PVS Pathway

PVS Laboratory Mission Report

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PVS SUSTAINABLE LABORATORIES REPORT FOR THE VETERINARY SERVICES OF NIGERIA

(08 – 29 November 2021)

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Acronyms and Abbreviations

Agg	Agglutination
AGID	Agar Gel Immunodiffusion Assay
AH	Animal Health
AHS	African Horse Sickness
AMR	Antimicrobial Resistance
ASF	African Swine Fever
BSL	Biosafety Level
CBPP	Contagious Bovine Pleuropneumonia
CE	Continuous Education
CIF	Cost, Insurance, and Freight
CIRAD	French Agricultural Research and International Cooperation Organisation
CONHESS	Consolidated Health Salary Structure
CONMESS	Consolidated Medical Salary Structure
CONRAISS	Consolidated Research and Allied Institutions Salary Structure
CVO	Chief Veterinary Officer
DET	Data Entry Tool
ELISA	Enzyme-Linked Immunosorbent Assay
EU	European Union
EUR	European Union Euro
FAO	Food and Agriculture Organization of the United Nations
FMARD	Federal Ministry of Agriculture and Rural Development
FMD	Foot and Mouth Disease
FOB	Free On Board
HPAI	Highly Pathogenic Avian Influenza
HPLC	High Performance Liquid Chromatography
IAEA	International Atomic Energy Agency
ILAC	International Laboratory Accreditation Cooperation
IBDV	Infectious Bursal Disease Virus
IFA	Immunofluorescence Assay
IGR	Internal General Revenue
ISO	International Organization for Standardization

K	Thousand
LIMS	Laboratory Information Management System
LSD	Lumpy Skin Disease
M	Million
NAFDAC	National Agency for Food and Drug Administration and Control
NCDC	Nigeria Centre for Disease Control
ND	Newcastle Disease
NGS	Next Generation Sequencing
NiNAS	Nigerian National Accreditation Service
NVRI	National Veterinary Research Institute
WOAH	World Organisation for Animal Health
PCR	Polymerase Chain Reaction
PPR	Peste des Petits Ruminants
PT	Proficiency Test
PVS	Performance of Veterinary Services
QMS	Quality Management System
RP	Rinderpest
RVF	Rift Valley Fever
rtPCR	Real Time PCR
SVL	State Veterinary Laboratory
TAD	Transboundary Animal Disease
TB	Tuberculosis
USD	United States Dollar
VS	Veterinary Services
VTH	Veterinary Teaching Hospital
WHO	World Health Organization

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Executive Summary

The PVS Sustainable Laboratories Mission provides in-depth analysis of the pertinence and efficiency of the national laboratory network, including appropriate balance of resources, based on national diagnostic needs in the veterinary domain.

The objective of the PVS Pathway Sustainable Laboratories Mission in Nigeria was to provide decision makers with information that will allow them to allocate appropriate resources to the veterinary laboratory network, and to make strategic decisions to support accurate and timely animal disease diagnosis, and to ensure the sustainability of the laboratory network.

The national veterinary laboratory network of Nigeria comprises the National Veterinary Research Institute (NVRI, Vom) as the national reference laboratory, 10 State Veterinary Laboratories, and 11 Veterinary Teaching Hospitals. Despite the efforts of the Expert Team and the Country Team to gather data from all network laboratories, information received was mainly provided by the NVRI.

Considering that the Veterinary Services do not conduct active surveillance for most diseases on an annual basis, it was difficult to estimate prospective demand for laboratory services. It was not possible to determine the exact operational capacity of the network due to its complexity and the paucity of information available and gathered. Nevertheless, and given the information provided, the Expert Team estimated that the current workload at NVRI could be absorbed by 29.9% of current technical staff, indicating that there are improvements to be made leverage existing human resources. Vaccine production is a very important activity of the NVRI and investing in the optimization of all vaccine production could be a feasible way to improve the NVRI's sustainability.

Four strategic options were purposed as potential alternatives to the current network configuration to improve its sustainability. Option 1 assumes that current sample throughput is stable over the next 5 years and no changes are made to the existing laboratory network. In Option 2, NVRI would be maintained as the National Reference Laboratory and supported by 2-4 specialized laboratories located strategically in areas of relevant intensive livestock production. In Option 3, NVRI would be maintained as the National Reference Laboratory, supported by 2-4 specialized laboratories, and the State Veterinary Laboratories participate in specific Animal Health programmes. Option 4 is like Option 3, but the State Veterinary Laboratories would be privatized.

The lack of some key information like the prospective demand related to Animal Health (AH) programmes and detailed budgetary data from NVRI hindered the full application of the mission tools to estimate the costs and financial benefits for each Option. Nevertheless, it was evident that National Veterinary Laboratory Network will benefit from reducing the number of laboratories and reviewing the overall role and mandate of the Veterinary Teaching Hospitals.

The Expert Team identified the following recommendations to strengthen the sustainability of the national veterinary laboratory network:

- ✓ Re-evaluate the NVRI organogram and human resources management.
- ✓ Formalize and strengthen the role of NVRI as the National Reference Laboratory.
- ✓ Optimize the Quality Management System and biosafety and biosecurity management.
- ✓ Ensure relevant data management.
- ✓ Define and implement Animal Health Surveillance Programmes for priority animal diseases.

- ✓ Re-evaluate the NVRI disease diagnostic price policy and encourage partnerships where relevant.
- ✓ Re-evaluate vaccine production management.
- ✓ Implement the experience gained from previous WOAH Twinning projects.
- ✓ Extend recommended action plans using the One Health approach.

As in many countries, the national laboratory network in Nigeria is underutilised by the Veterinary Services (VS): only 5.3% of the samples received by the NVRI were submitted by the VS. Due to the insufficient active surveillance activities, Nigeria is not taking advantage of the existing infrastructure and expertise of Nigeria's national laboratory network. To achieve sustainability in the medium-term, use of and demand for laboratory services is critical, concretely through increased sample submission into the national laboratory network. Linking demand and need for laboratory services to the size of the national laboratory network to produce results for action by the VS is essential.

This report demonstrates the importance that Veterinary Services official animal health programmes have on the sustainability of the national veterinary laboratory network. The Veterinary Services should prioritize establishment of official animal health programmes based on sound scientific data relevant to Nigeria's context. For the veterinary laboratory network to be sustainable and efficient, it is necessary to ensure regular submission of samples to the laboratories, the maintenance of a variety of relevant assays to meet current and future demand, the use of fully maintained and calibrated equipment by competent personnel, while avoiding duplication and wastage of resources.

I. Introduction

I.1. Scope and objectives of the mission

The PVS Sustainable Laboratories Mission provides in-depth analysis of the pertinence and efficiency of the national laboratory network, including an appropriate balance of resources, based on national diagnostic needs in the veterinary domain.

Nigeria's PVS Evaluation was conducted in 2007, followed by the Gap Analysis mission in 2010, and the PVS Evaluation Follow-up mission in 2019. A PVS Sustainable Laboratories Mission was conducted by video conference 8 to 29 November 2021 by a team of PVS Experts.

The PVS Mission reports, especially those from the Gap Analysis and Follow-up mission, made the following observations about the veterinary laboratory network and the VS in Nigeria:

- The National Veterinary Research Institute (NVRI) has relatively good physical facilities and adequate equipment to undertake the diagnosis of priority animal diseases in Nigeria. NVRI has excellent facilities for Highly Pathogenic Avian Influenza (HPAI) diagnosis and features a modern Biosafety Level (BSL) 3 laboratory in which Rinderpest (RP) virus sequencing was undertaken. The institute also produces and provides vaccines based on demand to the Federal and State governments as well as to private veterinarians and individual livestock owners. However, facilities and equipment are inadequate to produce sufficient vaccine doses to meet the requirements of effective vaccination programmes.
- The NVRI has a valuable asset of very well-trained staff (40 out of 180 hold a post-doctoral degree) which is grossly underutilised due to low number of samples resulting from the funding structure of NVRI activities dominated by research funding. Despite this difficult situation, staff participate in many training programmes, often supported by international partners, and the institute also organises short courses for Continuous Education (CE) of its staff.
- There is a need to strengthen the technical capacities of the State Veterinary Laboratories (SVLs) and to develop the Quality Management System (QMS) in the reference laboratory.
- Out of the 23 satellite laboratories that support the national laboratory network, the NVRI considers only 6 adequate to carry out diagnostic services. The other laboratories are mainly vaccine distribution centres or State VS centres for disease investigation. The diagnostic capacity at the State level is minimal, despite the availability of well-trained veterinary personnel. The SVLs can only provide basic diagnostic services such as complete blood counts, parasitological identification of haemoparasites and gastrointestinal parasites. Limitations are mainly due to unreliable power supply and insufficient consumables. Most equipment in these laboratories is old, or in various states of disrepair and often has not been routinely calibrated or maintained.

Other pertinent laboratory information from the 2007 PVS Gap Analysis Report and the 2019 PVS Follow-up Report is included in Appendix 1.

The purpose of many laboratory-related technical evaluation missions is to assess or evaluate technical capacity and suggest improvements. As these types of missions are generally constrained by the short-term technical objectives, they often do not allow for the in-depth examination of substantive systemic or strategic and management issues. The most frequent

outcome of these missions is at best partial examination of structures and systems, to the detriment of an overarching or strategic view. Often this leads to technical recommendations and thereafter over-investment in structures that countries are unable to properly maintain and financially support over time.

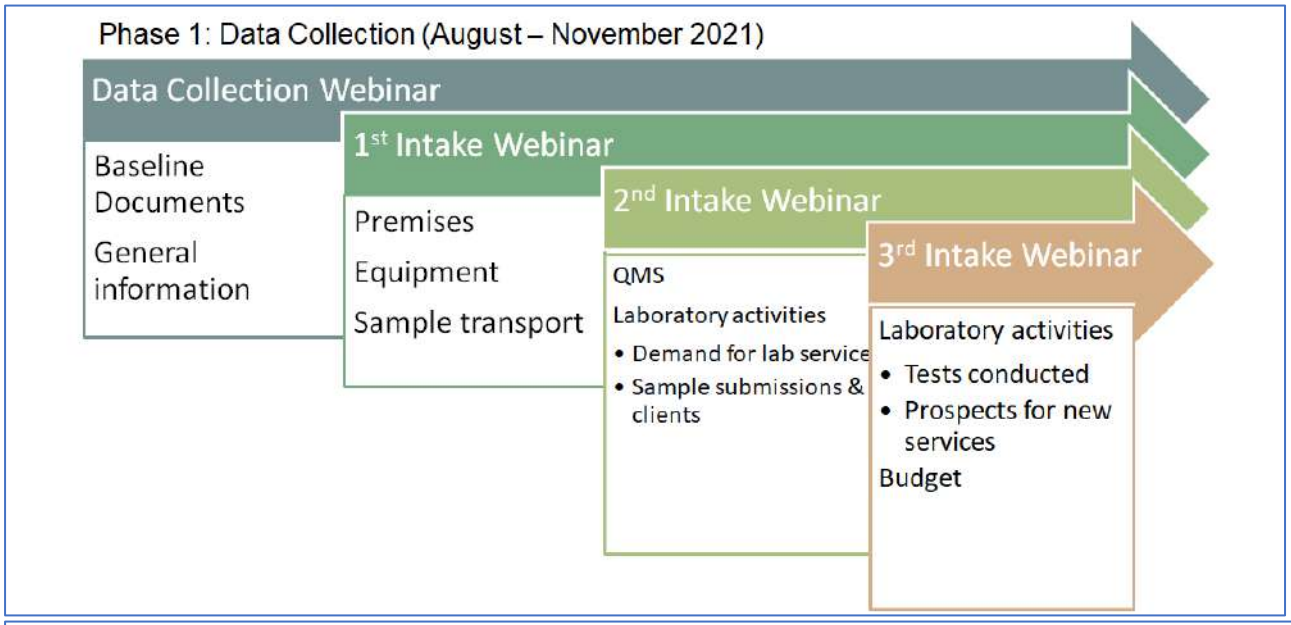
The overall objective of the PVS Sustainable Laboratories Mission is to provide Veterinary Services and its decision makers with information to advocate for the allocation of appropriate resources to the National Veterinary Laboratory Network and to make strategic decisions to support accurate, safe, and timely diagnosis, while ensuring the sustainability of the laboratory network through the provision of budgetary and resource simulations based on the demand for diagnostic services.

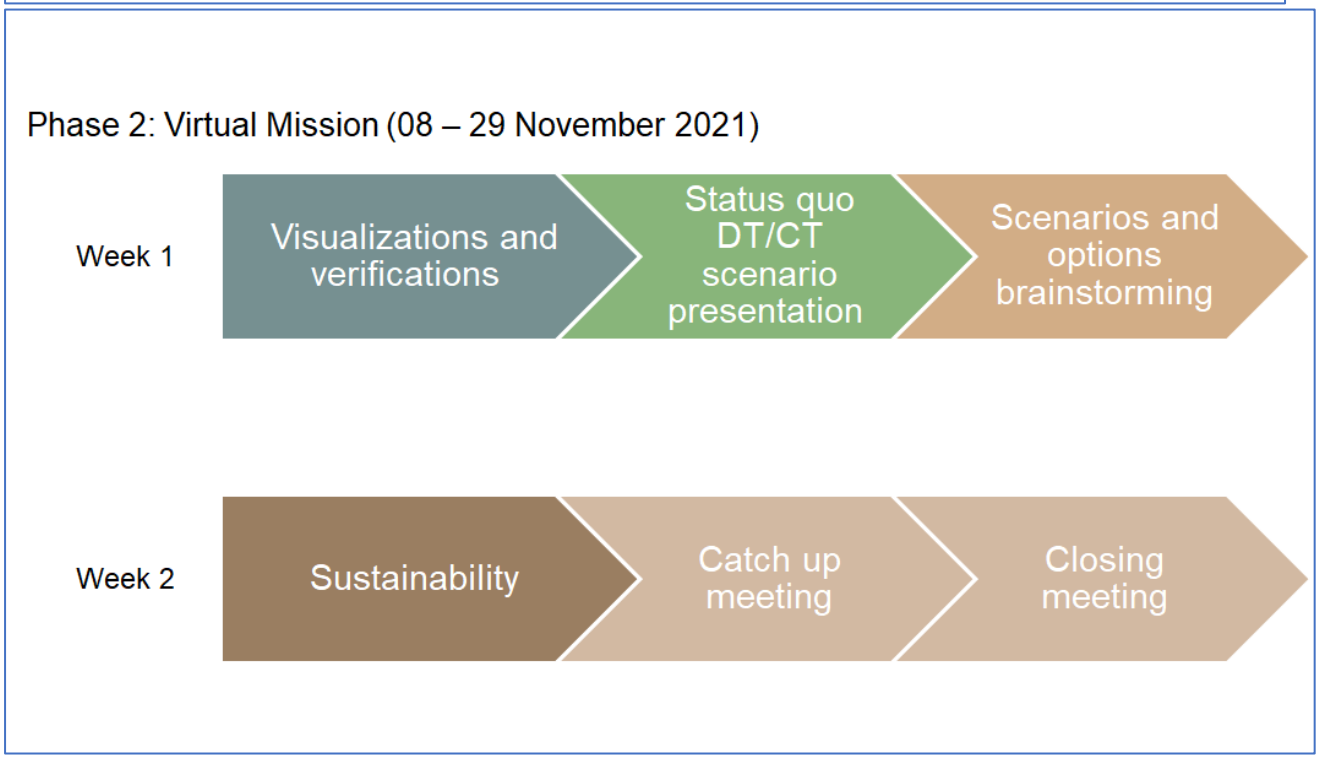
I.2. Context of the mission

The Nigeria mission was the second mission to be conducted using a fully virtual format without a face-to-face component, due to travel restrictions resulting from the COVID-19 pandemic. The Expert Team was made of independent PVS Experts: Dr André de Oliveira Mendonça as Team Leader, Dr Ibrahim Diallo, Ms Barbara Martin, and Mr David Korcal as technical experts, and Ms Jennifer Lasley, Dr Valentyna Sharandak, and Dr Karim Tounkara as WOAH Observers. The process consisted of the following phases:

- **Phase 1 - Data Collection** took place from August to November 2021 during a series of webinars with laboratory and VS representatives. The main goal of the webinars was to present and demonstrate the Data Entry Tool (DET), to assist in any issues encountered and to validate the data entered in the DET. The country team provided data from various laboratories including NVRI, Veterinary Teaching Hospitals (VTHs) and SVLs (Appendix 2).
- **Phase 2 - Calculation and Simulation** was conducted in November 2021. This phase began with the Mission Kick-off meeting, a broader meeting aimed at explaining the objectives of the mission, the tools used, and the importance of data collection, which will help determine possible options for working towards the goal of laboratory sustainability and discuss these options with the stakeholders. Meetings were held with the country team, in interview or discussion format with stakeholders of options and strategies to strengthen the laboratory network and ensure its sustainability
- **Phase 3 - Report Writing** conducted at the end of the mission was aimed at documenting and summarizing the mission's findings in a final report including options, data visualizations, and strategies for a sustainable national laboratory network.

