity of milk collection centers by region. · Amount of milk delivered to processors by each milk collection center. **Market related data:** · Number of licensed producers or processors. · Amount of product produced for consumption market. **Industry data:** · GDP contribution of the dairy sector. · Value chain actors integration across the horizontal and vertical market channels.	Hard or soft copy report submission and physical presentation to DDD and State Minister. **Quarterly** report to State Minister.	There are mandate overlaps between the DDD and that of EMDIDI in some aspects. There is duplication in expertise between various directorates, especially animal science and dairy production.

ANNEX 2:

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES – Cont

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
Feed Resources Development Directorate	Increasing animal feed production and productivity of smallholder farmers and pastoralists by identifying inefficiencies in the system and then designing strategies and policies to address them. Support to the regions including capacity building training, monitoring and supervision, promotion and scaling-up of new technologies and best practice activities from international and national level. Dissemination of research findings from EIAR to farmers using FTCs for demonstration purposes.	**Prepare and disseminate** the implementation strategy documents, guidelines, training manual and packages. **Conduct training** to all regions and the two city administrations upon the need assessment done from respective regions. **Prepare** plan, reports and provide feedback. **Assist** private investors interested in feed resource development by providing competence assurance certificates, technical advice and support letters for renewal of their working licenses. **Coordination** of experience sharing within regions, nationally and continentally. **Ensuring** the sustainability of the on-going feed development activities through supporting private and government forage seed multiplication centers. The directorate purchases seeds from private sector and disseminates these, and feed, to the regions. Some private sector actors obtain their seeds from research centers whereas others obtain poor quality seed informally from farmers. **Strengthen** the rangeland rehabilitation activities in the pastoral areas. **Control** invasive plant species particularly in Afar and Somalia. **Supply and distribute** industrial by-products such as molasses, brewery waste.	None	**Feed data:** · Amount of feed available per region. · Precise identification of rangeland or grazing land at national level. (estimated rangeland coverage is reported to be 62-65%). **Feed source data:** · Amount of feed from natural pasture, improved forage, crop residue for animal feed versus other purposes. · Amount of industrial by-products recycled versus the amount utilized for animal feed. **Market data:** · Current prices of industrial by-products, improved feed varieties and pre-mix or imported feed, seeds and biomass (hay). · Location of the forage markets. · Origin of forage supplied at the market and details of forage customers. **Feed production management data:** · Invasive weeds coverage. · Irrigated feed production. · Water requirements for different forage varieties. · Overall crop production. · Number of livestock per region.	**Weekly, monthly, and quarterly** report to the State Minister. There is no uniform reporting from regions. Some of them send reports to the National Planning Commission whereas others evaluate the report at regional council level. This results in delays in reporting on time. The various feed directorate structures across regions leads to issues in reporting as there are capacity restraints in some areas.	There is overlap between some aspects of the Feed Resources Development Directorate mandate and that of the Ethiopian Meat and Dairy Industry Development Institute (EMDIDI). Furthermore, as feed is important for multiple livestock directorates, there are overlaps of some mandates and activities with other directorates e.g. with Livestock Investment Support Directorate.

ANNEX 2:

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES – Cont

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
Meat, Hide and Skin Resource Development Directorate.	Enhance meat, skin, and hide production in quality and quantity mainly focusing on smallholder animal rearing, and to some extent commercial farms (feedlots/fattening). Work on the development of these commodities up to the point where the animals are sent to market or abattoir, i.e., the mandate does not cover market issues or abattoir activities (AMI and PMI).	**Build capacity** for various stakeholders, farmers, pastoralists and particularly training development agents on the market-oriented extension system. This includes preparing technology packages and delivering training for farmers that operate small farms right through to those that operate large farms. **Provide technical support** for farmers and pastoralists, commercial farmers and development agents by carrying out monitoring, evaluation, supervision and gap assessment activities. This includes support and advice for youth and women particularly in the pastoral sector, linking producers with the domestic and export markets, helping with investment planning and profitability modelling of scenarios. The technical support also includes feasible land area selection and guidance on health and improved breeding of the animals. The directorate also assists fattening operations by devising a mechanism for the supply of industrial by-products (from sugar factories, breweries, flour factories), facilitating credit and land access for small and medium scale fattening enterprises, and supporting the existing common interest groups (CIGs) pertaining to fattening practices. **Scaling up** best experiences including assessment of any best practice. **Giving** investment information for investors who want to engage in the sector. The sources of information for investors are from previous experiences, websites, field assessments, meetings and workshops.	None	**Production data:** · Meat, hides and skins from each region. · Number of livestock per species. **Employment data:** · Number and demographics of people employed in sector. · New jobs created in this sector. **Feedlot data:** · Numbers and types of feedlots per region. · Data on slaughterhouses, marketing facilities and animal health posts along marketing routes.	**Weekly**, **monthly**, **six monthly** and **annual** reports. On-demand urgent reports to State Minister.	None

ANNEX 2:

TABLE 12. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL HEALTH DIRECTORATES – Cont

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
Livestock Investment Support Directorate	Work to improve investment into the livestock sector including dairy, poultry, fattening, etc. The Directorate is focused on medium and large-scale livestock investment.	**Support** commercial investors in different regions that engage in livestock commodities through capacity building, creating market linkages, monitoring and evaluation, and supervision for new investors. **Identify** investment opportunities and challenges through assessment and then create platforms with the stakeholders to review the identified opportunities and challenges so as to make use of them. **Facilitate** linkages to resolve infrastructural and logistic challenges. **Dairy technology transfer and adoption** with dairy extension services. **Provide** TOT for all regions based on demand. **Review** curriculum for TVET to incorporate dairy related subjects and prepare COC exams for TVET Agency. **Experience share and scale up** best practices to regions and partners.	None	Investment data: – Production and productivity of commercial farmers in different agri-businesses (apiculture, dairy, etc.) and their respective contribution to GDP. – Identified land for livestock investments use stratified by agro-ecological zones. – Farm management details such as feed availability, AI services, input supply, etc. – Number of jobs created by livestock investment.	**Quarterly** based reporting system to Livestock State Minister, PPMED and Parliament.	A) There are overlaps between the mandates of LIS and Urban Agriculture & Livestock Investment Support (UALIS) Directorates e.g. supporting livestock investment at the national level. B) There are overlaps in the mandate with the Ethiopian Meat and Dairy Industry Development Institute C) Additional overlaps in mandate are with the Market Input and Promotion Agency which only focusses on large-scale investors. D) The Dairy Development Directorate also engages in assisting commercial dairy investments to some extent.
Urban Agriculture and Livestock Investment Support	Coordinating urban activities in livestock production and productivity, but only in approximately 20 cities due to budget and human resources constraints. It is also mandated to support livestock investment, but due to overlap with LISD's mandate, this has been deprioritized.	**Prepare** activity checklists. **Provide** technical support to producers, experts and enterprises. **Deliver** capacity building training after conducting detailed gap assessments. **Advocate** for agricultural bureaus in appropriate urban regions to establish a regional investment support unit. **Facilitate** job creation opportunities for women and youths to engage in urban livestock businesses. This involves coordination with SMEs, Micro-finance Institutions and TVETS.	None	Data on the urban livestock: – Population – Production – Productivity – Disease status (type, prevalence) Currently, the directorate has only administrative data. Data on supply and demand to understand the existing gap. Data on livestock technology uptake. Data on of job creation especially the number of women or youths.	**Monthly and Quarterly** to the State Minister, NPC and parliament.	Overlap with the Livestock Investment and Support directorate.

