

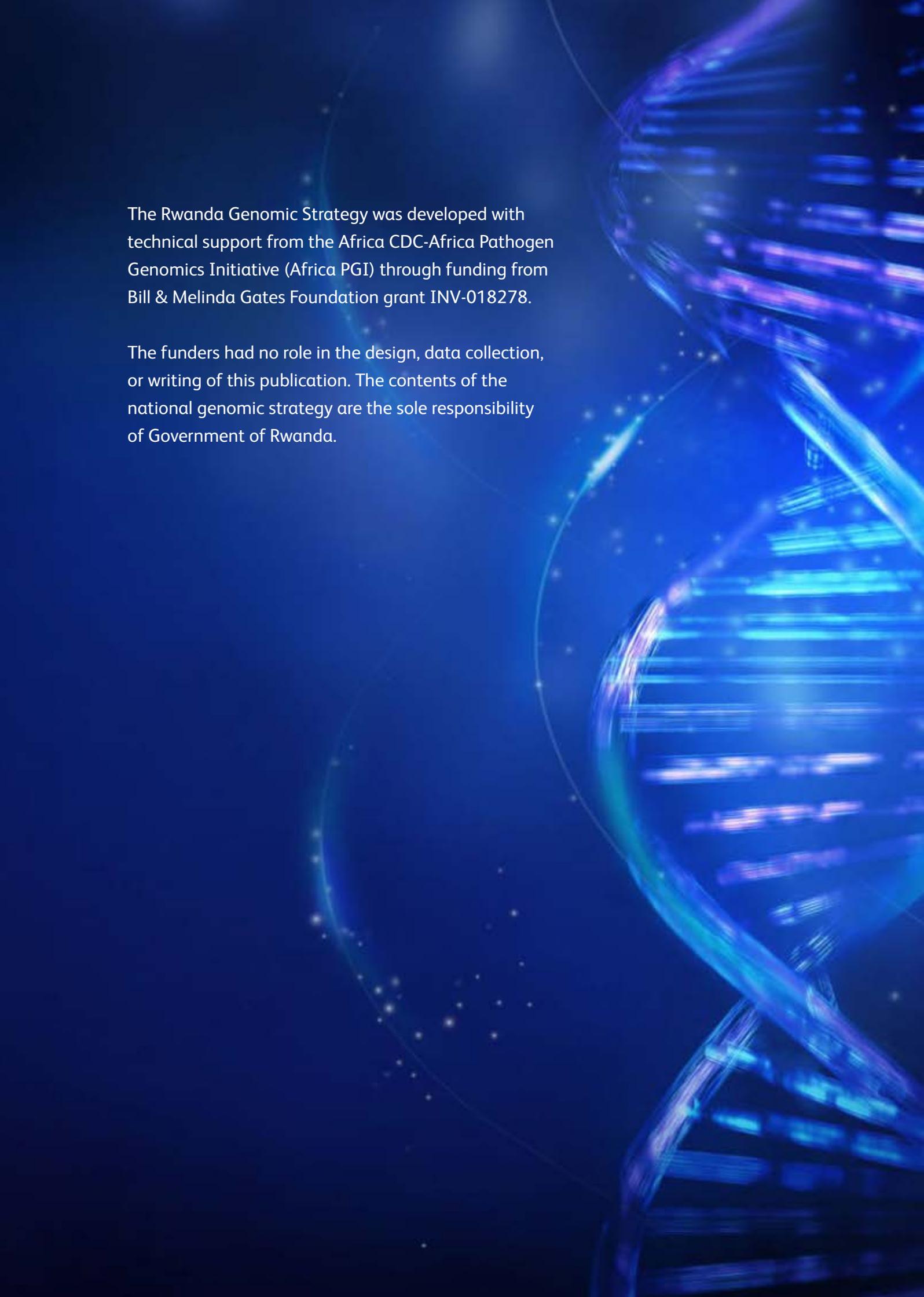


# RWANDA GENOMIC STRATEGY

(2026 - 2030)

Kigali, Rwanda





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## Foreword

The emergence and re-emergence of infectious diseases and genetic concerns at the interface of wildlife, livestock, humans and ecosystems constitute challenges to the globe. They are exacerbated by factors such as urbanisation, environmental degradation, climate change and global trade, demonstrate the need for transformative science-driven solutions. These challenges require not only cross-sectoral collaboration but also innovative technologies that provide timely, accurate and actionable insights. Owing to its high population density and dynamic interactions between people, animals and ecosystems, Rwanda is prone to more of such public health threats, which necessitates the adoption for effective monitoring strategies, including the genomics.