Figure 1. PVS Sustainable Laboratories mission for Nigeria





I.3. Limitations to the mission

The evaluation of the veterinary laboratory network's sustainability should consider various aspects such as the allocated budget, sanitary status, operational capacity, sample numbers, human and physical resources, cost of reagents, transportation logistics, environment, biosafety and biosecurity, and current and potential markets. The Expert Team used available information to evaluate possible and strategic options to improve the network sustainability. However, the Expert Team was confronted with the following challenges:

- ✓ **Remote format:** Due to travel restrictions, the Expert Team was not able to verify "in loco" some information, which may be gathered through observations during laboratory visits. Nigeria's complex and large veterinary laboratory network presented challenges for a fully remote format. While the remote format was suitable for the first phase of the mission, the teams faced limitations in the second phase, especially related to knowledge of the infrastructure and lack of in-person contact with laboratory staff. Pictures and videos of laboratories were requested but only received from the NVRI.
- ✓ **Time and time zones:** The mission team included professionals from Nigeria, Brazil, USA, Australia, and France. Because of time zone differences, the time dedicated to meetings was limited which affected the time for interactions with the country team.
- ✓ **Lack of data:** Few data were provided, especially by the SVLs and VTHs, on laboratory staffing, management, and resources, which made it challenging to see a complete picture of the laboratory network's current situation. In some cases, the laboratories had difficulties completing the DET due to use of outdated versions of Microsoft Excel software and the inability to run embedded macros. The lack of some key information like the prospective demand related to Animal Health (AH) programmes and detailed budgetary data from NVRI hindered the full application of the mission tools.
- ✓ **Gaps in the stakeholders' contact:** There was a limited access to some key stakeholders, such as the Nigerian Centre for Disease Control (NCDC) and other organizations of the Ministry of Health; producer associations, like the Poultry Association of Nigeria; main donors, like the Food and Agriculture Organization (FAO), World Bank and the Fleming Fund; representatives from the National Agency for Food and Drug Administration and Control (NAFDAC) and key private laboratories. This limited understanding of the Nigeria's context regarding Animal Health, One Health, and the funding landscape. The reasons for the difficulty to schedule interviews with these critical stakeholders was not clear to the Expert Team.
- ✓ **Limitations to evaluate some documents:** Several key documents were provided late in the mission, making thoughtful review and exchange difficult. The format of the information related to the financial management made the calculation of the costs related to each option more difficult, since the information provided considered both the vaccine production and diagnostic activities. The complexity of the salary policy and career plan of the civil servants brought further challenges to the calculation of human resources costs.

I.4. General organisation of the veterinary laboratory network[1]

The current national veterinary laboratory network of Nigeria comprises:

- The National Reference Laboratory (NVRI, Vom)
- 10 SVLs based in Lagos, Ekiti, Osun, Delta, Gombe, Ondo, Enugu, Ogun, Bauchi and Jigawa
- 11 VTHs (Ahmadu Bello University, Zaria; University of Ibadan; Usman Dan Fodio University, Sokoto; University of Ilorin; University of Nigeria Nsukka; University of Maiduguri; Federal University of Agriculture, Michael Okpara University, Umudike; University of Jos; Federal University of Agriculture, Makurdi; Federal University of Agriculture, Abeokuta; University of Abuja).

National Veterinary Research Institute in Vom (NVRI)

The NVRI started operation as a Veterinary Department in Zaria in 1913 and moved to Foron District of the then Bauchi-Plateau province in 1921/1922. Foron was hilly and unsuitable for pastoral growth required for cattle, so the then Chief of Vwang (Vom) offered alternative and attractive land at Vom which is the Institute's present site. By the Agricultural Research Institutes Act 35 of 1975, the name Federal Department of Veterinary Research was changed to National Veterinary Research Institute (NVRI) Vom. The NVRI organogram is shown in Appendix 3.

The NVRI is a parastatal of the Federal Ministry of Agriculture and Rural Development (FMARD), and its mandate has developed from being a serum production institution for the control of RP over 90 years to a broader-based Institute. NVRI currently conducts research on all aspects of animal diseases, their treatment and control, and produces animal vaccines. The Institute is the national laboratory responsible for disease surveillance and diagnoses, confirming and reporting any animal disease or epidemic to the FMARD; it is also responsible for extending veterinary services to livestock and poultry farmers and providing liaison and advisory services to farmers.

The NVRI is developing a QMS consistent with the International Organization for Standardization (ISO) 17025. There is a Quality Manual, effective since 23/08/2021. The Institute plans to apply for ISO 17025 accreditation in 2022, although the scope of accreditation has not been determined. The Nigerian National Accreditation Service (NiNAS) has been selected as the accrediting body and is affiliated with the International Laboratory Accreditation Cooperation (ILAC).

The NVRI has a Strategic Plan (2021-2025), which includes upscaling of vaccine production to meet national and regional demands; conducting research on all aspects of animal diseases and zoonosis with the development of intervention strategies; conducting disease surveillance and providing timely diagnosis; developing and maintaining a dynamic, comprehensive animal disease database, and establishing a QMS.

The salary policy of the civil servants employed by the NVRI comprises different structures: Consolidated Research and Allied Institutions Salary Structure (CONRAISS), Consolidated Health Salary Structure (CONHESS) and Consolidated Medical Salary Structure (CONMESS). These salary structures are complex and have various levels and steps of progression, based on level of education, qualification, and time of service. The positions for the laboratory staff include

[1] This section was based on the following references: Decree FMARD n. 35/1975; NVRI Annual Report 2019 and 2020; NVRI Audit Account 2018; One Health Strategic Plan 2019-2023; NVRI Quality Manual 2021; NVRI Strategic Plan 2021-2025

Veterinary Research Officer, Research Officer, Animal Health/Husbandry Technologist, Medical Laboratory Scientist, Medical Laboratory Assistant, Laboratory Attendant and Science Laboratory Technologist.

The NVRI has completed three WOAH twinning programmes: Rabies in 2012 (Onderstepoort Veterinary Institute, South Africa), Foot and Mouth Disease (FMD) in 2018 (Sciensano, Belgium), and HPAI in 2019 (Istituto Zooprofilattico Sperimentale delle Venezie, Italy). It has a BSL 3 laboratory built with the support of the Canadian Government.

The FMARD took part in the elaboration of the "One Health Strategic Plan (2019-2023)", under the coordination of the NCDC. The main goal of this Plan was to build a strategic, dynamic, and functional platform that advances human, animal, and environmental health through multidisciplinary and inter-sectoral collaboration to be implemented through five thematic areas: surveillance and response, training and research, governance and leadership, communication, and resource mobilization. This document lists the priority zoonotic diseases in Nigeria as showed in Table 1. The information related to the priority animal diseases was provided by the CVO. The NVRI Director commented that the Institute priorities should consider the following criteria: economic relevance (e.g., ND, PPR, FMD and CBPP), zoonosis diagnostic (e.g., brucellosis and rabies) and eradication programmes (e.g., PPR, CBPP, sheep and goat pox).

Table 1. Priority animal and zoonotic diseases in Nigeria

Priority animal diseases	**Priority zoonotic diseases**
Contagious Bovine Pleuropneumonia (CBPP)	Rabies
FMD	HPAI
Peste des Petits Ruminants (PPR)	Ebola
Newcastle Disease (ND)	Swine influenza
HPAI	Anthrax
Rabies	Tuberculosis
African Swine Fever (ASF)	African Trypanosomiasis
	Lassa Fever
	Escherichia coli O157
	Brucellosis

SVLs and VTHs

Less is understood about the role of the SVLs and VTHs in the laboratory network. The activities developed by the SVLs and VTHs related to AH programmes are essentially related to the early detection of suspected priority infectious diseases. The laboratory carries out an initial diagnosis and then sends samples to the NVRI for confirmation or sends the samples directly to the NVRI when the symptoms or the necropsy of carcasses suggest a suspicion of a priority infectious disease. Most of these laboratories carry out basic assays and most of them attend to clinical demands of pet animals.

The NVRI does not have authority over or supervision of SVLs and VTHs. The role of the NVRI in the network is focused on training and receiving samples for confirmatory diagnosis. Few information was provided about laboratory staffing, management, and resources of the SVLs and VTHs.

II.Demand for laboratory services

Livestock population and production

Table 2 shows the comparative numbers of livestock census in Nigeria considering two different sources FAOSTAT (2008) and Nigeria's census (2016). The ruminant population is concentrated in the Northern region of Nigeria[2], while poultry production is predominant in the Southern region.

Table 2. Nigeria's livestock census data

Animal species	Total Number according to FAOSTAT 2008[3]	Total Number according to Nigeria's census 2018[4]
Poultry	175,000,000	193,578,483
Goats	53,800,400	79,989,676
Sheep	33,874,300	45,617,031
Cattle	16,293,200	20,231,592
Pig	6,908,030	8,267,279
Asses	1,050,000	978,402
Horses	207,830	102,324

Methodology

Using the PVS Sustainable Laboratories Mission methodology and tools, the Expert Team collected information on the demand for laboratory services. The data was compiled from the DET filled in by NVRI divisions and interviews with laboratory staff to validate information provided. This information is presented in the demand and supply sections of the report.

Laboratory Clients

Despite the importance of livestock production in Nigeria and the high number of animals, especially ruminants and poultry, the current demand for the veterinary laboratory services in Nigeria is based mainly on passive surveillance undertaken for VS, although active surveillance for HPAI, ASF, Rabbit Haemorrhagic Disease and FMD was sporadically carried out. Other clients for laboratory services include:

- ✓ Research projects (individual projects and partnerships with universities and institutes)
- ✓ Individual Farmers/Owners requests primarily for basic parasitology and haematology

[2] According to a survey conducted by the Environmental Research Group Oxford Limited and released by the FAO (https://www.fao.org/livestock/agap/frg/FEEDback/War/t1300b/t1300b0g.htm)
[3] WOAH Gap Analysis report
[4] Source: Federal Department of Animal Husbandry Services, Federal Ministry of Agriculture & Rural Development

- ✓ Country programs such as HPAI and equine influenza surveillance, REDISSE, LIDISKI and AMR are supported by FAO, World Bank, EU and the Fleming Fund respectively
- ✓ Food and feed industry
- ✓ Pet animal clinics

Figure 2 shows the NVRI current annual demand by client category.

Figure 2. NVRI current annual demand by client category – 2021

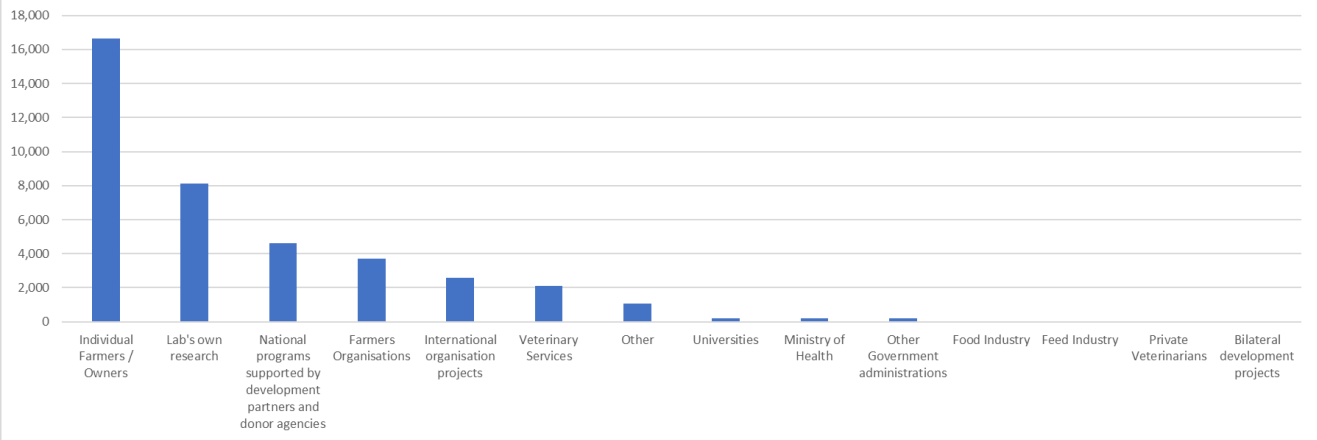


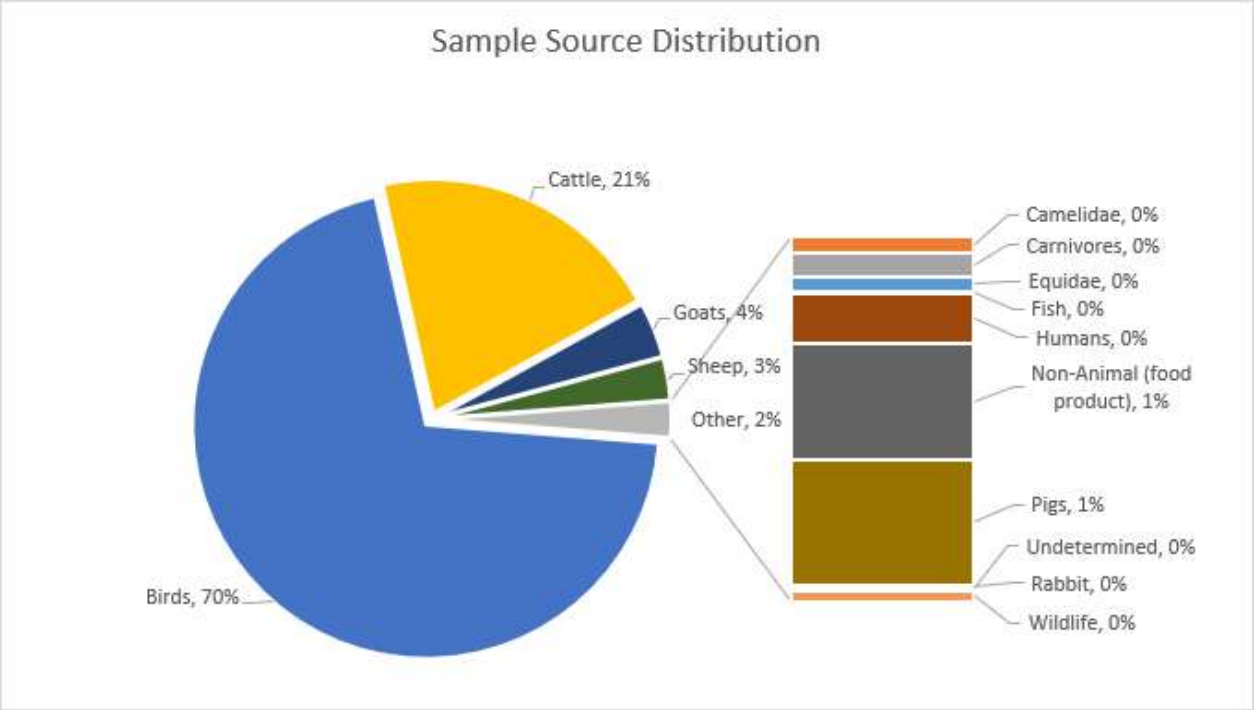
Figure 2 highlights the underutilisation of the laboratory function to support VS activities and the need to increase the sample submission to strengthen AH laboratory surveillance. Only 5.3% of the samples received by the NVRI are submitted by the VS. According to interviews carried out with the SVLs and VTHs representatives, the proportion of sample submissions may be similar or fewer in these laboratories.