ANNEX 2:

TABLE 13. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL PRODUCTION DIRECTORATES

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
National Veterinary Institute	Mandated to produce a world-class vaccine for the prevention and control of disease across a wide variety of animals. Engaged in diagnostic kit development and also participates in disease surveillance. Involved in the production of biologicals, reagents and drugs.	**Produce** a wide variety of vaccines for many livestock diseases, not only for local use but for the export market. **Despatch** reasonably-priced vaccines on request from the federal or regional livestock bureaus. **Export** vaccines to different countries on request. **Conduct** research on different disease-causing agents.	None	Data on livestock that need vaccination: – Number – Location – Species – Age Health data: – Type of diseases and coverage in each region. – Disease strain distribution. – Regional vaccine demand per season per species. – Number and types of imported vaccines and drugs. – Outcomes of vaccination.	**Monthly** report for each Directorate Director of Board. **Quarterly** for the MoA and House representative.	No overlap

ANNEX 2:

TABLE 13. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL PRODUCTION DIRECTORATES – Cont

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
National Animal Health Diagnosis and Investigation Center	Provides diagnostic testing and certification of export animals, animal products and by-products to enable export market access. Coordinates and performs national surveillance and diagnosis of the trans-boundary animal diseases of economic and public health importance. Trains laboratory personnel, field animal health professionals, abattoir and quarantine workers. Supports veterinary education by providing practical training and supervision for students. Regional diagnostic services for avian flu and Newcastle disease and provides technical support for East African national laboratories. Collects national animal health information to develop and implement strategic plan for animal disease prevention and control.	**Diagnostic testing and certification** of export animals confirming they are free from exotic, zoonotic or major transboundary animal diseases. Ensuring quality control and internationally acceptable standards are in place, regionally and nationally. **Develop and implement** policies and strategies that use animal health diagnostics and research outcomes. **Deliver** reference diagnostic laboratory services on animal health. **Conduct** national surveillance and diagnoses on transboundary animal diseases and zoonotic diseases for prevention and control purposes. **Train** the RVLs after identifying technical gaps at labs. **Conduct** research on animal health problems mainly on diseases of major economic and public health importance. **Implement** fast and efficient animal health information exchange system between the central laboratories, RVLs and other stakeholders. **Establish** linkages with international and sub-regional animal health reference laboratories, research institutions and universities to remain up to date with developments. **Organize**, document and dispatch animal health information of the country for stakeholders. **Support** veterinary colleges/ schools/faculties by providing practical laboratory training and supervision for students. **Assist** with preparation of national standards, guidelines and manuals for diagnostic and research on animal health issues.	SILABFA	Data on the results of passive, active and risk-based surveillance conducted by the Epidemiology Directorate at MoA, mainly data from DOVAR2 and ADNIS. **Data on livestock in each region:** · Number and type of stock · Age of animal · Sex · Location · Disease status · Vaccination status	**Annually and bi-annually** report prepared or generated from the database by the epidemiology unit and sent to MoA. On demand report summary to different stakeholders.	NAHDIC is structurally accountable to MoA (Epidemiology Directorate), but there are overlaps and mix-ups of activities with respect to disease surveillance and investigation. There is no clear demarcation and coordination between NAHDIC and the relevant directorates at the Ministry.

ANNEX 2:

TABLE 13. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL PRODUCTION DIRECTORATES – Cont

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
National Animal Genetics Improvement Institute	Mandated to undertake research on increasing production and productivity of animals through genetics. Organize and lead animal multiplication centers that contribute genetic improvement. Collect breed improvement data by establishing national animal recording system. Prepare and implement National Breeding Policy, programs and strategy. Involved in technical trainings for stakeholders on animal breed improvement.	**Recruit** bulls of high pedigree records, both of indigenous and exotic breeds for semen collection. **Import** semen of Holstein-Friesian and Jersey, and live heifers for breed improvement. **Collect** and distribute semen and liquid nitrogen (LN_2). **Train** AI technicians, semen lab technicians, liquid nitrogen plant operators and various TOTs. **Manage** nucleus herd for recruiting AI and natural mating bulls of high pedigree records. **Populate** dairy performance recording and feedback system. **Strengthen** the regional AI field service delivery and AI Centers. Monitor and evaluate activities.	ADGG: Managed by NAGII's Dairy Cattle Performance Recording and Feedback Directorate and supported by ADGG.	**Data on livestock:** · Animal performance data. · Production data (growth, milk yield, etc.). · Administrative data. · Reproductive performance (birth date or insemination date and calving data). · Health related data. · Market information of animal products.	**Quarterly, semi-annual, and annual** paper reports to MoA.	No Overlap
Veterinary Medicine, Feed Administration and Regulatory Authority	Ensures the delivery of safe and quality feed and efficacious veterinary drug to consumers by regulating and controlling the veterinary drug and feed manufacturers, importers, wholesalers, experts, and institutions involved in the sector.	**Control quality of veterinary drugs** through: · Dose evaluation. · Good Manufacturing Practices (GMP) inspection. · Drafting and approval of veterinary drug regulations. · Monitoring and evaluating regional veterinary drug regulatory bodies. · Advising stakeholders on responsible drug use. · Conducting laboratory tests on drug quality. · Providing safety standards for imported and local treatments. · Following up the implementation of post-market surveillance by random sample methodologies. **Control quality of feed** through: · Laboratory testing of feed to ensure it meets guidelines. · Issuing quality certificates for producers, wholesalers, and distributors of animal feed. · Building the capacity of feed professionals and stakeholders. · Preparing directives and guidelines for feed quality. · Assessing illegal animal feed.	None	Data on feed retail prices. Drugs management data from veterinary clinics in the regions. Location of drug and feed suppliers. Data on illegal feed and drug routes.	**Monthly** report from branch coordination offices sent to the Planning Directorate. **Quarterly, and annual** report sent to MoA and the Agriculture and Pastoral and Environment Protection Committee of Parliament.	None