The number of samples related to research and projects represents almost 40% of the total, which is in direct correlation with the sources of financial resources but may compound the underutilisation of the laboratory function by the VS: the volume of activity of external priorities may drive perception about the laboratory's capacity to increase VS active surveillance or laboratory usage.

Another critical observation is the low number of samples from the feed and food industry. According to the data gathered, the feed and food industries' submissions constitute less than 1% of testing demand (0.1%). These data reveal a window of opportunity for NVRI to strengthen its client base in this field. On the other hand, the data suggest that not all feed and food products on the market are checked for their quality and safety, highlighting an area of concern for consumers and opportunity for expansion. The current mission did not have access to information about the submission of samples from feed and food industry for other public or private laboratories who did not participate in the mission, besides NVRI.

The distribution of samples from different species (Figure 3) is consistent with Nigeria's livestock census data, although the number of samples from sheep and goats is significantly lower when compared to their population. While the sheep and goat population represent approximately 30% of the animal population in Nigeria, the number of samples sent to the NVRI from these species is less than 10%, suggesting an opportunity to improve disease diagnostics in these species.

Figure 3. Sample source distribution by species – NVRI 2021



Note: 0% represent values < 1%

Demand for Laboratory Services

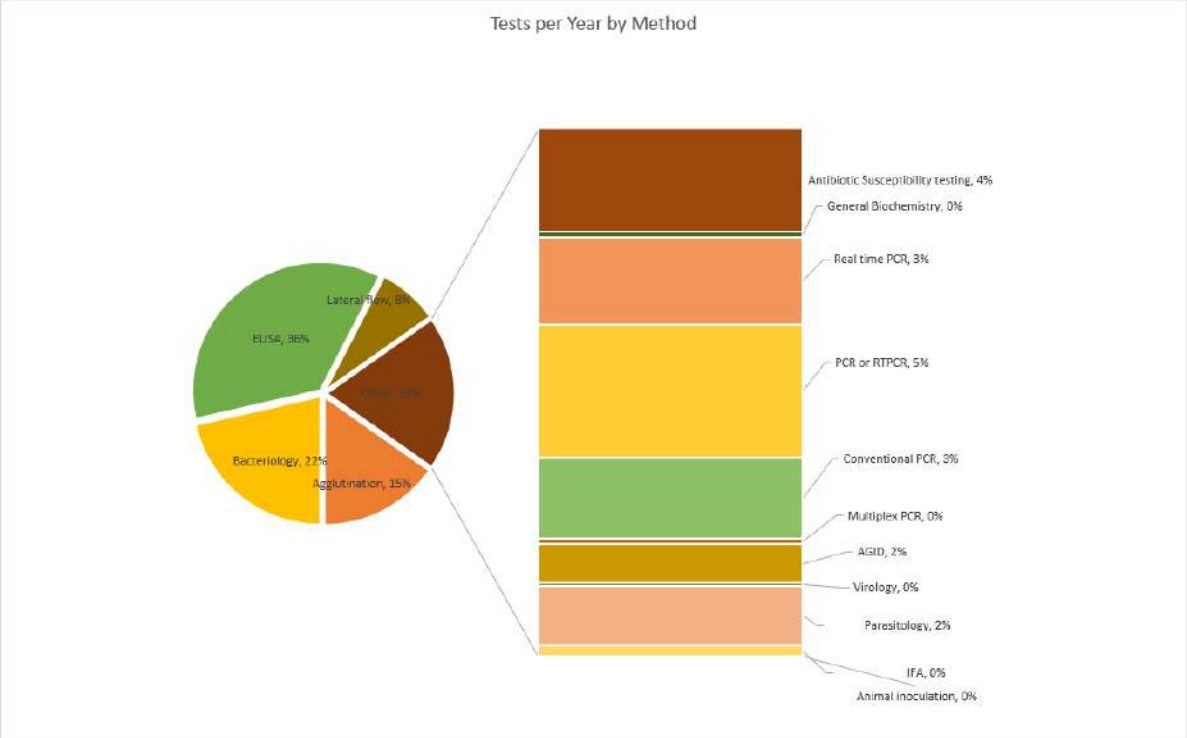
Appendix 4 shows the detailed demand for laboratory services received by the NVRI in 2021, by disease and by method. These data show that there is a large discrepancy between the number of samples received by the Bacteriology Research Division and the other Divisions. This difference can be explained by the research projects carried out by students in the Bacteriology Research Division.

A positive aspect observed is the capacity of the NVRI to provide a broad array of diagnosis and methods. On the other hand, the processing of a low number of samples for some purposes may affect the efficiency of the laboratory, especially when the method used demands specific reagents, such as primers, positive controls, and standards. Reagent costs can be optimized by using all reagents according to protocol within the expiry date. The same principle can be applied to the costs related to equipment calibration and maintenance. The total cost of conducting a test decrease when run sizes are optimized, taking full advantage of the reagents and equipment.

The high number of samples related to the diagnosis of goat pox is related to a recent outbreak of this disease in Nigeria and those related to PPR are from an active surveillance program for this disease carried out in 2020 and funded by the European Union (EU, LIDISKI project).

The distribution as a percentage of the total tests carried out in 2021 by method is showed in Figure 4.

Figure 4. Distribution of tests carried out by the NVRI in 2021 by methods



Note: 0% represent values < 1%

The demand of the SVLs and VTHs was not compiled with the NVRI's demand, because few and incomplete information from these laboratories were received. However, based on interviews held with SVLs and VTHs representatives, it can be concluded that the demand for these laboratories' services was predominantly related to basic parasitology and haematology and samples taken from pet animals. When there is a suspicion of a priority animal disease, based on the clinical symptoms or necropsy findings, the SVLs and VTHs send the samples to the NVRI.

The Federal Government does not routinely allocate funds to the SVLs and VTHs, because they are funded by the state governments and the universities respectively. However, when there is an outbreak of a priority animal disease or when the VS organizes epidemiological surveillance, the Federal Government allocates required financial resources or distributes reagents or equipment needed for the activity (e.g., outbreak of ASF) to SVLs and VTHs.

Prospective Demand for laboratory services

Considering that the VS does not routinely carry out active surveillance, it was difficult to estimate the prospective demand during the mission. Nevertheless, it is estimated that the Bacteriology Research Division will receive a high number of samples next year related to the diagnosis of Brucellosis, Salmonellosis, and Mycoplasmosis for research purposes, as shown in Table 3. However, it was not possible to evaluate if this scenario is feasible because the Expert Team was not given enough information regarding the source of funding, the real numbers of samples expected to be tested by disease, and the time schedule of such research. The FMD Division expects an increase in prospective demand for the diagnosis of African Horse Sickness due to the occurrence of outbreaks in neighbouring countries.

Table 3. Estimates of the NVRI prospective demand for 2022

Test	Method	Potential Client	Potential number of tests per year
Salmonellosis (*S. abortusovis*)	Bacterial identification	Farmers and students	400,000
	Antibiotic Susceptibility testing	Farmers and students	500,000
Mycoplasma mycoides subsp. mycoides	Bacterial identification	Farmers and students	100,000
	Enzyme-Linked Immunosorbent Assay (ELISA)	Farmers and students	250,000
Brucella abortus, B. melitensis and B. suis	Agglutination (Agg)	Farmers	40,000
	Lateral Flow	Farmers and students	10,000
	Bacterial identification	Farmers	40,000
Feed analysis	Chemistry	Feed industry, farmers	1,000
AI	Real Time Polymerase Chain Reaction (rtPCR)	Farmers	500
ND	rtPCR	Farmers	500
Antibiotics	Gas Chromatography	Academia, government agencies	500
Hormones and anabolics	HPLC	Polo Tournaments & Horse owners	200
Other residues or contaminants	HPLC	Government regulatory agencies	200
Pesticides	Chemistry	Academia, industry, and government agencies	200
Infectious Bursal Disease Virus (IBDV)	AGID	Farmers	200
Fowl pox	AGID	Farmers	100
African horse sickness virus	ELISA	Polo Club	100
Total			1,343,500

Another opportunity for increased prospective demand is related to honey production and exportation. According to some stakeholders, this market is promising for Nigeria. Another market which may increase is that related to dairy cattle (e.g., milk and other products). No information was provided for other important diseases such as PPR, Anthrax, LSD, FMD, haemorrhagic septicaemia, etc.

Another promising activity is vaccine production. The NVRI oversees livestock vaccine production in Nigeria. Table 4 shows annual production since 2018.

According to the information gathered during interviews, the demand for vaccine production is higher than the volume produced in the past years, despite increases in production observed in 2020. Aside the demand from Nigerian farmers, the NVRI receives orders from neighbouring countries, especially for CBPP.

Table 4. NVRI Vaccine production (2018-2020)

Vaccine		Doses produced		
		2018	2019	2020
Viral	Fowl Pox	2,046,200	4,279,600	5,469,000
	Rabies	38,951	54,454	37,878
	ND LaSota	13,225,600	13,361,200	20,546,600
	ND Komarov	3,386,000	5,359,600	5,638,200
	ND Hitchner B1	3,118,000	0	2,392,200
	ND I2	7,444,150	8,012,400	12,632,250
	PPR	1,942,150	2,338,850	3,873,350
	IBDV	4,518,400	6,093,800	5,818,600
Bacterial	Anthrax	1,850,000	2,042,800	1,527,080
	CPBB	8,721,100	5,917,400	5,141,600
	Fowl Cholera	433,200	383,400	68,600
	Clostridium choevoei	2,273,500	3,484,000	2,959,560
	Clostridium novyi	187,480	195,600	112,880
	Fowl Typhoid	3,555,200	3,946,400	2,534,500
	Brucella 19 V	2,595,300	0	0
	HS	378,080	341,120	263,120
TOTAL VIRAL		**35,719,451**	**39,499,904**	**56,408,078**
TOTAL BACTERIAL		**19,993,860**	**16,310,720**	**12,607,340**
TOTAL		**55,713,311**	**55,810,624**	**69,015,418**

When vaccine production is analysed closely, a different pattern appears. There is an overall increase in vaccine production, influenced by ND, fowl pox and PPR vaccine production. On the other hand, there is a notable decrease in the vaccine production for major, economically important animal diseases such as CBPP, anthrax, haemorrhagic septicaemia, and rabies. Furthermore, brucella vaccine went from 2,395,500 doses in 2018 to zero in 2019 and 2020 for no justified reason. It is to be noted that despite the economic importance of the above-mentioned diseases, there are no systematic annual vaccination programmes, which might explain the decrease in their production.

When vaccine production is compared to animal population by species, it becomes obvious that NVRI is struggling to satisfy the demand for its vaccines. Nigeria's poultry population in 2020 was reported at 145M chicken, 11.6M ducks and 1.2M turkeys, totalling 157.8M poultry[5]. Vaccine production for fowl pox is at approximately 5.5M doses, fowl cholera at 68,600 doses, and fowl typhoid at approximately 2.5M doses. These numbers suggest an opportunity to increase the avian diseases vaccine production. It is interesting to note that there is no porcine vaccine produced by NVRI, although Nigeria has a porcine population of 7.1M.

[5] Nigeria Premium Times – premiumtimesng.com: Nigeria releases census of goats, sheep, pigs and other livestock in country, June 2, 2016. https://www.premiumtimesng.com/news/top-news/204577-nigeria-releases-census-goats-sheep-pigs-livestocks-country.html

Analysis of the supply of veterinary laboratory analysis

III.1 Current capacity of the national veterinary laboratory network

According to the CVO, the current capacity of the national veterinary laboratory network is sufficient to meet the demands of the VS in terms of methods offered and testing of pathogens/analytes.

The NVRI is the national reference laboratory with the capability to carry out a wide variety of assays, except for genetic sequencing. Although it has two sequencers[6], they are currently not functional, requiring the NVRI to send samples to be sequenced to international laboratories in South Korea and the Netherlands.

It was not possible to determine the exact operational capacity of the network due to its complexity and the lack of information gathered from the SVLs and VTHs. The laboratory network is composed of 39 laboratories, of which 13 are part of the NVRI, 11 are VTHs, 10 are SVLs, two are private laboratories, one is from the NAFDAC, one is from a Federal College, and one is from the Ministry of Health (NCDC). Eighteen (46.2%) laboratories filled the DET: 13 from NVRI (100%), two VTHs (20.2%), two SVLs (20.0%) and one Federal College (100%). However, the DET had many gaps in the information provided, as shown in Appendix 5.

The NVRI's capacity is likely sufficient to meet current VS demands, especially considering that the VS does not routinely carry out active surveillance programmes. However, the Expert Team estimates that the NVRI could increase testing capacity by at least 120%, to accommodate more active surveillance programmes. Even if the NVRI operational capacity is sufficient to meet the current and prospective demand, the decision to have other laboratories in the network should consider sample transportation and logistics issues. Transportation of some samples from remote regions of Nigeria could take more than 7-10 hours to reach the NVRI, which suggests the need to maintain laboratories located in different regions in the network.

The evaluation of the SVLs and VTHs structures was more difficult due to the remote format of the mission. The Expert Team asked for videos and pictures from all laboratories, but these were only provided by NVRI representatives. Additionally, information about the premises of these laboratories (e.g., surface area and biosecurity) was incomplete.

Despite the lack of information, it was possible to conclude from the interviews that only very few SVLs and VTHs could carry out molecular and isolation assays that require elevated biosafety measures and sophisticated equipment.

Unfortunately, additional information from other laboratories performing public health diagnostics in the country, like the NCDC and other Ministry of Health laboratories, private laboratories, and NAFDAC laboratories was not available.

III.2. Challenges to sustainability

The implicit role of the veterinary laboratory network as part of the VS is to provide accurate, reliable, and timely test results which support sound VS decision making. The veterinary laboratory network in Nigeria, led by the NVRI, should be seen and used as a resource to promote AH, assist

[6] API for Sanger and Mini Ion for Next Generation Sequencing – NGS

in providing a safe food supply, and provide support to the VS in the detection and control or eradication of priority animal diseases.

According to the information received, the Expert Team identified the following challenges to the sustainability of the veterinary laboratory network:

External factors

- ✓ Underutilization of the laboratory network's operational capacity.
- ✓ Presence of more than one laboratory with similar mandate in the same region.
- ✓ Limited national programmes for priority animal diseases as well as a lack of national plans to detect residues and contaminants in food and feed stuff.
- ✓ Insufficient Federal Government budget to carry out AH programmes targeting priority animal diseases (as part of an active national surveillance programme).
- ✓ Lack of information related to prospective demand makes it difficult to ensure that appropriate reagents and supplies are available for testing.
- ✓ Lack of local companies capable of carrying out maintenance and calibration services for key equipment.
- ✓ Challenges related to sample transport to NVRI due to Nigeria's size.

Internal factors

- ✓ A high proportion of the NVRI budget is destined to cover human resource expenses, with an imbalance between administrative and support staff and technical staff.
- ✓ Duplication of some activities between different NVRI technical divisions (e.g., molecular diagnostic testing in divisions other than the Biotechnology Division).
- ✓ Apparent excessive/redundant number of technical divisions at NVRI (e.g., FMD, AI, rabies, and Virology Research could be joined in a unique "Virology Division").
- ✓ Limited partnership between VS/NVRI and other governmental bodies (e.g., to carry out genetic sequencing tests).
- ✓ Non-functional key equipment and/or long period to install or repair them (e.g., High Performance Liquid Chromatography – HPLC – and Gas chromatograph in the Biochemistry laboratory and freeze-dryer in the Bacterial Vaccine Production Unit).
- ✓ Inability to cross-train staff and/or share staff between different NVRI's divisions.
- ✓ Prices of the vaccines sold by the NVRI do not cover production costs, which seems to be linked to a lack of strategic evaluation of costs, enabling the setting prices based on a minimum objective of cost recovery. Prices of the services provided by the NVRI do not cover the cost of testing.
- ✓ Insufficient partnerships with the private sector.
- ✓ Lack of an electronic LIMS at NVRI.
- ✓ Lack of ISO 17025 accreditation, limiting Nigeria's possibilities to access the international market for trade of agricultural and livestock products.
- ✓ Apparent excessive number of vehicles, leading to high maintenance costs.

Specific challenges related to human, physical, and financial resources are described in the following sections.

III.3. Human Resources

The gender distribution is unbalanced in terms of the total number of employees (67% male, 33% female) as well as in terms of educational level. The percentage of males with graduate degrees is disproportionately higher (Figure 5). The percentage of support staff seems to be excessively high (Figure 6), and the age distribution is apparently well balanced (Figure 7).

Figure 5. NVRI human resources according to education/gender

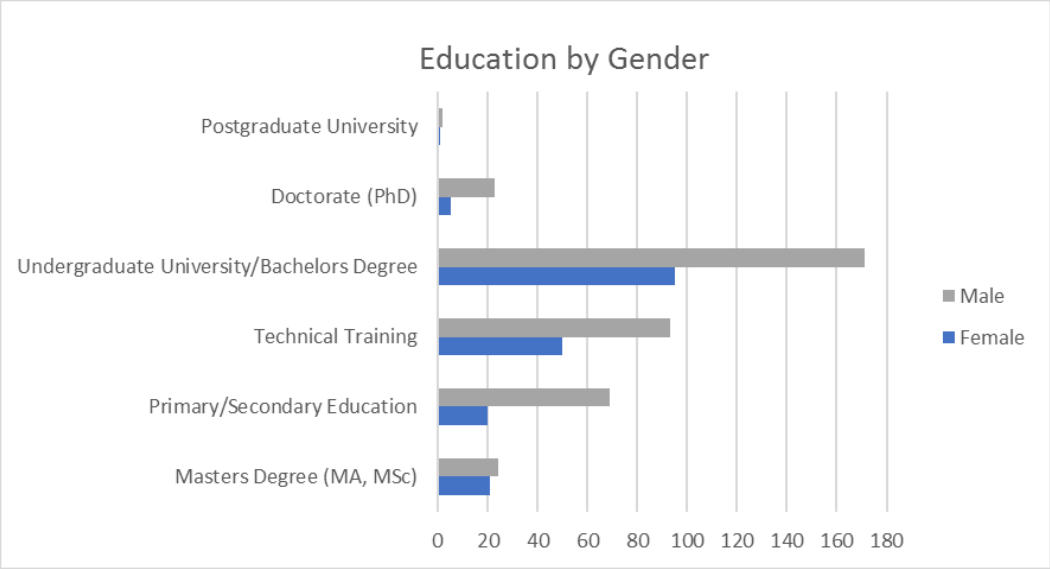


Figure 6. NVRI human resources according to position

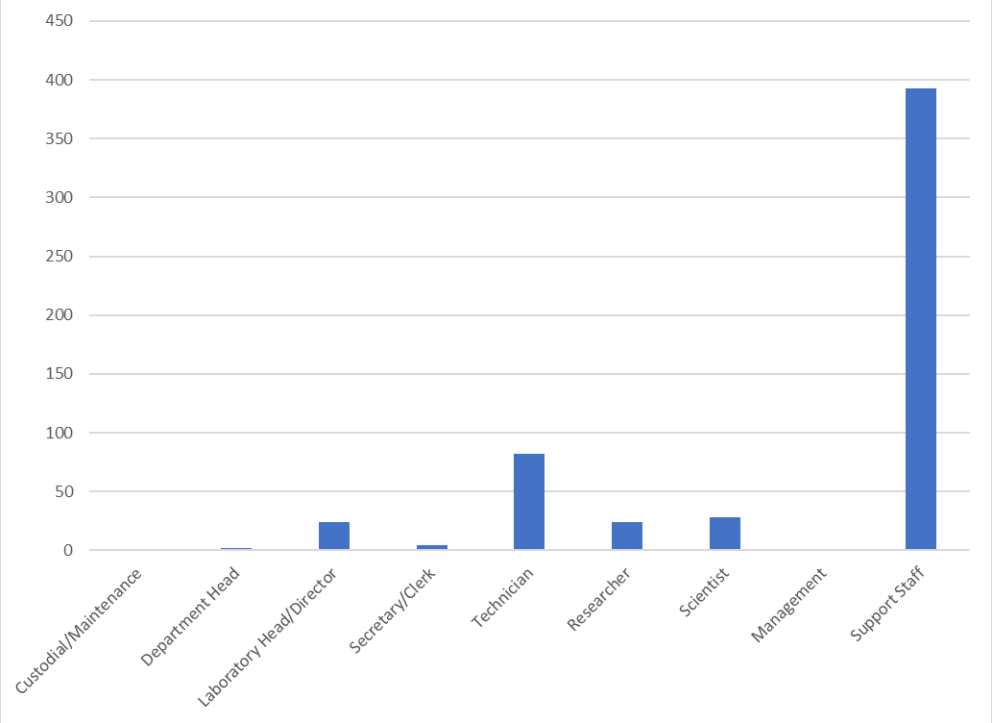


Figure 7. NVRI human resources distribution by age (years)

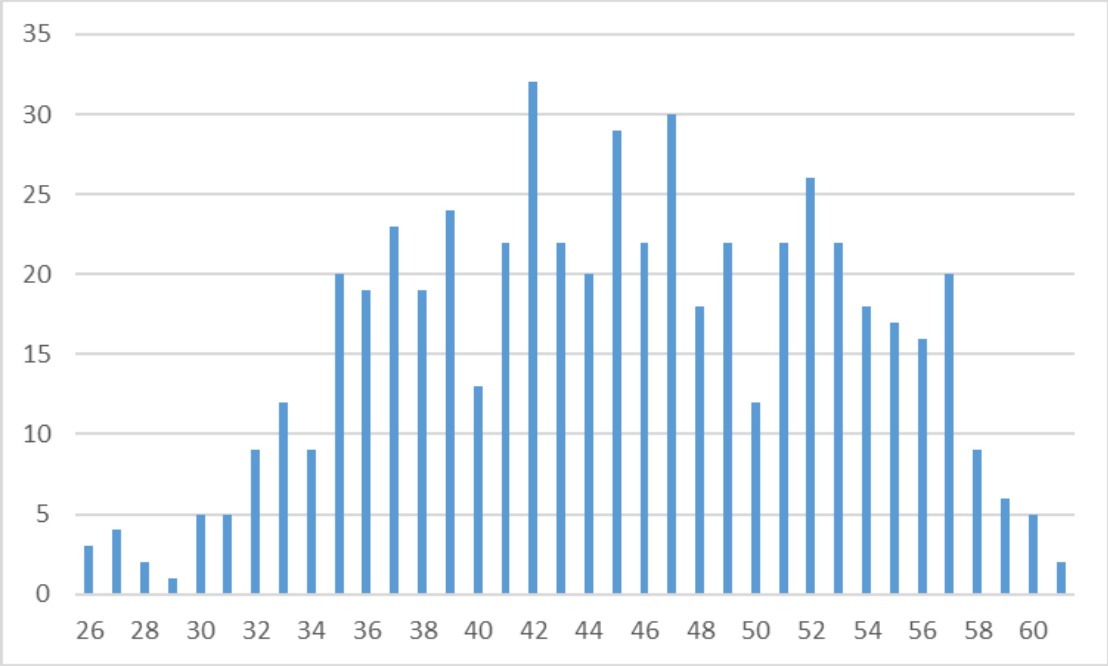
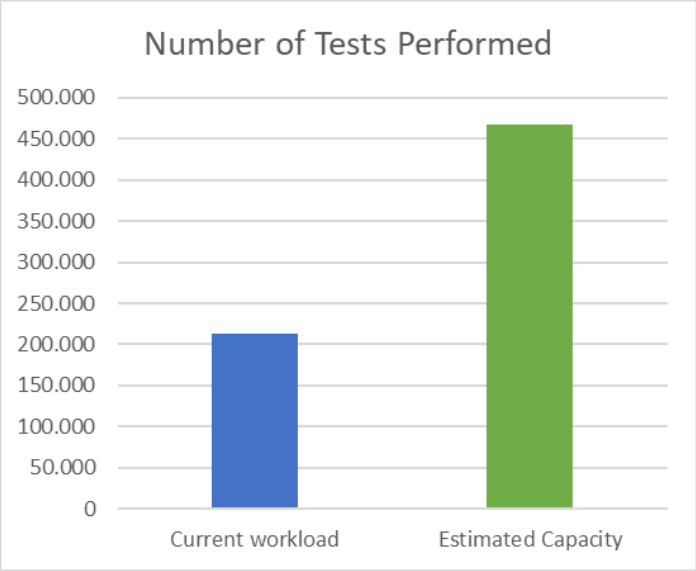


Table 5 and Figure 8 highlight the underutilization of operational capacity at NVRI based on current technical staff numbers. According to the Calculation Tool used for all PVS Sustainable Laboratories missions, it would be possible to increase testing capacity approximately 791% based on the number of technical staff currently employed at NVRI. On the other hand, the current workload at NVRI could be absorbed by 29.9% of current technical staff, indicating that there are improvements to be made to leverage existing human resources.

Table 5. NVRI Capacity, based on Human Resources

Staff Type	Estimated Number Considering the Current Workload	Current Number	Difference (%)
Technicians	40	134	29.9
Managers	8	27	29.6
Support Staff	11	398	2.8
Total	59	559	10.6

Figure 8. NVRI Capacity, based on the current workforce



Due to misunderstanding of questions about Continuing Education (CE) days taken per staff, the Expert Team couldn't evaluate the value-added of a well-implemented CE programme.

The employee retention time (roughly 161 months) seems to be satisfactory. Salaries vary according to seniority, salary scale, and structure; however, the average monthly salaries are currently approximately 1,024 EUR for a veterinarian or other professional, 340 EUR for a technician, and 230 EUR for support staff. It was mentioned during interviews that the salaries at NVRI are lower in comparison to private companies, but higher than other governmental agencies, which can explain the satisfactory employee retention time.

Unfortunately, the information provided by the SVLs and VTHs was insufficient to provide an overview of the human resources management in these laboratories, so the Expert Team couldn't infer their operational capacity and evaluate other aspects on this issue.

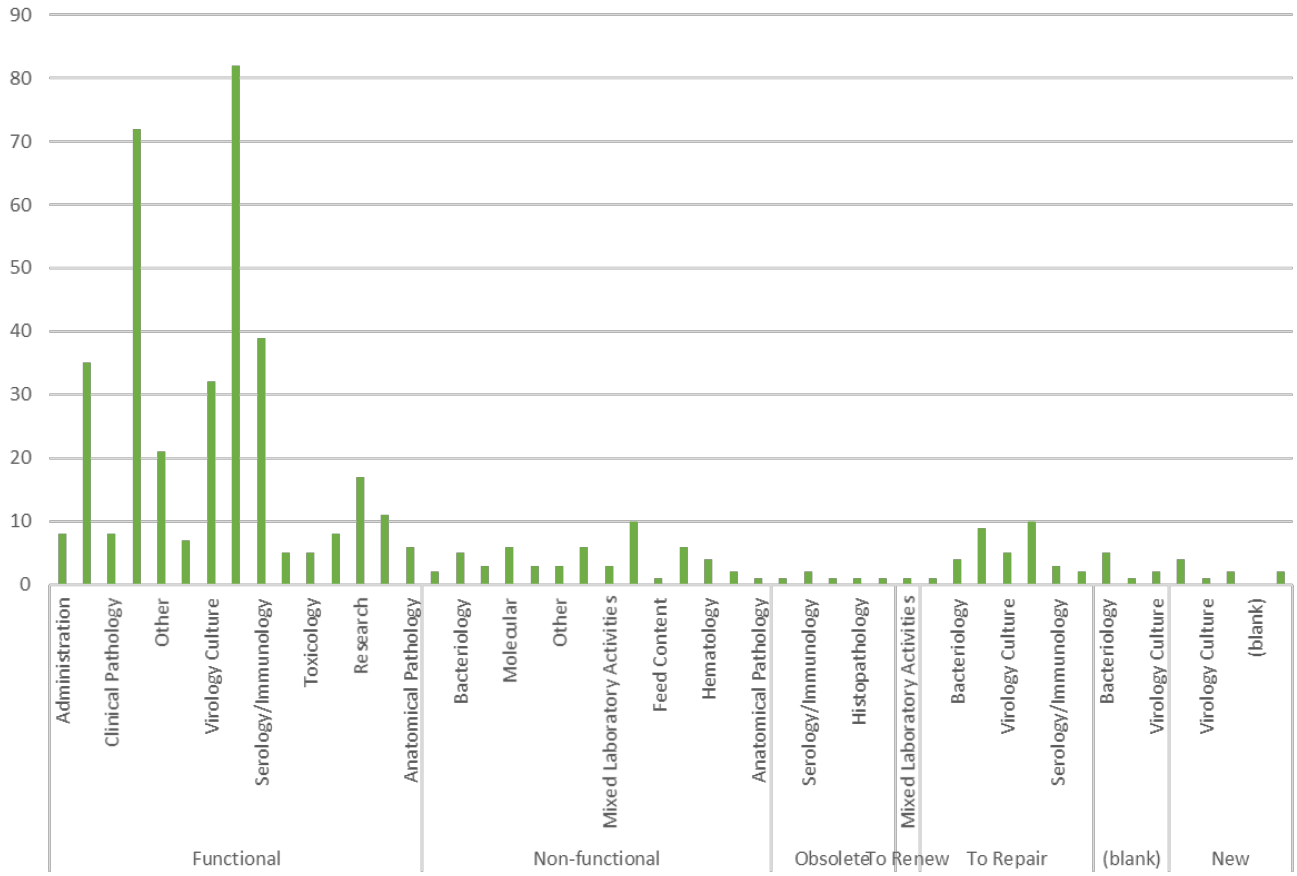
III.4. Physical resources

As mentioned above, the Expert Team gathered only limited data from the VTHs and SVLs. Two VTHs and two SVLs filled in the DET, but the information was incomplete. In addition, no pictures or videos from these laboratories were provided, so it was not possible to evaluate the physical resources. Therefore, only the NVRI's structure is considered in this section.