ANNEX 2:

TABLE 13. LANDSCAPE ASSESSMENT FINDINGS FROM THE ANIMAL PRODUCTION DIRECTORATES – Cont

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
Agricultural Transformation Agency	Identifies systemic constraints of agricultural development. ATA then recommends solutions to alleviate these constraints and works with other institutions, or alone, to implement the solutions. Supports partners to identify and address systemic bottlenecks within an Agricultural Transformation Agenda (MoA and affiliates). Supports integration of solutions to systemic bottlenecks in high-priority commodity value chains and geographies through the Agricultural Commercialization Clusters (ACC) Initiative (mainly led by Regional Governments and Regional Bureaus of Agriculture).	**Support** implementation of transformation agenda deliverables (TAD). **Assist** in the prioritized commodity development using the ACC approach across more than 220 woredas in 4 regions and implementing more than 20 projects addressing various systemic issues.	SMS 8028 farmers hotline	Data on agricultural systems under investigation prior to, and then on a regular basis after implementation to monitor progress and impact. Data for designing projects. Data for high-level analytics work to address specific issues. Data for extension materials.	**Monthly** internal report. **Quarterly** report to MoA and Parliament. **Bi-annual and/or annual** reports to donors based on requirements. Implementation Management Platform (IMP) software for reporting.	None

ANNEX 2:

TABLE 14. LANDSCAPE ASSESSMENT FINDINGS FROM THE POLICY, PLANNING, MONITORING AND EVALUATION DIRECTORATE

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
Policy, Planning, Monitoring and Evaluation Directorate	Develop strategic plans for the MoA,and undertakes monitoring and evaluation of the plan's implementation. Establish a data system for the agricultural sector that collects and integrates administrative data, indicators, etc. Leads collaboration activities with other directorates in short and long-term projects that support livestock development. The coordination and supervision role stretches to very large projects that are sometimes prepared by Committees and consultants.	Prepares the long-term (5-10 years) strategic plan and then cascades it to the regional agricultural bureaus. Prepares annual operational plan. Creates the platform to present, evaluate and align federal and regional plans. Tracks the performance of the plan after it has been implemented. Reviews and evaluates regional and federal reports.	None	Data on livestock administration, including: · Animal numbers. · Production. · Consumption including the export of live animals, local meat consumption and other animal products consumption level. · Marketing per region.	Quarterly report to Parliament and PM's office. Monthly and quarterly report to the State Minister. Annual plan to NPC.	None

ANNEX 2:

TABLE 15. LANDSCAPE ASSESSMENT FINDINGS FROM ASSOCIATED INSTITUTIONS

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
Ethiopian Meat and Dairy Industry Development Institute	Develop policy and strategy related to livestock products and by-products processing (honey, feed, and dairy). Market development by supporting import substitution and export promotion. Technology development and information dissemination to ensure the provision of input supply to the meat and dairy industries.	**Conduct research and development:** identify and support the technology transfer of technologies applicable to the development of the meat and dairy industries. **Encourage** the industry to establish a research and development unit. **Provide advisory services** for the meat and dairy industries concerning product processing, planning and quality assurance. **Establish** pilot plants and laboratories to support the industry and provide internationally-recognized testing services. **Provide** practical training on technology, technical matters, marketing and management and other training that assists the development and competitiveness of the meat and dairy industry sectors, and collaborate with the relevant stakeholders to produce qualified manpower.	None	**Data on livestock, including:** · Number, type and breed of animals categorized by sex. · Age of animals. · Location of animals. · Sale price of animals. · Body condition of livestock. · Milk production (daily or monthly) by breed. · Milk quality data. **Data on feed, including:** · Major feed sources. · Feed composition or formulation. · Feed type. · Price. · Agro-ecological location. · Feed requirements for each species of animal. · Land area and location required for feed. production per specific feed type (perennial, annual). · Available inputs for the meat and dairy industries.	**Monthly and quarterly** report to MoTIn and PM's Office.	Livestock directorates under the MoA including the Dairy Development Directorate, Export Abattoir Inspection and Certification Directorate, Livestock Investment Support Directorate, QIEICD and Feed Resources Development Directorate. Also, with the Market Research and Promotion Directorate under MoTIn.
Market Research and Promotion Directorate	Coordinate and lead the livestock market data collection, analysis, and dissemination. To carry out market research, market linkage and promotion.	**Collect and analyze** data on markets. **Train** data collectors and carry out follow up field assessments on them. **Identify** market centers. **Carry out** market linkage and promotion.	NLMIS	**Data on markets, including:** · Live animal export. · Live animal import. · Major local market prices of animal and animal products. **Data for market linkage, including lists of:** · Cooperatives. · Abattoirs. · Livestock importing countries.	**Weekly, monthly, quarterly, and annual** reports to MoTIn and respective directorates in the Ministry.	None

ANNEX 2:

TABLE 15. LANDSCAPE ASSESSMENT FINDINGS FROM ASSOCIATED INSTITUTIONS – Cont

Institutions	Mandate	Activities	Database and Status	Institutional Data Need	Reporting system	Mandate overlap
Central Statistical Authority	To establish and lead an integrated and well-coordinated National Statistical System that produces robust official statistics that meet the current and evolving needs of users in a transparent and timely fashion, using standards and best statistical practices.	**Conduct** surveys and census data. **Collect, analyze and disseminate** socio-economic, health and agricultural data. **Produce** official statistics.	None	Data on livestock: – Type. – Health. – Price.	**Every** survey report is sent to the National Plan Commission.	None

ANNEX 2:

TABLE 16. LANDSCAPE ASSESSMENT FINDINGS FROM THE REGIONAL LIVESTOCK BUREAUS/AGENCIES

Region	Mandate	Activities	Institutional Data Need	Reporting system	Major Challenges
Amhara Regional Livestock and Fisheries Resources Development and Promotion Agency	Work on livestock resources development to increase production and productivity.	**Livestock production, product, and forage development:** · Breed improvement and protecting indigenous species. · Improve grazing land, and forage development. · Facilitate and coordinate resources. · Address the water shortage for livestock. **Livestock Extension Service:** · Genetic improvement. · Feed resources production, utilization and management. · Training packages for farmers. **Animal Health and Supervision Service:** · Prepare, implement and monitor animal health development packages in collaboration with research bodies. · Prevent disease by improving clinic and vaccination coverage and improving the quality of the treatment. **Multiplication of animal technology, input supply and distribution service:** · Disseminating improved livestock technologies to farmers through trainings and field day workshops. · Marketing of livestock and fishery inputs. · Distribution of animal health and production inputs to zones.	**Data on livestock, including:** · Population and type of animal. · Breed performance. · Location of animals. Feed sources and availability. **Data on animal health including:** · Disease type. · Coverage of the outbreak. · Date of outbreak. Number of businesses engaged in the fishery, dairy, and fattening sectors.	**Monthly** reports from zone, woreda and kebele. These reports are sent to respective subject matter experts in each directorate for compilation and analysis. PPMED aggregates the data and prepares the **monthly and quarterly** reports that are sent to MoA and the Regional Council.	To develop systems for the development of the livestock industry and in particular for the quality and health of the regional livestock resources and their products.