a) **Facilities:** The NVRI has a main water supply and acceptable electricity (80% of the time) with a 1,000 kVA generator for backup. Biological waste disposal is done by incineration. Insufficient information was provided to understand surface area of the NVRI and related challenges. According to the CVO, the NVRI BSL-3 facility is sufficient to meet demand related to high-risk pathogens and exotic diseases. Unfortunately, the remote format of the mission did not allow the Expert Team to understand the biosafety and biosecurity features of the high containment facility. Nevertheless, it is important to highlight that high-containment measures require significant resources to maintain biosafety and biosecurity operations of the NVRI BSL-3 facility.

b) **Equipment/systems:** Currently NVRI is not supported by a LIMS. The total value of equipment installed at NVRI is estimated at 2M EUR. The total value of refrigerators and freezers is 250K EUR. Figure 8 shows the proportion of functional equipment compared to the total of equipment owned by NVRI. In general, most equipment is functional, but during the interviews it was apparent that some of the non-functional equipment were crucial to certain assays, e.g., the HPLC and gas chromatograph for the biochemistry division, sequencer for the biotechnology division, and the freeze-dryer for the bacterial vaccine production unit. Repairs, especially of sophisticated equipment, take a long time to occur, leading to the interruption of sample testing and vaccine production. Table 6 shows the general status of the equipment calibration/certification and Table 7 represents the status of equipment preventive maintenance. Around one third of the equipment is not appropriately calibrated/certified and a similar proportion of equipment has no preventive maintenance performed. The high proportion of uncalibrated/certified and improperly equipment can lead to inaccurate results.

Figure 9. Distribution of equipment according to the technical division and functionality[7]



[7] Category of "blank" is due to incomplete data provided in the DET

Table 6. General status of the equipment calibration/certification

Requirement	% of Calibration or Certification Performed
Calibration	26.19%
None	32.74%
Certification	11.90%
Not applicable	29.17%
Total	**100.0%**

Table 7. General status of the equipment preventive maintenance

Preventive Maintenance Performed	
Yes	52.93%
No	33.62%
Not applicable	13.45%
Total	**100.0%**

c) **Transportation:** The NVRI has 23 vehicles. Almost 50% of the vehicles are less than 3 years old and none have refrigeration or biosafety features. The number of vehicles is likely too high compared to the samples tested to justify, which represents a challenge to sustainability due to maintenance costs.

III.5 National budget: Capital and operational investments

The Expert Team received budget information from the NVRI, so other laboratories weren't considered in this section. Table 8 summarizes the NVRI budget for the period of 2018-2020.

Table 8. NVRI budget for the period of 2018-2020 (EUR)

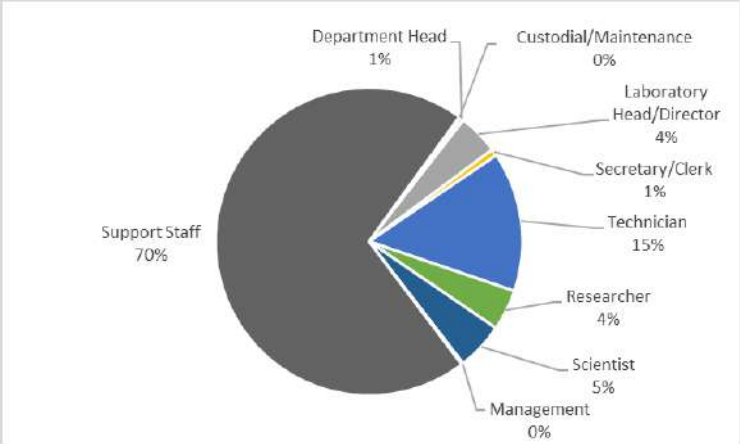
Year	Budget item	Appropriation	Releases	Expenditure
2020	Capital	1.614.593,24	1.538.266,01	1.538.266,01
	Overhead	155.708,94	138.293,03	138.293,03
	Personnel	5.026.611,83	5.026.611,83	5.026.611,83
	Internal General Revenue (IGR)	-	867.292,54	867.292,54
	Aids & Grants	-	106.351,23	106.351,23
	TOTAL	6.796.914,01	7.676.814,63	7.676.814,63
2019	Capital	2.622.280,07	1.048.912,03	1.048.909,60
	Overhead	227.575,11	227.575,11	151.438,77
	Personnel	5.244.783,95	4.992.313,44	4.992.313,44
	IGR	-	624.695,71	624.695,71
	Aids & Grants	-	47.318,96	47.318,96
	TOTAL	8.094.639,14	6.940.815,25	6.864.676,48
2018	Capital	2.752.661,11	2.569.333,88	2.569.329,02
	Overhead	227.575,12	227.575,11	132.981,65
	Personnel	5.304.625,37	4.316.873,51	4.316.873,51
	IGR	-	493.425,30	493.425,30
	Aids & Grants	-	83.213,36	83.213,36
	TOTAL	8.284.861,60	7.690.421,16	7.595.822,84

The NVRI's most relevant revenue source is the sale of vaccines, but the Expert Team could not determine the exact proportion of the revenue generated by the vaccine production compared to other revenue sources, as that data was not made available. In any case, investing in the optimization of all vaccine production could be a feasible way to improve the NVRI's sustainability.

Another revenue source is the diagnostic service, but according to various interviews, prices can vary according to the type of project or the laboratory providing the service. In general, the costs seem to be known, but the expert team was not able to confirm the presence of a cost accounting system where costs are attributed, as well as if the costs influence the prices determined for services rendered. In most cases the price is similar or even lower than the cost, so external subsidies are very high.

As shown in Table 8, personnel costs represent approximately 65% of the total budget and 75% of total expenses, which is very challenging to the sustainability of the NVRI's business model. Of the 5M EUR invested in personnel, 70% of NVRI employees are classified as support staff, as shown in Figure 9. The proportion of grants and aid in comparison to overhead increased in 2020, and reached 44%, which is also challenging in terms of the sustainability of the NVRI's business model.

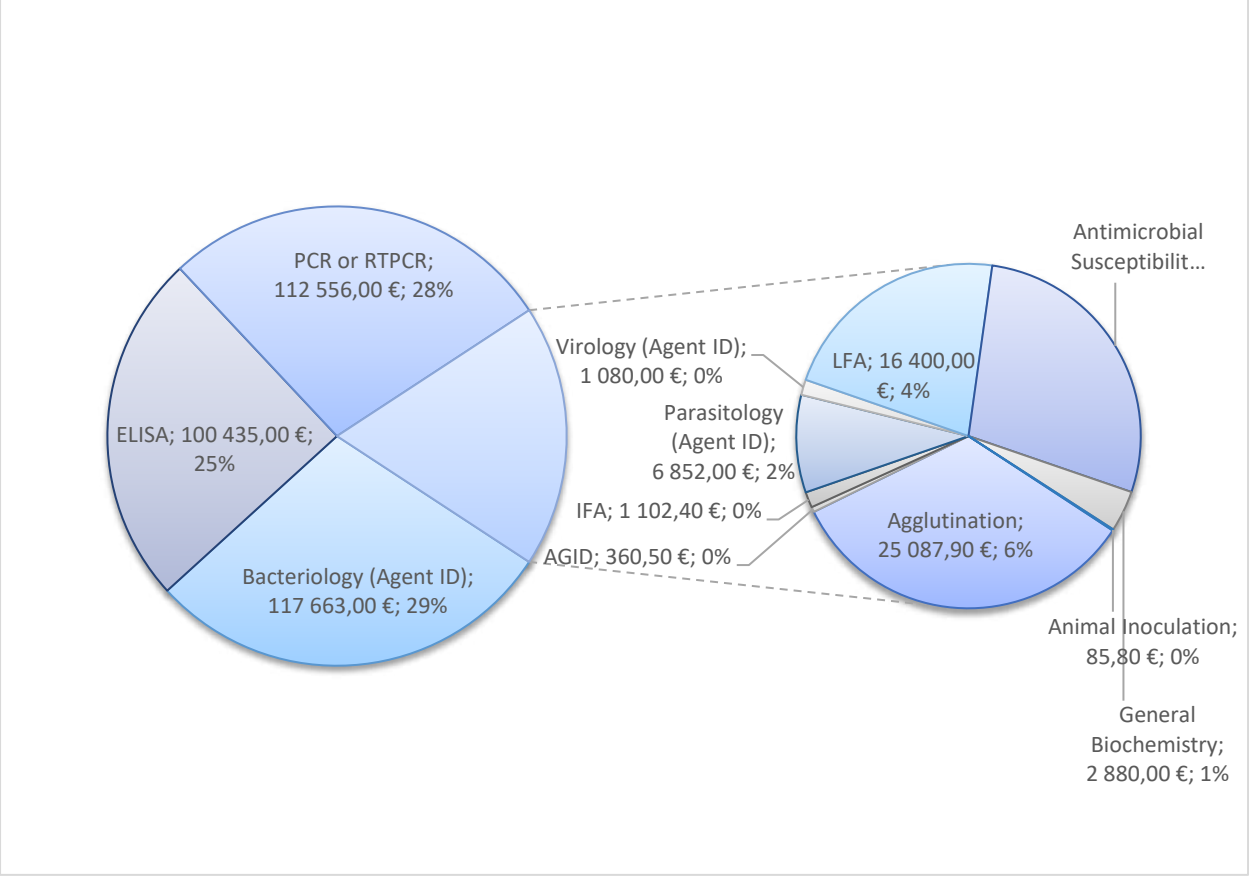
Figure 10. Proportion of NVRI staff, by position type



* Note: 0% represent values < 1%

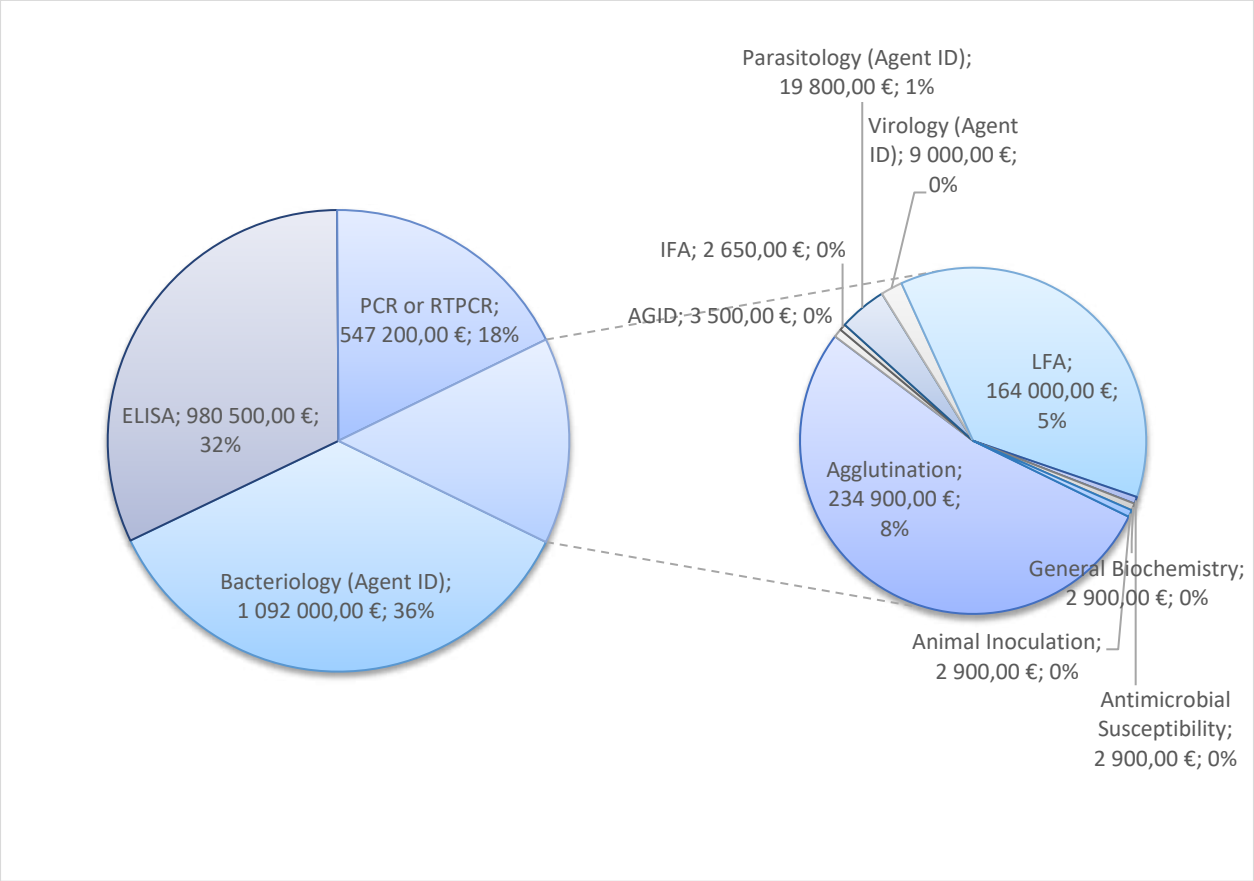
The overhead value is very low, considering that it should include the raw materials used for vaccine production as well as reagent purchasing. As a result, there will be a lower capacity of testing which in turn will result in an underutilization of the workforce as shown by Figures 10 and 11.

Figure 11. Current Annual Cost of laboratory service delivery by Method



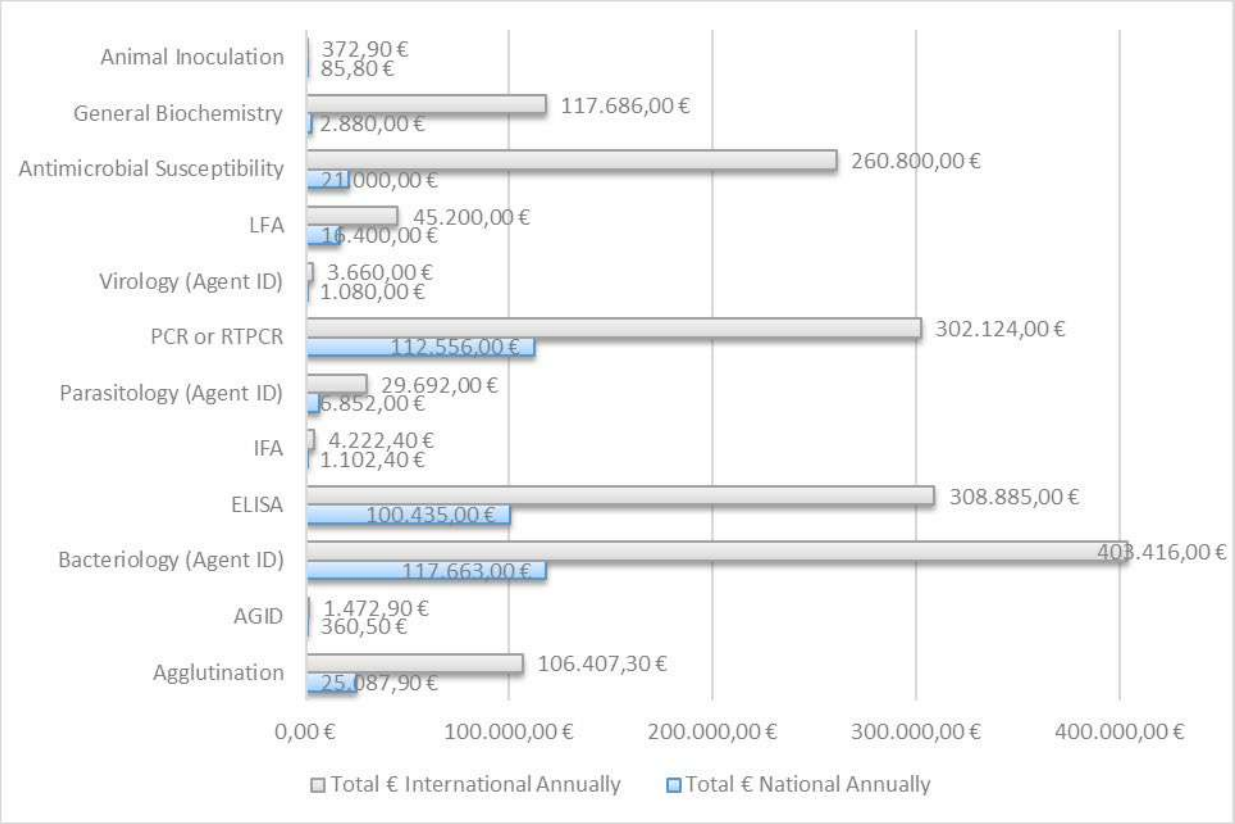
The Expert Team simulated the cost of ELISA for FMD and PPR in a hypothetical surveillance programme as shown in Figure 11. In this simulation, ELISA would be used for screening 10 000 samples. In this simulation, the cost of ELISA was nearly 13% lower than the cost related to the current demand. Besides decreasing the unit cost of each ELISA and increasing sample throughput, this kind of initiative would optimize human resources and add value to the laboratory network and the VS. The same approach would be valid for many diseases relying on high-throughput technology.

Figure 12. Annual Cost by Method at Increased Estimated Capacity



Currently, the NVRI is a sound investment that could be better leveraged for additional value for Nigeria's VS and veterinary domain stakeholders. Investment in the NVRI is justified, as it costs 3.2 times more to purchase the same test results on the international market (1.58K EUR) than to obtain test results in Nigeria (362K EUR). However, the investments and resources at NVRI's disposal could be better utilised to create more value for the VS and stakeholders in the form of higher quality test results and higher sample throughput, as shown in Figure 13.

Figure 13. Current Annual Cost Vs International Cost by Method[8]



The VS should establish strategies (including expansion of active surveillance programmes) to monitor and control priority animal infectious diseases and to prevent exotic, emerging and re-emerging animal diseases to better leverage its investments in laboratory service delivery in Nigeria. These programmes should use a risk analysis approach to calculate the number of samples that will be sent for laboratory analysis. AH programme development should include the budgetary needs and the operational capacity needed from the laboratory sector to achieve established VS goals in terms of priority animal disease control and eradication in Nigeria.

It is imperative that the VS has the necessary resources from the Federal (and State, where relevant) Government to develop AH programmes in line with controlling endemic diseases as well as preventing the introduction of exotic diseases. In the long term, this will ensure the overall sustainability of the Nigeria's Veterinary Laboratory Network.

[8] The estimated local transportation cost for a 2 kg package (sufficient for approximately 25 samples) is 50 EUR and the value for the international shipping of the same package is 200 EUR.

III. Possible options for improved sustainability of the veterinary laboratory network

IV.1. Options

Three strategic options are proposed as potential alternatives to the current network structure to improve the National Veterinary Laboratory Network's sustainability and overall management of available resources. The current laboratory network (*status quo*) is considered as Option 1 to show that optimisation of resources in the current network configuration is possible for improved sustainability.

A major option to improve the sustainability of the existing laboratory network is to increase (and optimise) its utilisation and efficiency as described above. Unfortunately, little evidence was provided to indicate that a significant increase in demand for laboratory services to optimise existing capital resources is likely in the next 5-10 years. Therefore, adaptation of the national laboratory network to the size and dimensions of current demand for laboratory services is more likely to provide an acceptable degree of sustainability.

In all the proposed options, it is assumed that NVRI will have the role of the national reference laboratory and will provide support to the national laboratory network to ensure the long-term viability of the national laboratory network.

One of the factors considered for the national laboratory network structure was to ensure laboratory services were available in concentrated livestock areas. During the mission, it was established that poultry production was more intensive in the southern part of Nigeria, while ruminant production was predominantly located in the northern part of the country. Additionally, efforts to intensify poultry production in the North are ongoing.

IV.1.A. Option 1: Status Quo (current veterinary laboratory network)

The NVRI is maintained as the National Reference Laboratory and is supported by current SVLs and VTHs on an *ad hoc* basis, as shown in Figure 12.

Figure 14. Current localization of the laboratories in the national laboratory network

* Yellow triangle – NVRI; blue stars – SVLs; red stars – VTHs

IV.1.B. Option 2: NVRI as the National Reference Laboratory supported by Specialized Laboratories

NVRI is maintained as the National Reference Laboratory and is supported by 2-4 specialized laboratories located in areas of relevant animal production. Specialized laboratories should be in areas where the livestock production is most relevant, e.g., laboratories for poultry and diseases in other species like fish, turkey, pigs, etc. in the South and ruminant diseases in the North). The Expert Team considered that this strategy is more advantageous than the designation of some laboratories to specific diseases, as recommended by the PVS Evaluation Follow-up Mission 2019.

Ideally, some of the existing SVLs should be selected as specialized laboratories to use existing infrastructure and avoid unnecessary (and potentially unsustainable) costs associated with the construction of new facilities. In this Option, VTHs will be fully committed to teaching/education/learning as their primary mandate but may contribute to sample collection and transfer to SVLs and NVRI and participate in AH programmes funded by the VS. The SVLs that are not selected as specialized laboratories would be closed.

IV.1.C. Option 3: NVRI as the National Reference Laboratory supported by Specialized Laboratories and SVLs

In Option 3, NVRI is the National Reference Laboratory and is supported by 2-4 specialized laboratories located in areas of relevant livestock production, as in Option 2. The remaining existing SVLs would be maintained in the network, participating in specific AH programmes, actively participating in outbreak investigations, and carrying out screening tests at sufficient levels to justify their existence. Option 3 requires a review of the VTHs' mandate as it contributes to the national veterinary laboratory network.

IV.1.D. Option 4: NVRI as the National Reference Laboratory supported by Specialized Laboratories and privatization of remaining laboratories

In Option 4, the NVRI is the National Reference Laboratory and is supported by 2-4 specialized laboratories located in areas of relevant production as in Option 2. The remaining SVLs that are not part of the network would be privatized. Option 4 envisages the start-up of private laboratories that will service pet animal needs.

Options 2 or 4 seem to be more sustainable given current sample flow, demand for the laboratory network's services, and that there would be fewer laboratories in the network, reducing expenses inherent to personnel, maintenance of facilities and equipment, and reagents and reference materials. The current demand for laboratory analysis does not justify size of the laboratory network. The difference between Options 2 and 4 is the future of the superfluous laboratories: in Option 2 the laboratories would be closed while in Option 4 they would be privatized.

IV.2. Benefits associated with Options

Benefits commonly seen when optimizing the management and operations of a laboratory or laboratory network include timeliness and efficiency of testing, while ensuring reliability of results through quality assurance; early detection of emerging and/or re-emerging diseases; and significant budgetary savings which may strengthen sustainability. Some of the identified benefits apply to each of the Options, and some are Option-specific, as shown in Table 10.

Table 9. Benefits associated with Options

Potential Benefits	Option 1	Option 2	Option 3	Option 4
Takes advantage of existing infrastructure and staff (trained professionals and technicians), given sample throughput is addressed	X		X	
Maintenance of the status quo, avoiding distress caused by changes	X			
No negative economic impact due to loss of jobs	X			
The high number of laboratories spread throughout the country increases accessibility to samples close to producers/farmers, given sample transport and logistics are addressed	X		X	
The high number of laboratories working with priority animal diseases provides technical capacity and potential to fulfil the national mandate to address AH challenges	X		X	
Increased role of NVRI, the national reference laboratory, provided it attains ISO 17025 accreditation		X		
A lower number of laboratories in the network, adjusted to the current demand for services will result, in theory, in the increased efficiency of the network.		X		
Oversight and coordination by the national reference laboratory can be more effective		X		
Less budgetary burden on the Federal Government. Significant savings in infrastructure and equipment maintenance and salaries, which may strengthen the sustainability of the federal veterinary laboratory network		X		X
More efficient use of human, financial, physical resources		X		
Early detection of emerging and/or re-emerging diseases		X	X	
VTHs would be fully committed to their primary mandate (teaching/education/learning)		X	X	
Savings made by redefining the VTHs mandate could be redirected to AH programmes		X	X	
Takes advantage of specialized existing knowledge, experience, and expertise pertaining to the region/area/species		X	X	X
Faster delivery of priority disease screening test results			X	
Less burden on the national reference laboratory as the specialized laboratories would provide expertise in some areas of veterinary diagnostics			X	
Re-assignment of certain veterinary laboratory activities to private laboratories will allow the national veterinary network to focus its efforts and resources towards public good, trade, and regulatory activities				X
Incentive for some laboratory staff to start private laboratories that will service pet animal demand while SVLs are assigned activities of public benefit e.g., livestock disease monitoring and control				X

IV.3. Risks associated with Options

There are many risks to sustainability inherent in the management and operations of a laboratory and laboratory network including financial costs, quality, and accuracy of test results, and physical and human resources, among others. Each of the risks associated with the Options are common risks in many laboratories and are not specific to Nigeria's laboratories. Some risks may be of higher consequence, but all risks must be identified, assessed, and controlled. Some of the identified risks apply to each of the Options, and some are Option-specific, as shown in Table 11. Sustainability risks that apply to all Options include the duplication of roles, equipment, and staff and the high costs of equipping and maintaining laboratories.

Table 10. Risks associated with Options

Potential Risks	Option 1	Option 2	Option 3	Option 4
High cost to maintain existing infrastructure	X			
Low effectiveness of resources due to duplication of roles, equipment, and staff	X			
High costs due to the need to equip and maintain laboratories to ensure accurate and reliable results	X			
Difficulty for the national reference laboratory to oversee the network	X		X	
Disconnect between the national reference laboratory and other laboratories in the network	X		X	
Underutilization/redundancy of laboratories due to their proximity and servicing of the same clients/producers/farmers and competition instead of synergistic collaboration between laboratories in the network	X		X	
Underutilization of NVRI capacity, unless the number of samples increases significantly	X		X	
Underutilization of the other laboratories that are currently part of the national network and would not be part of the proposed new network		X		X
Existing infrastructure and equipment of defunct laboratories will need to be redeployed or reassigned new roles		X		X
Outreach and sample collection and transportation issues to relevant laboratories		X		X
Negative economic impact due to redundancies and/or retrenchment and cancellation of some positions		X		X
Loss of connectivity with some producers given that some laboratories in their region would have closed		X		X
Loss of experienced staff who would move into private laboratories				X

IV.4. Annual operating costs of proposed Options

It was not possible to calculate the precise operating costs of all proposed Options because of the lack of data from some SVLs and VTHs as well as from the VS about prospective demand for laboratory analysis. Data from only three SVLs was provided and only the *Area Veterinary Clinic Diagnostic Laboratory of Bauchi* provided both test demand and budget information. Therefore, an extrapolation of the operating costs of SVLs for the proposed Options was done using the sparse data provided.

One benefit of Option 2 and 4 is a decreased budgetary burden. This budgetary change is directly related to the restructuring of the SVLs to create an efficient and focused network comprising specialized laboratories, resulting in fewer SVLs supported by the government. Assuming four specialized laboratories with the current test demand being redistributed to them, the cost of keeping the specialized laboratories in Option 2 and 4 is estimated at 6.2 million EUR, 3% lower than the estimated cost of the status quo in Option 1 (Table 12, Table 13, and Figure 13).

Option 3 has similar operating costs as Option 1 due to keeping the SVLs not selected as specialized laboratories. Option 4 provides similar budgetary relief as Option 2 due to the privatization of the SVLs not selected as specialized laboratories.

Table 11. Proposed estimated budget for Options 1 & 3[9]

Proposed Budget based on PVS Laboratory Mission	Budget Category Abrviations	Unit Cost	Number	Renewal Rate	Annual Budget
Capital Investment					
Buildings and Premises	Building	6,176,880.00 €		0.05	308,844.00 €
Vehicles	Vehicles	609,000.00 €		0.2	121,800.00 €
IT and Office Equipment	IT Equip	0.00 €		0.33	0.00 €
Telecommunication Equipment	Telecom Equip	0.00 €		0.2	0.00 €
Refrigerators & Deep Freezers (-20°C & -80°C)	Fridge / Freezer	0.00 €		0.1	0.00 €
Laboratory Equipment	Lab Equip	2,123,718.47 €		0.2	424,743.69 €
Other Equipment	Other Equip	0.00 €		0.2	0.00 €
Salaries and Remuneration					
Veterinarians and Other Professionals	Professionals	14,266.00 €	27	1	385,182.00 €
Laboratory Technicians	Technicians	7,796.00 €	144	1	1,122,624.00 €
Support Staff	Support staff	5,035.00 €	408	1	2,054,280.00 €
Per diem and travel allowance in the country	Travel local	0.00 €	0	1	0.00 €
Per diem and travel allowance abroad	Travel abroad	0.00 €	0	1	0.00 €
Operating Costs					
Continuing Education (short courses, etc.)	CE			0.05	178,104.30 €
Administrative Expenditures (office supplies, etc.)	Admin Costs			0.3	1,068,625.80 €
Reagents and Consumables	Reagents	300,330.00 €		1	300,330.00 €
Maintenance, Calibration and Metrology	Equip Maintenance			0.2	424,743.69 €
External Services (Reference Laboratory, External Analysis, Transport, etc.)	External Service	0.00 €		0.2	0.00 €
Other	Other			1	0.00 €

Annual Budget	Total	%
Capital Investment	855,387.69 €	13%
Salaries and Remuneration	3,562,086.00 €	56%
Operating Costs	1,971,803.79 €	31%
Total Annual Budget	**6,389,277.49 €**	

[9] Based on extrapolations, as sparse data were provided.