ANNEX 2:

TABLE 16. LANDSCAPE ASSESSMENT FINDINGS FROM THE REGIONAL LIVESTOCK BUREAUS/AGENCIES – Cont

Region	Mandate	Activities	Institutional Data Need	Reporting system	Major Challenges
Oromia Regional Livestock and Fisheries Resources Development and Promotion Agency	Support the generation and adoption of improved livestock technologies to increase the productivity and production of diverse livestock species and hence improve the livelihood of communities.	**Breed improvement:** · Improve the genetics of indigenous cattle breeds to increase productivity of milk and meat. **Feed resources development and utilization:** · Improve livestock feed resources and rangeland to alleviate feed shortages. **Health:** · Actively engage in livestock disease control, prevention and eradication through well-designed treatment and vaccination. **Extensions services:** · Prepare various extension packages to train farmers in using new technologies and improving their handling and processing of livestock products.	**Data on livestock, including:** · Population and type of animal. · Location of animals. · Market information. · Feed sources and demand per zone and woreda.	**Monthly and quarterly** report to MoA and Oromia Regional Council.	

ANNEX 2:

TABLE 16. LANDSCAPE ASSESSMENT FINDINGS FROM THE REGIONAL LIVESTOCK BUREAUS/AGENCIES – Cont

Region	Mandate	Activities	Institutional Data Need	Reporting system	Major Challenges
SNNPR Bureau of Livestock and Fisheries Resources Development	Work towards increasing the production and productivity of the livestock resources through genetic improvement, health services for disease prevention and control, and provision of quality and standardized production input. The bureau structure and directives are cascaded down to kebele level.	**Genetic improvement:** · Improve the genetics of indigenous cattle breeds to increase dairy production. · Lead the regional semen production (Hawassa) and liquid nitrogen centers (Hossana, Wolayita, Wolkite and Mezan). · Improve sheep and goat fattening breeds using exotic breeds and select local breeds. **Feed resources production, utilization, and management:** · Improve the animal feed supply through incorporating crop residue production and utilization as per the breed type requirement. **Health Services:** · Deliver a wide range of disease control initiatives (especially vaccinations) and treatments for animals at local health posts and clinics. · Collect surveillance data and report in them. · Coordinate health management in each abattoir by conducting the Post-mortem and ante-mortem examinations. **Extension services:** · Deliver advisory services for improving the production and productivity of livestock resources e.g. new production and processing technologies, animal husbandry, genetic improvement. **Animal production:** · Enhance the quality of animal products including beef, dairy, poultry, hide and skin, apiculture, and aquaculture. **Provision of agricultural inputs:** · Provide inputs required to increase livestock production such as hormones, feeds and forages, veterinary drugs, vaccines and animal genetic resources.	**Data on livestock:** · Animal population data. · Location data. · Production data (milk, eggs, honey, etc). · Market information such as price, outlets and centers. · Abattoir level data such as disease occurrences. **Data on Inputs, including:** · Suppliers of hormones. · Bull locations. · Vaccinations and treatment. **Data on feed:** · Potential sources of feed. · Feed types and volumes that have been produced at the required standard with quality control procedures in place. · Feed utilization. · Feed suppliers and their locations. · National and international standards for feed production and utilization. · Potential suppliers of feed in the region and at national level.	Monthly report. On demand reports based on data collection from the district/kebele level in regional standardized data collection format.	The CSA livestock population data has a major discrepancy with the region's district data. Market information is collected by experts in each woreda and city administration once or twice a week predominantly from the terminal markets. However, the informal livestock market dominates the market value chain. Thus, the information discrepancy misleads farmers. The SNNPR Livestock and Fisheries Development Bureau collects abattoir related data only from rural abattoirs and slaughterhouses but not from the Hawassa city municipal abattoir which is one of the important missing data sets. There is very poor communication between the Bureau and MoA due mainly to the absence of uniform and consistent channels regarding reporting and data flow.

ANNEX 3:

Summary of use cases and data needs from national workshops and interviews

TABLE 17. USE CASES

1	Current market price information for caprine meat
2	Current market price information for bovine meat
3	Current market price information for camel meat
4	Current market price information for ovine meat
5	Current market price information for camel hides
6	Current market price information for caprine skins
7	Current market price information for bovine hides
8	Current market price information for ovine skins
9	Current market price information for bovine milk
10	Export revenue (in USD) from bovine meat
11	Export revenue (in USD) from camel meat
12	Export revenue (in USD) from caprine meat
13	Export revenue (in USD) from ovine meat
14	Export revenue (in USD) from camel hides
15	Export revenue (in USD) from bovine hides
16	Export revenue (in USD) from caprine skins
17	Export revenue (in USD) from ovine skins
18	Export revenue (in USD) from live bovine animal export trade
19	Export revenue (in USD) from live caprine animal export trade
20	Export revenue (in USD) from live camel export trade
21	Export revenue (in USD) from live ovine animal export trade
22	Export revenue (in USD) from bovine milk
23	Price difference for vaccinated bovine animals at market
24	Price difference for vaccinated caprine animals at market
25	Price difference for vaccinated ovine animals at market
26	Price difference for vaccinated camels at market
27	Change in volume of ovine products on legal markets
28	Change in volume of caprine products on legal markets
29	Change in volume of bovine products on legal markets
30	Change in volume of camel products on legal markets
31	Change in volume of ovine animals on legal markets
32	Change in volume of bovine animals on legal markets
33	Change in volume of caprine animals on legal markets
34	Change in volume of camel on legal markets

ANNEX 3:

TABLE 17 USE CASES - Cont

35	Percentage annual price increase of caprine products
36	Percentage annual price increase of camel products
37	Percentage annual price increase of ovine products
38	Percentage annual price increase of bovine products
39	Number of new markets entered by type of bovine product
40	Number of new markets entered by type of camel product
41	Number of new markets entered by type of caprine product
42	Number of new markets entered by type of ovine product
43	Number of new markets entered by caprine animals
44	Number of new markets entered by bovine animals
45	Number of new markets entered by ovine animals
46	Number of new markets entered by camels
47	Volume and ovine products exported
48	Volume of bovine products exported
49	Volume of caprine products exported
50	Volume of camel products exported
51	Volume of bovine meat products exported
52	Volume of caprine meat products exported
53	Volume of ovine meat products exported
54	Volume of camel meat products exported
55	Volume of bovine milk exported
56	Percentage annual increase/decrease of ovine products exported by country
57	Percentage annual increase/decrease of camel exported by country
58	Percentage annual increase/decrease of bovine exported by country
59	Percentage annual increase/decrease of caprine products exported by country
60	Number of bovine animals marketed at appropriate age
61	Number of ovine animals marketed at the appropriate age
62	Number of caprine animals marketed at the appropriate age
63	Number of camels marketed at the appropriate age
64	Caprine skins that meet international quality standards
65	Camel hides that meet international quality standards
66	Bovine hides that meet international quality standards
67	Ovine skins that meet international quality standards
68	Number of ovine animals that meet international quality standards