Table 12. Proposed Budget for Options 2 & 4

Proposed Budget based on PVS Laboratory Mission	Budget Category Abrviations	Unit Cost	Number	Renewal Rate	Annual Budget
Capital Investment					
Buildings and Premises	Building	5,168,640.00 €		0.05	258,432.00 €
Vehicles	Vehicles	656,800.00 €		0.2	131,360.00 €
IT and Office Equipment	IT Equip	0.00 €		0.33	0.00 €
Telecommunication Equipment	Telecom Equip	0.00 €		0.2	0.00 €
Refrigerators & Deep Freezers (-20°C & -80°C)	Fridge / Freezer	0.00 €		0.1	0.00 €
Laboratory Equipment	Lab Equip	2,032,968.47 €		0.2	406,593.69 €
Other Equipment	Other Equip	0.00 €		0.2	0.00 €
Salaries and Remuneration					
Veterinarians and Other Professionals	Professionals	14,266.00 €	27	1	385,182.00 €
Laboratory Technicians	Technicians	7,796.00 €	138	1	1,075,848.00 €
Support Staff	Support staff	5,035.00 €	402	1	2,024,070.00 €
Per diem and travel allowance in the country	Travel local	0.00 €	0	1	0.00 €
Per diem and travel allowance abroad	Travel abroad	0.00 €	0	1	0.00 €
Operating Costs					
Continuing Education (short courses, etc.)	CE			0.05	174,255.00 €
Administrative Expenditures (office supplies, etc.)	Admin Costs			0.3	1,045,530.00 €
Reagents and Consumables	Reagents	294,300.00 €		1	294,300.00 €
Maintenance, Calibration and Metrology	Equip Maintenance			0.2	406,593.69 €
External Services (Reference Laboratory, External Analysis, Transport, etc.)	External Service	0.00 €		0.2	0.00 €
Other	Other			1	0.00 €

Annual Budget	Total	%
Capital Investment	796,385.69 €	13%
Salaries and Remuneration	3,485,100.00 €	56%
Operating Costs	1,920,678.69 €	31%
Total Annual Budget	**6,202,164.39 €**	

IV.Roadmap towards improved sustainability of the veterinary laboratory network

V.1. Re-evaluate the NVRI organogram and human resources management

The Institute should consider reviewing the NVRI organizational structure. The Expert Team suggests reorganizing the organogram of NVRI based on disciplines such as Bacteriology, Serology, Molecular Diagnostics, Virology, Parasitology, Pathology, Biochemistry to address the dispersion of specific disease programmes and molecular capacity and increase efficiency. The proposed organizational structure optimizes and leverages the use of equipment and human resources. Regardless of the path forward, the NVRI should fulfil a role as the national reference laboratory, but the re-evaluation of its mandate, organisation, and efficiency is necessary. The general recommendations made to address the Nigeria veterinary laboratory network's sustainability will assist Nigeria's strategic goals to be achieved.

Human resources are one of the most important laboratory assets. The Expert Team noted that there are abundant technical skills at NVRI. Data provided indicate the need to improve the balance between support staff, technicians, and professionals. The PVS tools, developed by international experts and based on WOAH international standards and best practice, recommend one professional for every five technicians and one support staff for every five technicians or for every three professionals, with total staff numbers being based on current and anticipated testing and vaccine production needs. Reviewing and implementing AH programmes on a scientific basis will better utilise the laboratory as a resource and increase sample flow to the laboratory, therefore resulting in a better utilisation of existing human resources. Given the low demand for laboratory diagnostic services, current staff should be leveraged to maintain a wide range of laboratory activities in additional to bench work, including cross-training of staff to provide future surge capacity, as well as development and implementation of a QMS.

Nevertheless, it is important to highlight the importance and relevance of CE and training as well as training in quality management and biosafety and biosecurity to nurture emerging experts who will contribute to the international body of knowledge and to achieve international reference laboratory status.

V.2. Formalise and strengthen the role of NVRI as the National Reference Laboratory

The Institute has expertise in various disciplines and has the capacity and capability to play the role of a national reference laboratory. Although the Expert Team could not find any official recognition of that status, some typical activities of a reference laboratory are currently conducted by the NVRI, such as offering training to staff from other laboratories and receiving samples for confirmatory testing. However, many relevant activities/functions of a national reference laboratory should be implemented or strengthened including:

- The development, standardization, use, promotion, and dissemination of methods validated according to WOAH international standards;

- The development of reference materials and other reagents used in the diagnosis of priority animal diseases according to WOAH international standards;
- Storage and distribution of reference materials and reagents to other laboratories in the national laboratory network;
- The collection, processing, analysis, publication, and dissemination of epizootiological data relevant to priority animal diseases;
- The implementation and maintenance of a QMS and a biosafety and biosecurity management programme relevant to priority animal diseases;
- The organization and distribution of PT programs for priority animal diseases which are implemented for the laboratory network.

V.3. Optimise QMS and biosafety and biosecurity management and improve methods

While the first accreditation is targeted to be achieved in 2022, there are many obstacles to be overcome, most of them depending on financial resources (e.g., calibration services and PTs). The scope and order of accreditation of laboratories should be determined by a cost-benefit analysis as well as considering laboratories and methods that are ready for accreditation. A detailed annual budget should be developed based on the determined scope and necessary activities such as equipment calibration and appropriate reference materials. Since the QMS will incur additional resources, informational materials should be developed for fund holders demonstrating the positive impact of accreditation including improved quality and quantity of food and improved ability of producers to export products.

Biological risk assessment to establish fit-for-purpose and evidence-based biosafety and biosecurity measures should be conducted and costed, and biological risk management programmes subsequently built into annual budget formulation. The NVRI has a BSL 3 laboratory which enables the laboratory to handle high-risk pathogens and gives certain autonomy to the country to address outbreaks of diseases caused by these pathogens. The Federal Government should guarantee the continuous provision of resources needed to maintain this facility. Some of the maintenance costs can be high, like the periodic certification of the air handling system, which maintains the level 3 biosecurity containment through a constant and controlled negative pressure throughout the facility.

The professionals in charge of the biological risk management should receive CE to be prepared to address the challenges related to a high-containment laboratory. Since the country can provide all the resources needed to keep the BSL 3 laboratory in operation according to the biosafety and biosecurity regulations, it should consider the possibility of acting as a regional high-containment reference veterinary laboratory. Another aspect to be considered in this context is the partnership opportunities with the human and environmental sectors, according to the One Health approach. Any potential scenarios developed should be considering the demands of these sectors in high-containment facilities, the existence of other BSL 3 laboratories in the country, and the possibility to obtain resources and funding to cover expenses.

It is also critical to complete the installation of HPLC and Gas Chromatography equipment in the Biochemistry Toxicology department to ensure the monitoring of residues and contaminants, which is a key activity in terms of market expansion for animal products. The NVRI should allocate a budget for maintenance and calibration of biochemistry equipment and support academia, government agencies, and industry across sectors by providing testing for residues and/or

contaminants, including antibiotics, hormones, and anabolic products. It should also prioritize ISO 17025 accreditation of these methods.

Although the NVRI has a Biotechnology Division with sequencing expertise and the required specialized equipment for Sanger sequencing, the latter is performed overseas due to equipment maintenance issues. Given the cost involved and the potential time delays due to sample shipment, it would be advisable for the NVRI to determine the cost of carrying out sequencing in-house. This will allow the utilization of NVRI existing expertise in biotechnology and in sequencing and data analysis. This activity can be expanded, in the future, into more powerful technologies such as Next Generation Sequencing (NGS) and Whole Genome Sequencing (WGS). However, for this to happen it is necessary to ensure that the sequencing equipment is fully functional and is regularly maintained. This requires a cost-effectiveness study, comparing all costs related to conducting sequencing or sending samples to another facility for sequencing. The prospective demand for sequencing across sectors in Nigeria must also be considered.

V.4. Ensure relevant data management

An implementation plan should be developed for the procurement, installation, customization, and implementation of an electronic Laboratory Information Management System (LIMS). A LIMS would allow access to critical laboratory data, analysis of which will support diagnostic, disease surveillance as well as research activities at NVRI. Additional benefits include statistical evaluation of diagnostic test results, prevalence studies, ability to use geo-referencing for outbreaks, and more accurate budget forecasting based on past demand for testing and services.

V.5. Define and implement AH Surveillance Programmes for priority animal diseases relevant to Nigeria's context

The CVO advised that the following diseases were identified as priority animal diseases in Nigeria: CBPP, FMD, PPR, NDV, Rabies, HPAI and ASF. The Expert Team suggests including other endemic diseases such as brucellosis and other relevant animal diseases circulating in neighbouring countries such as African Horse Sickness (AHS). Additionally, the VS should establish strategies including active surveillance programmes to monitor and control priority animal infectious diseases and to prevent exotic, emerging, and re-emerging animal diseases. These programmes should use risk analysis to calculate the number of samples that will be collected and sent to the laboratory for testing. Programme development should include the budgetary needs and the operational capacity for diagnostic testing needed.

Surveillance and control programmes for priority animal diseases should be developed and implemented by VS with various government agencies and private sector input, including animal industry representatives. Working with all stakeholders will help to ensure quality outputs. Increased communication between these actors will improve the understanding and commitment of all involved. It is known that programmes developed collaboratively have increased success rates.

V.6. Re-evaluate the NVRI disease diagnostic price policy and encourage partnerships where relevant

Although the NVRI charges for some of the services provided, the price and cost accounting policy is not well defined. Potential clients and investors should be identified, notably among the

government, intensive and extensive private sectors, research partners, and external donors, to establish partnerships and reduce the burden on the Federal Government.

To enable the veterinary laboratory network to respond to private sector demand for laboratory services in a sustainable way, a price for testing should be established for all relevant tests. The prices should be based on local parameters but should also consider the real cost of analysis. It could be easier and simpler to establish prices based on international prices. A similar approach should apply to vaccine production, as detailed below.

V.7. Re-evaluate vaccine production management

Vaccine production is a key activity for NVRI and is crucial for the continued development of animal health programmes in Nigeria. However, NVRI's vaccine production is not sufficient to cover the country's demand and there are reoccurring equipment maintenance issues, reducing the effectiveness of production.

Therefore, NVRI should define a strategy to increase the effectiveness of vaccine production, which may include prioritization of vaccines and quantities to be produced, the revision of the pricing policy (cost recovery versus price), the participation of the private sector, and technology and facilities' upgrades. NVRI should also consider the potential use of a portion of the revenue from vaccine sales to purchase reagents for the diagnosis of priority animal diseases.

V.8. Implement the experience gained from previous WOAH Twinning projects

The NVRI has completed three WOAH Twinning projects: rabies (South Africa, 2012), FMD (Belgium, 2018), and HPAI (Italy, 2019). The NVRI should envisage recognition as a regional or a WOAH Reference Laboratory for these diseases because of these programmes. If affirmative, the Institute should evaluate the steps (including the accreditation to ISO 17025) to achieve these goals and include them in its strategic plan. This analysis should consider the priorities for the country and for the African Region as well as the existence of reference laboratories for animal diseases such as rabies, FMD and HPAI in the region.

V.9. Extend recommended action plans using the One Health approach

In December 2019, an initiative by the Nigerian Ministry of Health and the FMARD, as well as the NCDC with the support of World Health Organization (WHO) and WOAH, organized the National Bridging Workshop on the International Health Regulations (IHR) and the PVS Pathway.

During the Bridging Workshop, areas of synergy were identified but not implemented, leading to potential duplication or underutilization of available expertise from either of the federal organizations.

The outputs and actions proposed during this event related to the laboratory activities should be prioritized, including the development of a process for laboratory information sharing, data exchange, and exploration of sharing reagents between human health, animal health and environmental sectors. These actions would help build sustainable and effective collaboration and information sharing data exchange among human, animal, and environmental health sectors.

The establishment of partnerships and collaboration programmes with stakeholders related to the One Health approach is crucial to face zoonosis such as rabies, influenza, salmonellosis, Tuberculosis (TB), brucellosis, Lassa fever, Monkey pox etc., as well as AMR.

Nigeria has a “One Health Strategic Plan”, for the period of 2019-2023. The document is very complete and well done, but documentation was not available to demonstrate that the action plan is being implemented as initially agreed.

V. Appendices

VI.1 Appendix 1: Additional extracts from previous PVS Missions Reports (Gap Analysis, 2007 and Follow-up, 2019)