ANNEX 3:

TABLE 17 USE CASES - Cont

69	Number of caprine animals that meet international quality standards
70	Number of bovine animals that meet international quality standards
71	Number of camels that meet international quality standards
72	Volume of milk that meets international quality standards
73	Volume of ovine meat products that meet international quality standards
74	Volume of caprine meat products that meet international quality standards
75	Volume of camel meat products that meet international quality standards
76	Volume of bovine meat products that meet international quality standards
77	Number of ovine animals retained by cross border control
78	Number of caprine animals retained by cross border control
79	Number of camels retained by cross border control
80	Number of bovine animals retained by cross border control
81	Markets covered in market information system
82	Number of registered users of NLMIS by type of user
83	Number of active users of NLMIS by type of user
84	Price difference in ETB from production and sale of concentrate feed disaggregated by male, female and youth head of household
85	Number of hides and skins supplied from farmers/pastoralists to the market disaggregated by male, female and youth head of household
86	Percentage annual change in number of hides and skins disaggregated by gender of the head of the household and young and adult stock mortality (YASM) rate
87	Percentage difference in the yield of skins and hides as split by male and female household heads
88	Percentage difference in the yield of milk as split by male and female household heads
89	Percentage annual change in carcass weight per camel on commercial farms disaggregated by gender of the head of the household
90	Percentage annual change in carcass weight per bovine animal on commercial farms disaggregated by gender of the head of the household
91	Percentage annual change in carcass weight per goat on commercial farms disaggregated by gender of the head of the household
92	Percentage annual change in carcass weight per sheep on commercial farms disaggregated by gender of the head of the household
93	Percentage annual change in carcass weight per goat on smallholder farms disaggregated by gender of the head of the household
94	Percentage annual change in carcass weight per bovine animal on smallholder farms disaggregated by gender of the head of the household
95	Percentage annual change in carcass weight per camel on smallholder farms disaggregated by gender of the head of the household
96	Percentage annual change in carcass weight per sheep on smallholder farms disaggregated by gender of the head of the household

ANNEX 3:

TABLE 17 USE CASES - Cont

97	Percentage annual change in carcass weight per sheep for pastoralist farming systems disaggregated by gender of the head of the household
98	Percentage annual change in carcass weight per goat for pastoralist farming systems disaggregated by gender of the head of the household
99	Percentage annual change in carcass weight per camel for pastoralist farming systems disaggregated by gender of the head of the household
100	Percentage annual change in carcass weight per bovine animal for pastoralist farming systems disaggregated by gender of the head of the household
101	Percentage difference in the yield of carcass weight per livestock unit as split by male and female household heads
102	Percentage annual change in carcass weight per sheep disaggregated by gender of the head of the household and young and adult stock mortality (YASM) rate
103	Percentage annual change in carcass weight per bovine animal disaggregated by gender of the head of the household and young and adult stock mortality (YASM) rate
104	Percentage annual change in carcass weight per goat disaggregated by gender of the head of the household and young and adult stock mortality (YASM) rate
105	Percentage annual change in milk yield on commercial farms disaggregated by gender of the head of the household
106	Percentage annual change in milk yield on smallholder farms disaggregated by gender of the head of the household
107	Percentage annual change in milk yield on pastoralist farms disaggregated by gender of the head of the household
108	Percentage annual change in milk yield disaggregated by gender of the head of the household and young and adult stock mortality (YASM) rate
109	Volume of milk supplied from farmers/pastoralists to the market disaggregated by male, female and youth head of household
110	Number of camels supplied from farmers/pastoralists to the market disaggregated by male, female and youth head of household
111	Number of bovine animals supplied from farmers/pastoralists to the market disaggregated by male, female and youth head of household
112	Number of goats supplied from farmers/pastoralists to the market disaggregated by male, female and youth head of household
113	Number of sheep supplied from farmers/pastoralists to the market disaggregated by male, female and youth head of household
114	Number of cattle market sheds covered through the ET-LITS system
115	Commodities covered in market information system (NLMIS)
116	Number of heifers sold to livestock keepers
117	Number of bovine exported through the ET-LITS system
118	Number of caprine exported through the ET-LITS system
119	Number of ovine exported through the ET-LITS system
120	Number of camels exported through the ET-LITS system

ANNEX 3:

TABLE 17 USE CASES - Cont

121	Number and breed of goats registered and tagged
122	Number and breed of sheep registered and tagged
123	Number and breed of cattle registered and tagged
124	Number and breed of camels registered and tagged
125	Number of animals per indigenous breed by species
126	Number and breed of each livestock species included in ET-LITS
127	Number of indigenous caprine breeds farmed
128	Number of indigenous bovine breeds farmed
129	Number of indigenous ovine breeds farmed
130	Number of indigenous camel breeds farmed
131	Number of improved bovine breeds
132	Number of improved caprine breeds
133	Number of improved ovine breeds
134	Number of improved camel breeds
135	Proportion of improved breeds in relation to local breeds
136	Number of bovine animals tested for blood levels per exotic breed
137	Number of caprine animals tested for blood levels per exotic breed
138	Number of ovine animals tested for blood levels per exotic breed
139	Number of camels tested for blood levels per exotic breed
140	Number of indigenous caprine animals selected for cross breeding
141	Number of indigenous ovine animals selected for cross breeding
142	Number of indigenous bovine animals selected for cross breeding
143	Number of bovine animals artificially inseminated
144	Number of caprine animals artificially inseminated
145	Number of ovine animals artificially inseminated
146	Number of farmers and pastoralists using exotic semen to produce crossbred bovine animals
147	Number of farmers and pastoralists using exotic semen to produce crossbred caprine animals
148	Number of farmers and pastoralists using exotic semen to produce crossbred ovine animals
149	Amount of semen collected by species
150	Number of AI technicians trained
151	Number of farmers using AI services
152	Average number of AI services per conception
153	Number of AI centers established by location
154	Number of AI centers (by region) for provision of exotic dairy genetics

ANNEX 3:

TABLE 17 USE CASES - Cont

155	Number of camels screened for zoonotic diseases (date range applicable)
156	Number of caprine animals screened for zoonotic diseases (date range applicable)
157	Number of bovine animals screened for zoonotic diseases (date range applicable)
158	Number of ovine animals screened for zoonotic diseases (date range applicable)
159	Number of camels vaccinated against a zoonotic disease (date range applicable)
160	Number of bovine animals vaccinated against a zoonotic disease (date range applicable)
161	Number of animals vaccinated against a zoonotic disease (date range applicable)
162	Number of ovine animals vaccinated against a zoonotic disease (date range applicable)
163	Number of caprine animals vaccinated against a zoonotic disease (date range applicable)
164	Percentage of bovine animals treated/vaccinated by location
165	Percentage of caprine animals treated/vaccinated by location
166	Percentage of ovines treated/vaccinated by location
167	Percentage of camels treated/vaccinated by location
168	Percentage of immune bovines after vaccination
169	Percentage of immune caprines after vaccination
170	Percentage of immune ovines after vaccination
171	Percentage of immune camels after vaccination
172	Number of caprine animals treated for a zoonotic disease (date range applicable)
173	Number of ovine animals treated for a zoonotic disease (date range applicable)
174	Number of camels treated for a zoonotic disease (date range applicable)
175	Number of bovine animals treated for a zoonotic disease (date range applicable)
176	Percentage annual reduction of incidences of zoonotic diseases in caprine animals
177	Percentage annual reduction of incidences of zoonotic diseases in bovine animals
178	Percentage annual reduction of incidences of zoonotic diseases in ovine animals
179	Percentage annual reduction of incidences of zoonotic diseases in camels
180	Number of negatively diagnosed ovine exported
181	Number of negatively diagnosed caprine exported
182	Number of negatively diagnosed bovine animals exported
183	Number of negatively diagnosed camels exported
184	Rejection rate of bovine animals at abattoir
185	Rejection rate of caprine animals at abattoir
186	Rejection rate of ovine animals at abattoir
187	Rejection rate of camels at abattoir
188	Annual change in number of rejected livestock products traded

ANNEX 3:

TABLE 17 USE CASES - Cont

189	Effect of vaccination rate on national production
190	Percentage of total woreda that submit disease outbreak reports each month
191	Percentage annual reduction in livestock disease outbreaks by category of disease
192	Annual increase or decrease in percentage of animals vaccinated
193	Number of vaccinated ovine animals
194	Number of vaccinated bovine animals
195	Number of vaccinated caprine animals
196	Number of vaccinated camels
197	Percentage of each notifiable disease identified by region
198	Number of farmers and pastoralists who have vaccinated their animals
199	Where should vaccine teams be deployed?
200	Where should vaccines be deployed?
201	Percentage annual reduction in prevalence of livestock disease incidence by disease category
202	Number of new vaccines developed by species
203	Number of new veterinary drugs developed by species
204	Number of doses of vet drugs sold to smallholder farmers and pastoralists
205	Percentage of disease-free farmland by region
206	Areas under surveillance for targeted diseases
207	Percentage reduction in morbidity and mortality rate by species of livestock
208	Number of caprine animals with adequate feed supplies
209	Number of ovine animals with adequate feed supplies
210	Number of bovine animals with adequate feed supplies
211	Number of camels with adequate feed supplies
212	Number of pastoralists/agro-pastoralists with adequate feed supply for their livestock
213	Number of farmers with adequate feed supply for their livestock
214	Number of hectares of farmland managed
215	Total hectares of land where 60% of a Prosopsis infestation has been controlled
216	Total hectares of land where 90% of a Prosopsis infestation has been controlled
217	Total hectares of land where 100% of a Prosopsis infestation has been controlled
218	Reduction in area covered by bush encroachment
219	Area of communal grazing land rehabilitated
220	Number of pastoralists practicing backyard forage development
221	Number of pastoralists practicing feed conservation practices for feed scarce season
222	Number of new forage and pasture varieties developed for different agro-ecologies

ANNEX 3:

TABLE 17 USE CASES - Cont

223	Number of farmers and pastoralists/agro-pastoralists with access to concentrate feed
224	Volume of livestock input sold to farmers and pastoralists
225	Average retail price by feed input type
226	Volume of feed bought by farmers by type of feed
227	Volume of fodder utilized by SHFs, agro-pastoralists and pastoralists
228	Number of developed water points
229	Location of water resources
230	Number of pastoralists who have access to watering points
231	Proportion of livestock products produced and processed on-farm
232	Percentage annual increase in the number of small specialized dairy units
233	Percentage increase in the number of medium-sized specialized dairy units
234	Number of fully functional ranches
235	Number of functional animal health clinics/posts
236	Number of fully functional milk collection centers
237	Number of hides and skins collection centers
238	Number of rearing units established by region
239	Number of private enterprises engaged in the production and distribution of crossbred heifers
240	Number of heifers sold to livestock keepers by type of service provider
241	Percentage year-on-year reduction of animal power (oxen) for traction /threshing purposes
242	Financial value of livestock as collateral for lenders

ANNEX 4:

Action plan to develop the Future-LIS

Annex 4.1
Pre-development

Establish a Future-LIS Governance Group and a Technical Committee

The Governance Group is needed to advise the development team on strategic questions that will arise from time to time. The Governance Group also needs to oversee that the development is progressing according to plan and that it is resourced appropriately. The members of the Governance Group should come from within MoA, MoA affiliates and external stakeholders, as well as independent advisors. The members should come from a range of livestock backgrounds including the health, genetics and feed sectors. The Governance Group should also have representatives with knowledge on different livestock species. A key activity of the Governance Group will be to oversee the data policy implementation and to ensure that the metadata requirements of users are going to be fulfilled.

The formation of a Technical Committee is also needed to ensure that the development of the Future-LIS is proceeding according to plan, identify and solve emerging issues with the technical build, and confirm that the system will deliver to the needs of the users. It is likely that, during the course of the development phase, further use cases and additional data bases are identified, so the Technical Committee will need to help the development team to adapt and prioritize where to focus their efforts. It is envisaged that the Technical Committee will be comprised of representatives from the development team, MoA and external advisors.

Identify and establish the development team

Given the simple design of Stage 1 of the Future-LIS, there are many ICT teams that could execute the development of the system. Rather than recruiting specialist technologists and forming a team of contractors within the MoA, it is likely to be more efficient and cost-effective to engage a third-party to carry out the work. The Project Manager will have the responsibility of identifying multiple potential partners and, based on the system architecture described in this report, enter into discussions with each party. With the support of the Governance Group, the Project Manager will select the third-party that will perform the development build. The selection is recommended to be based on technical capability, experience, cost effectiveness, timeframes for delivery and cultural fit.