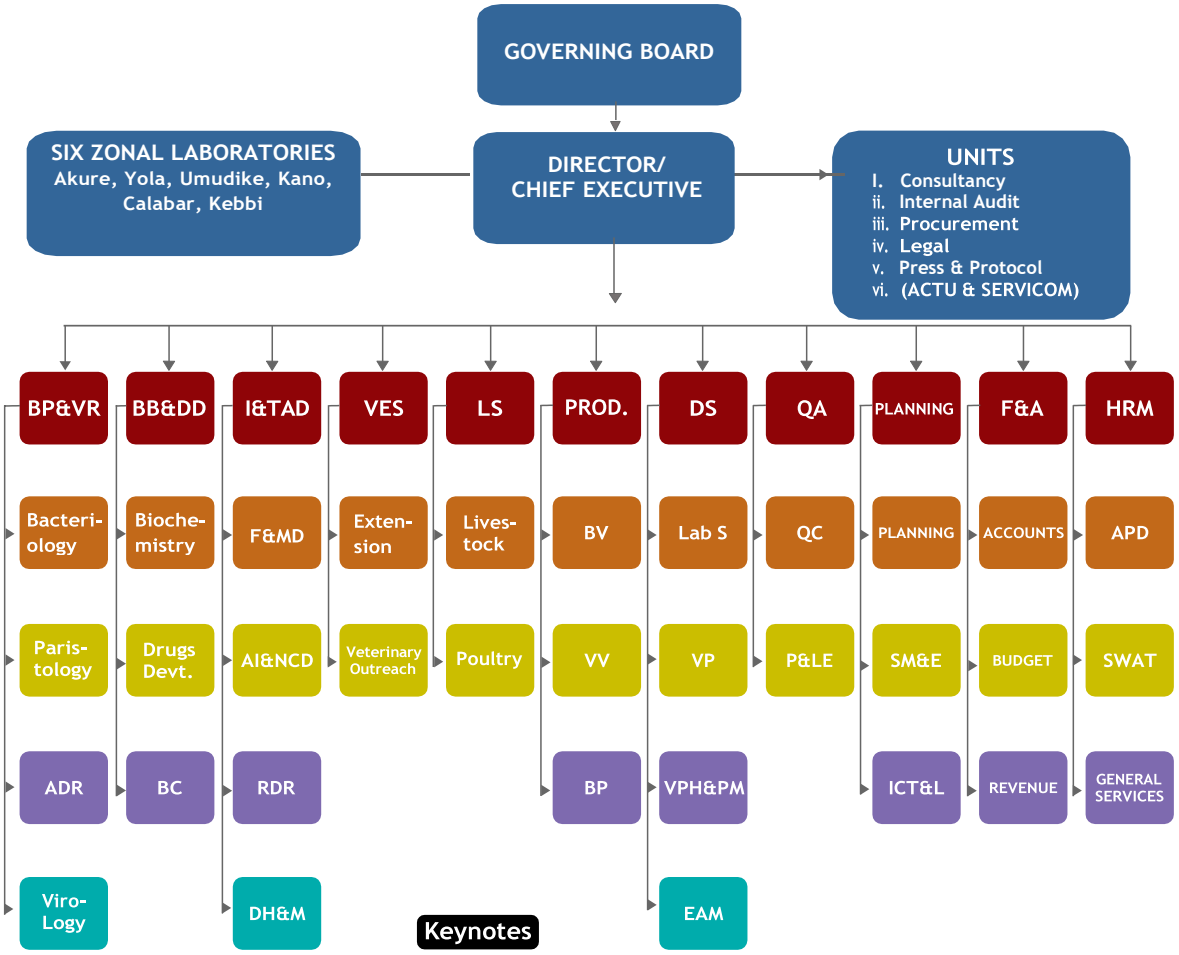
- The NVRI is developing a formal Quality Management System (QMS) to be compliant with the International Organization for Standardization (ISO) 17025 requirements but has currently not applied for accreditation. There was one external audit of the Quality Assurance Technical department in the framework of an international training on laboratory management, however, no other such external audit has been done since or is being planned. The NVRI plans to apply for ISO 17025 accreditation to the Nigerian National Accreditation Service (NiNAS), an accrediting body.
- The NVRI participates in Proficiency Testing (PT) with international laboratories such as the French Agricultural Research Centre for International Development (CIRAD), the Agency for Food, Environmental and Occupational Health & Safety (ANSES), WOAH Reference Laboratory in Padova, Italy, FAO, International Atomic Energy Agency (IAEA), the Pan African Veterinary Vaccine Centre (PANVAC).
- NVRI has completed three WOAH twinning programmes on Rabies, FMD, and HPAI.
- While the capacity to produce vaccines for ruminants is adequate and could even be scaled up, the capacity to produce poultry vaccines is insufficient and poultry vaccines are being imported at an annual cost of 7 million United States Dollar (USD). Therefore, the institute proposes that the Nigerian Government privatise vaccine production. To facilitate this venture, the NVRI has already registered a company, hoping that an investor could be found. This would allow the institute to redistribute its budget to research, diagnostic services, and training.
- It is necessary to develop regulations for veterinary laboratories to involve private laboratories in the VS network and to identify all the laboratories involved in animal health and veterinary public health activities. The priority is to strengthen the network of laboratories (public and private) involved in animal health and food safety testing.
- It is necessary to establish disease-free compartments in selected areas to allow the country to export animal products, mainly poultry products. Nigeria could export some animals and animal products (poultry and pigs) to neighbouring countries. Therefore, consultations for trade agreements should be developed.
- Disease reporting for all diseases is currently based on passive surveillance only. There is a necessity to implement active surveillance for diseases like TB, Brucellosis and AF) to verify the prevalence of these diseases in zones targeted for eradication. ASF has been identified as the main disease to be eradicated. Since Lagos State has the most extensive pig production, implementation of ASF surveillance should be prioritized in this State.
- The necessity to improve early detection and emergency response for HPAI, RP, ASF, FMD, PPR, CBPP, Rabies and ND, especially CBPP, because this disease have a huge economic impact on Nigeria.
- There is a need to control CBPP and PPR through mass vaccination of susceptible animal population as well as ND for which vaccination is only around 25% of the free-range birds.

- The PPR National Strategy Plan requires a risk analysis on disease distribution and prevalence. Active surveillance is not carried out routinely primarily due to insufficient funds. NVRI uses three different ELISA kits dictated by availability. NVRI is equipped to perform PPR conventional and rtPCR and virus isolation. It shares PPR strains with the depository in the IAEA, and it is collaborating with CIRAD for virus sequencing. NVRI has made many attempts and efforts to encourage satellite laboratories to send samples. It has even provided virus transport media, but the response has been minimal, as satellite laboratories claim they have no funds to cover the costs of transport of samples.
- Active surveillance programme for Brucellosis could be concentrated on dairy cattle by testing raw milk or serum samples.
- FMD is present in the country, however the economic impact is not well known. One of the objectives must be a better identification of the strains circulating in the country. Initially four serotypes were identified as strains circulating in Nigeria: O, A, SAT 1, SAT 2.
- Animal diseases introduced into the country in the past years are HPAI H5N1 in 2006 and 2014; HPAI H5N8 in 2016 and 2019; Equine Influenza in 2018. The emerging diseases in the last years include HPAI, Monkey Pox, Rift Valley Fever (RVF) and Lassa Fever. A recent outbreak of Equine Influenza in Sokoto State has led to a communication campaign advising all States to be on the alert for this equid disease, but a systematic sampling for detection of antibodies was not mentioned.
- There are no official residue monitoring programmes, although a residue plan for honey is being developed. Residue monitoring in large commercial establishments manufacturing products for the national and export markets should be implemented. The NAFDAC regulates manufacturers of processed and packaged food. To check on various parameters such as contaminants and residues, it uses its own laboratories, 3 of which are ISO 17025 certified.
- As with food safety, there are several competent authorities with conflicting or overlapping mandates for regulatory authority, once again leading to weaknesses and insufficient controls on sales and usage, particularly at the retail level. This situation raises concerns over the possibility of the presence of residues in animal products and the development of AMR.
- Most veterinary laboratories have microbiology capacity and routinely perform antibiotic sensitivity testing. There is no national capacity to serotype *Salmonella* isolates; culture identification is only done to *Salmonella* spp. There is no national reference laboratory for AMR.
- Synergies can be created; joint programmes can be established; and trust built by formalising the relationship with the poultry and livestock associations. It was observed that the poultry sector is well organised, and the Poultry Association of Nigeria is a very strong organisation with representation in every State.
- Recommendations: Develop a sustainable mechanism for sampling and sample submission including replenishment of transportation equipment (e.g., cooler boxes); prioritise and designate some laboratories to specific diseases, e.g., PPR, and equip accordingly to distribute specific capacities in a wider geographic spread; support the intention to commercialise NVRI's vaccine production so that NVRI can focus on research and diagnostics.

VI.2 Appendix 2: DET responses

DET available in the link
https://oieoffice365.sharepoint.com/:f:/r/sites/SustainableLaboratoriesProject-EXPERTNigeriaPVSLab/Documents%20partages/EXPERT%20Nigeria%20PVS%20Lab/Phase%203/Report/report%20appendices?csf=1&web=1&e=4klJnu

VI.3. Appendix 3. NVRI Organogram



BP&VR - Bacterial, Parasitic and Viral Research
BB&DD - Biochemistry, Biotechnology & Drug Development
I&TAD - Infectious and Trans-boundary Animal Diseases
VES - Veterinary Extension Services
LS - Livestock Services
PROD. - Production
DS - Diagnostic Services
QA - Quality Assurance
F&A - Finance & Accounts
HRM - Human Resource Management
ADR - Avian Diseases Research
BC - Biotechnology Center
F&MD - Foot and Mouth Disease
AI&NCD - Animal Influenza and Newcastle Disease

RD&R - Rabies Diagnostic and Re
DH&M - Dermatophilosis, Immun
BV - Bacterial Vaccine
VV - Viral Vaccine
BP - Biological Products
Lab S - Laboratory Services
VP - Veterinary Pathology
VPH&PM -Veterinary Public Health Medicine
EAM - Experimental Animal Ma
QC - Quality Control
P&LE - Plant and Laboratory Eq
SM&E - Statistics, Monitoring an
ICT&L - ICT & Library
APD - Appointment, Promotio
SW&T - Staff Welfare and Trainir

VI.4. Appendix 4. NVRI current demand, according to tests requested (2021), by disease and by method

Disease/Pathogen/Matrix/Analyte/Assay	Method		Number of tests
Mycoplasma mycoides subsp. mycoides	ELISA		16,000
	PCR		9
Brucella abortus, B. melitensis and B. suis	Agg		8,000
	Lateral Flow		4,000
	Multiplex PCR		41
Salmonellosis (S. *abortusovis*)	Bacteriology (Bacterial identification)		10,000
	Antibiotic Susceptibility testing		2,000
ASF	PCR		1,782
	rtPCR		950
Sheep pox and goat pox	ELISA		1,800
	PCR		8
General Bacteriology	Bacteriology (Bacterial identification)		1,166
General Parasitology	Parasitology (Parasite identification)		1,031
	PCR		915
PPR	ELISA		1,000
	PCR		65
NCD	AGID		651
	rtPCR		318
Trypanosomosis (tsetse-transmitted)	PCR		462
HPAI	rtPCR		419
Rabies	IFA		208
	PCR		38
	Animal Inoculation		33
Antibiotics	PCR		150
FMD	ELISA		150
	PCR		90
	Virology (Viral identification)		60
Specific bacteria (Listeria, Salmonella, ...)	PCR		150
Bovine babesiosis	Parasitology (Parasite identification)		111
IBDV	AGID		101
Surra (*Trypanosoma evansi*)	PCR		90
Campylobacteriosis	PCR		90

Escherichia coli O157	PCR		67
Cryptosporidiosis	Multiplex PCR		64
	PCR		22
Biochemistry	General Biochemistry		59
Listeriosis	PCR		50
Echinococcus granulosus	PCR		50
African horse sickness virus	PCR		41
Salmonellosis (*S. enteritidis, S. typhimurium*)	Bacteriology (Bacterial identification)		40
Feed	General Biochemistry		25
Mycology	PCR		22
Lumpy skin disease virus	PCR		17
Rabbit haemorrhagic disease	rtPCR		14
Heavy metals	General Biochemistry		6
Fowl pox	AGID		2
TOTAL		**52,367**	

VI.5. Appendix 5. Data Validation Laboratories Tracking Table[10]

	Data Tool Received		
Lab Name	DET rec'd	Date rec'd	Complete on reception
Ahmadu Bello University, Zaria	No		
University of Ibadan	No		
Usman Danfodio University, Sokoto	No		
University of Ilorin	No		
University of Nigeria Nsukka	Yes	15/10/2021	No
University of Maiduguri	No		
Federal University of Agriculture, Michael Okpara University, Umudike	No		
University of Jos	Yes	15/10/2021	No
Federal University of Agriculture, Makurdi	No		
Federal University of Agriculture, Abeokuta	No		
University of Abuja	No		
Nigeria Centre for Disease Control	No		
Olam private lab	No		
Animal care private lab	No		
National Agency for Food and Drug Administration and Control, Veterinary Medicines Directorate	No		
Lagos state veterinary hospital lab	Yes	15/10/2021	No
Ekiti state veterinary hospital lab*	Yes		
Osun state veterinary hospital	No		
Delta state veterinary hospital	No		
Gombe state veterinary hospital	No		
Ondo state veterinary hospital	No		
Enugu state veterinary hospital	No		
Ogun state veterinary hospital	No		
Bauchi state veterinary hospital	Yes	15/10/2021	No
Jigawa state veterinary hospital	No		
Parasitology Division NVRI	Yes	15/10/2021	No
NVRI Regional laboratory for influenzas and Transboundary Animal Diseases	Yes	15/10/2021	No
Foot and Mouth Disease Laboratory	Yes	15/10/2021	No
Public Health and Epidemiology Unit			
Federal College of Animal Health Vom	Yes	15/10/2021	No
Biochemistry Division NVRI	Yes	15/10/2021	No
BSL-3 NVRI	Yes	15/10/2021	No
Biotechnology Division NVRI	Yes	15/10/2021	No
Molecular Bacteriology NVRI	Yes	15/10/2021	No
Molecular Parasitology NVRI	Yes	15/10/2021	No
Vrial Diagnosis NVRI	Yes	15/10/2021	No
Diagnostic Services NVRI	Yes	15/10/2021	No
Rabies Diagnosis NVRI	Yes	15/10/2021	No
Pathology Unit NVRI	Yes	15/10/2021	No
Virology Research NVRI	Yes	15/10/2021	No
Quality Control Division NVRI	Yes	15/10/2021	No
NVRI General Centrailzed Data	Yes	15/10/2021	No

[10] Full document available in the link: https://oieoffice365.sharepoint.com/:x:/r/sites/SustainableLaboratoriesProject-EXPERTNigeriaPVSLab/Documents%20partages/EXPERT%20Nigeria%20PVS%20Lab/Phase%203/Report/report%20appendices/Appendix%205%20Data%20Validation%20Lab%20Tracking%20Table.xlsx?d=w1fccfdacffe24b8fa98e10ccac25a67d&csf=1&web=1&e=qd7Udy

VI.6. Appendix 6. List of documents provided during the mission

Title	Author / Date
Decree n. 35/1975	FMARD 1975
PVS Evaluation – Nigeria	WOAH 2007
PVS Gap Analysis Report – Nigeria	WOAH 2010
Veterinary Legislation Programme Mission Report – Nigeria	WOAH 2011
Joint External Evaluation of IHR Core Capacities – Nigeria	WHO 2017
NVRI Annual Report	NVRI 2018
NVRI Audit Account	NVRI 2018
PVS Evaluation Follow-Up Mission Report – Nigeria	WOAH 2019
One Health Strategic Plan 2019-2023	Various* 2019
NVRI Annual Report	NVRI 2019
NVRI Audit Account	NVRI 2019
NVRI Annual Report (Draft)	NVRI 2020
PVS Sustainable Laboratories Mission: Steps for a successful mission	WOAH 2021
Information and data to provide in advance of a PVS sustainable laboratories mission	WOAH 2021
NVRI Quality Manual	NVRI 2021
NVRI Strategic Plan 2021-2025	NVRI 2021

* Nigerian Ministry of Health, FMARD and Federal Ministry of Environment

VI.7. Appendix 7: Organisation of the PVS Sustainable Laboratories Mission

Expert Team	
Team Leader	**André de O. Mendonça**
Technical expert	**Ibrahim Diallo**
Technical expert	**Barbara Martin**
Technical expert	**David Korcal**
Observer/Facilitator	**Jennifer Lasley**
Observer/Facilitator	**Valentyna Sharandak**
Regional support	
WOAH Regional Representation for Africa	**Karim Tounkara**
Information of the mission	
Contact point in the country	**Maimuna Abdullahi Habib (current WOAH Delegate)**
Contact point in the country	**Mwapu Ndahi (CVO representative)**
Contact point in the country	**Maryam Mohammed (NVRI Executive Director)**
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Period	**08 to 29/11/2021**
Language of report	**English**
Language of the mission	**English**
Subject of the evaluation	**National Laboratory Network of Nigeria** **Laboratory Budget** **Human Resources** **Equipment** **Premises** **QMS** **Current and prospective demands** **Biosafety and Biosecurity**
References and Guidelines	**Terrestrial Animal Health Code (especially Chapters 3.1. & 3.2.)** **PVS Tool for the Evaluation of Performance of VS** **Interaction with stakeholders** **PVS Laboratory Mission Manual (2013)** **Manual of Diagnostic Tests and Vaccines for Terrestrial Animals**