Agree on data standards with MoA directorates, other relevant government ministries, institutions, universities and REDFS

One of the key themes of this report is interoperability. In the past, many databases have been set up in isolation using different standards, classifications and formats meaning that it is cumbersome to combine datasets for analysis. If all of the stakeholders in the Ethiopian livestock sector can agree that any new data will be collected using the same criteria this will be an important step in the utility of the Future-LIS. We recommend that ICAR standards are adopted for Future-LIS as this is an internationally used set of standards meaning that Ethiopian datasets may be easily combined with datasets from other countries.

Determine and document minimum service levels

An SLA is a service-based commitment between the providers of the information system and the users of the system, and covers aspects of service performance, support and service level targets (i.e. agreed upon maintenance and response processes). The MoA will need to enter into an SLA with the cloud provider so that expectations can be set for performance. These expectations will need to parallel the expectations of the users of the Future-LIS, and the administrators of Future-LIS will need to engage with internal and external users to ascertain access rights as well as the qualities of the service levels expected. Such qualities could include attributes such as uptime, speed of response, timeliness of data, etc. When the cloud provider does not achieve the metrics specified in the

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SLA, penalties are usually enforced. The MoA may also enter into SLAs with the users of the Future-LIS to give stakeholders confidence in the service quality.

Establish partnerships with other stakeholder organizations

Engagement with stakeholders within the Ethiopian livestock sector is important for the success of the Future-LIS. Stakeholders will have an important role with collecting and formatting data according to the data standards that are agreed upon by the sector. The supply of accurate and timely data into the Future-LIS will be driven by stakeholders understanding the value of the data. If the stakeholders can generate reports that assist them with reporting duties or provide them with useful insights, they are more likely to ensure data are collected according to protocol. It is also important for stakeholders to use and advocate for Stage 1 of the Future-LIS or it will be hard to justify its maintenance or further development into Stage 2.

Engage cloud service provider e.g. AWS

An active partnership with a cloud service provider needs to be established so that costs, componentry, service levels and analytics support can be understood. Engagement with the provider will be shared by the MoA and the developers of the Future-LIS.

Annex 4.2 Development

Annex 4.2.1 User interface

The user interface is the visual part of an information system through which a user can interact with the system. It determines how commands are given to the computer or the program and how data are displayed on the screen.

Develop reports user interface (i.e. Future-LIS Web Console and PowerBI components)

The user interface proof of concept activity will inform the implementation of conventional business intelligence and reporting tooling to develop, test and deploy static and ad hoc reports to MoA stakeholders and wider livestock sector consumers. Regarding the system component model the report user interface is implemented into the Future-LIS Web Console and PowerBI components. Reports can be generated and accessed via reporting interfaces in the data lake user web console or locally via reporting apps in PowerBI.

Select Future-LIS data search facility (e.g. AWS ElasticSearch and DynamoDB)

Due to the complexity of the livestock data environment where a variety of different livestock data sources are integrated and analytical insights are managed, it can become hard to locate data. The data search facility allows users to construct complex natural language type queries to locate data content across the entire Future-LIS analytics platform. Search facilities will be implemented with standard AWS services. In this case, AWS ElasticSearch is recommended to provide the key search functions and associated heavy lifting compute. DyanamoDB is recommended to provide indexed views of livestock data assets.

Select Future-LIS data visualization tooling (e.g. PowerBI)

The data visualization tooling enables the MoA users and livestock participants to perform exploratory data discovery, data analysis, information presentation, data-driven decision-making and other forms of data-related collaboration and investigation. Data visualization tooling functions are recommended to be implemented on PowerBI.

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Select Future-LIS data capture facility (e.g. Future-LIS Web Console)

The data capture facility is designed to allow authorized Future-LIS platform users to capture, catalog and store new datasets that will enrich the Future-LIS data and analytics platform to provide deeper insights into the Ethiopian livestock sector. These datasets may include ad hoc hierarchical structures, new lookup sets and other external reference data from research models through to commercial datasets. The Future-LIS Web Console is recommended to provide the primary data capture facility as a simple webform that can capture additional metadata and tag data fields.

Select Future-LIS data collaboration tooling (e.g. PowerBI)

The data collaboration tooling is designed to enable Future-LIS data platform users such as MoA analysts to easily share and discuss information and insights through existing communication methods as well as contemporary channels such as controlled discussion forums, commentary, "likes" and other concepts adapted from commonly used social media. PowerBI is recommended to be used as the collaboration tool.

Develop Future-LIS advanced analytical modelling environment (e.g. PowerBI)

As the Future-LIS data and analytics platform capability matures and deeper insights are required from both structured and unstructured livestock data sources, an advanced analytical modelling environment will be required to enable advanced users to develop, test and interactively run advanced analytical livestock models. PowerBI has the functionality to provide this advanced analytical modelling tooling.

Annex 4.2.2 Technology enabler deliverables

Technology enablers will provide the back end heavy lifting capabilities to drive the Future-LIS data platform and analytics functionality.

Develop Identity Access Management Security (IAMS) - federated data access

IAMS is a core enabling capability which transparently accesses and integrates data from a variety of MoA and remote databases and other data sources to present livestock data as a logically integrated and coherent dataset in business terms to the end users and stakeholders. To this end, the federated data access tool decomposes the query into (physical) subqueries for submission to the relevant constituent databases and data systems, after which it integrates the result sets of the composite subqueries. Because various database management systems employ different query languages, federated database systems typically apply wrappers to the subqueries to translate them into the appropriate query languages. Through this data abstraction, the federated data access tool will provide a uniform user interface to all the Future-LIS user interface tools. This will enable users to search, store, access and retrieve data from multiple and different databases through a single (logical) query, irrespective of how different the constituent databases are with respect to structure and interface language.

Develop Future-LIS Data Quality Management (DQM) facilities

The Future-LIS data and analytics platform will be operating in a complex technical environment where a large variety of different data sources are integrated. Data quality measurement, reporting and integrated data quality management are of crucial importance to ensure quality information is provided to all stakeholders. Where this is not possible, e.g. due to bad quality source data, the level of data quality will be established and escalated to the appropriate operational or livestock data governance authorities for mitigation. The Future-LIS DQM facilities are recommended to use serverless lambda functions, S3 storage and AWS glue to implement DQM rules and logic.

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Develop Future-LIS data lake - structured and unstructured data

A data lake capability will be required for the Future-LIS to store structured, semi-structured and unstructured livestock information from multiple internal, external and ad hoc data sources. The data lake capability will be implemented on inexpensive cloud storage to enable a scaled approach to livestock data storage while drastically reducing initial capital expenditure. Structured datasets such as extracts from MoA will be ingested through the web console, receipted as raw storage in S3, processed through lambda and AWS glue before being moved to cleaned and curated S3 storage buckets.

Develop data discovery engine

The data discovery engine interrogates remote database schemas and data structures, as well as investigates their content data at a detailed level. The engine also catalogs the data in physical and logical terms in the integrated metadata management tool. The mapping component of the data discovery engine allows users to discover, explore and define mappings between the various data sources, using typical joins, business rules and other user-defined data aggregation definitions. For Future-LIS, data discovery is designed to be implemented in the web console. Metadata values detailing key attributes that make MoA datasets discoverable to data consumers, such as reports, are stored in DynamoDB.

Develop ETL - Processing

ETL processing refers to the data movement capability required to move livestock data from the source systems into the Future-LIS data lake as an initial batch load and/or incrementally on an ongoing basis. ETL processing will also enforce interoperability standards and policies as defined. It is recommended that for Future-LIS the ETL processing function is executed via AWS glue functions.

Develop data stream processing engine

As the Ethiopian livestock sector matures, a data streaming capability will be required to ingest streaming data such as livestock IOT (internet of things) feeds. High volume livestock market data will be ingested into the Future-LIS data and analytics platform for processing and value generating modelling.

Develop analytics engine

The analytics engine capability is a core component of the Future-LIS as it will drive the storage and compute analytics processing of the data and analytics platform. Data analytics engine functionality of the Future-LIS will be addressed using cloud watch logs and cloud watch monitoring. The exact analytics requirements and specifications need to be determined by the MoA once prioritization of data needs has been established.

Develop Artificial Intelligent services

Cognitive Analytics is an emerging area which brings human interaction, intelligence and learning characteristics into analytical systems. It includes capabilities such as Natural Language Processing (NLP), Machine Learning, Artificial Intelligence (AI), Semantic Search & Retrieval (across structured and unstructured data sources), large-scale parallel processing and reasoning, data-robots, self-regulating feedback and iteration, and human-style question-and-answer based interfaces. Implementation of AI services is recommended to be configured through AWS machine learning and big data tooling.

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Annex 4.2.3 Metadata

The metadata layer relates to the metadata management capability which forms the cornerstone component of the Future-LIS data and analytics platform. Metadata management creates the connective relationships that bind everything together, and it is the key component through which all the other components interact with each other. The metadata management capability and tooling interact with all the components of the Future-LIS data and analytics platform. Conceptually, it consists of two tightly-coupled dimensions of metadata - data dictionary tooling and business domain tooling.

Establish data dictionary tooling

The data dictionary defines technical metadata such as data sources, mappings, structures, data records and items, table layouts, indexing structures, data types, databases, connectivity details, access methods, sizing and volume details, process logs, audit trails and usage logs. It is recommended that for Future-LIS, data dictionary tooling is comprised of a basic web console form and DynamoDB back end.

Establish business domain tooling

Logical business glossary defines logical / business metadata (e.g. logical data inventory, user views, business rules, definitions, meanings, interpretations, hierarchies, glossaries and derivations). Similar to the data dictionary a basic web form and DynamoDB backend are recommended to be deployed to support business domain tooling.

Annex 4.2.4 Implementation tasks

Once the Future-LIS has been developed, a number of actions will be launched to ensure that is functional and delivering value to users.

Perform user acceptance testing and bug identification

User testing is a process that is used to test the interface and functions of a website, application, mobile app or service where users perform testing processes in realistic conditions. Users give real-time feedback and experiences and make recommendations to improve the product. To ensure that the Future-LIS is fully functional and operating smoothly, extensive user testing and bug identification is recommended.

Appoint Technical Officer to manage Future-LIS post-development

The MoA will need to appoint a Technical Officer to manage the day-to-day running of the Future-LIS and coordinate stakeholder training sessions. There will also need to be ongoing support around Power BI analytics and report generation, so that stakeholders use the Future-LIS to its maximum potential. The Technical Officer will have responsibility for ensuring that the system is working optimally and that any issues are managed quickly and effectively.

Develop a monitoring and evaluation plan

A monitoring and evaluation plan needs to be prepared to measure ongoing usage and the value that the Future-LIS is bringing to the livestock sector in Ethiopia. Metrics around accuracy and amount of collected data together with number of reports that have been generated are central to understanding the utility of the system. It will also be important to receive feedback from a wide range of stakeholders to ensure that the Future-LIS is fit for purpose and being used optimally. Monitoring the performance of the cloud provider will be another focus of the monitoring and evaluation plan.

Train subject matter experts on Power BI

Power BI is a collection of software services, apps, and connectors that interact to transform disparate sources of data into understandable, visually-displayed, and interactive insights. Subject matter experts may need training and assistance to generate the types of reports that will allow them to do their jobs efficiently, and to understand the potential of the Future-LIC for their particular needs.

Schedule regular training by subject matter experts for data consumers on Power BI report generation

Trained subject matter experts will need to train data consumers on the capabilities and potential of using the Power BI function of the Future-LIS. Users are likely going to need to:

- Build graphic and interactive dashboards, and reports that can be shared across their organization;
- Connect to different data sources via direct query;
- Manage various levels of access to reports curated in Power BI; and
- Utilize the alerts and insights features.

Conduct regular training and development for cloud provider support and management

There will need to be general and specific upskilling of MoA staff in cloud technology to provide support, management and ongoing development of the Future-LIS. For AWS cloud service, there are multiple options for training, ranging from online courses through to hosted classes. This training should be targeted at ICT staff including the Technical Officer.

Develop manuals

To support training initiatives, it is recommended that manuals are developed for users to refer to from time to time. A user manual should contain all of the essential information for the user to make full use of the Future-LIS and should have sections covering:

- High level system capabilities overview;
- System functions such as required inputs and expected results;
- Operating instructions;
- Error handling; and
- Policy guidelines.

Annex 4.2.5 Data collection tasks

Develop and complete data collection applications

Data collection has been challenging in the Ethiopian livestock sector. There is a wide range of skill levels amongst the data collectors as well as technological hurdles to overcome. These issues could be mitigated by developing new applications for data collection to augment those already in place. All data collection systems will need to adhere to the agreed data standards so that the data can be incorporated into the Future-LIS. There also needs to be a concerted effort to distribute tools to data collectors, train personnel in the correct use of the tool, and for there to be continued upgrading of technology across the regions.

Conduct training for trainers on data collection tooling across Ethiopia

To disseminate information on how to collect data according to established protocols, a significant number of trainers will need to be upskilled in the use of the data collection tooling. The trainers are recommended to be MoA personnel from across all regions to maximize the impact of the Future-LIS.

Conduct training for data collectors on data collection tooling across Ethiopia

Trainers will be required to implement training sessions on data collection with data collectors throughout the region where they are located.

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