Genomics provides unprecedented insights into the genetic basis of disease and health, enabling the development of tailored interventions that are more effective and equitable. By embedding genomics within healthcare systems, forensic and public health frameworks, we can accelerate the development of novel diagnostic approaches, therapeutics, and vaccines. As we stand at the forefront of a new era in healthcare and public health, the integration of genomics into our strategies represents a transformative opportunity to enhance the prevention, diagnosis, and treatment of diseases, as well as addressing criminal cases. This broader Genomic Strategy is designed to harness the power of genomic data and technologies to improve health outcomes through precision medicine, innovative research

and robust public health surveillance. This National Genomic Strategy emphasizes on a collaborative and multi-sectoral approach that places crosscutting issues at its centre, ensuring leadership, ownership and sustainability. It was developed through efforts led by the Ministry of Health through the Rwanda Biomedical Centre (RBC) in collaboration with the Rwanda Forensic Institute (RFI), the Rwanda Agriculture and Animal Resources Development Board (RAB), the Rwanda Environment Management Authority (REMA), University of Rwanda, with the technical and financial support from Africa Centres for Disease Control and Prevention (CDC)-Africa Pathogen Genomics Initiative (PGI) and African Society for Laboratory Medicine (ASLM). It calls for building strong infrastructure, workforce capacity, data governance and ethical standards to maximize the outcome and value of genomic information while maintaining a public trust.

The Strategy envisions establishing a sustainable ecosystem for an integrated National Genomics Strategy that supports public health action, environmental protection, livestock management, forensics, research and development. Its mission is to build a sustainable, ethical and inclusive genomic ecosystem aligned with Rwanda's Vision 2050 and Universal Health Coverage goals.

Together, through shared vision and coordinated action, we can realise the promise of genomics to transform healthcare delivery and public health, positioning ourselves as leaders in the knowledge-driven economy of the future.

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## Executive Summary

The National Genomic Strategy for Rwanda is the outcome of a collaborative, multi-sectoral and evidence-driven planning process led by the RBC in collaboration with various local and international stakeholders. The Strategy lays the foundation for Rwanda to harness the transformative potential of genomics in addressing public health challenges, improving healthcare outcomes and accelerating precision medicine. Rwanda, one of Africa's most densely populated countries, faces a growing burden of emerging and re-emerging infectious diseases, non-communicable diseases (NCDs) and other genetically-identifiable concerns. Rapid urbanisation, environmental pressures and cross-border movement further complicate disease control. However, the field of genomics in Rwanda remains nascent and is constrained by limited infrastructure, workforce gaps, immature regulatory frameworks and low public awareness.

This Strategy was guided by the principles and strategic objectives of the Africa CDC Pathogen Genomics Surveillance Policy Framework as well as national documents. It aligns with the objectives outlined in national strategies, including the 2nd National Strategy for Transformation (NST2), the Health Sector Strategic Plan V (HSSPV) and the National Strategy for the Implementation of a Biosafety Framework for Genetically Modified Organisms (GMOs), as well as DNA evidence provided by the Rwanda Forensic Institute.

A group of experts from contributing institutions conducted a Strengths Weaknesses Opportunity and Threat (SWOT) analysis and developed a national strategy tailored to the context to respond to the country's real needs. Strategic actions will be coordinated by a National Genomics Steering Committee (NGSC), which will oversee their implementation. This committee will include representatives from human, animal, environmental health, Rwanda Forensic Institute (RFI), Rwanda Development Board (RDB), and academia. The NGSC will ensure alignment with national priorities, mobilise resources, monitor progress and coordinate the writing of future strategies pertaining to its mandate. Technical implementation will be led by specialized groups within key implementing institutions.

Invested efforts to develop this National Strategy together with the support of contributing institutions, lay the foundation to improve early disease detection, personalise treatment, track pathogens and understand population health at the molecular level. The implementation of this Strategy will boost research activities and lead to the development of novel diagnostics, therapeutics and vaccines.

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## List of abbreviations

ACE:	African Centers of Excellence
Africa CDC:	Centres for Disease Control and Prevention
AIDS:	Acquired Immune Deficiency Syndrome
AMR:	Antimicrobial Resistance
ASF:	African Swine Fever
AU:	African Union
BGI:	Beijing Genomics Institute
CBHI:	Community-Based Health Insurance
CCHF:	Crimean-Congo hemorrhagic Fever
CHUB:	University Teaching Hospital of Butare
CHWs:	Community Health Workers
CPD:	Continuous Professional Development
CPDS:	Coordinated Procurement and Distribution System
DG:	Director General
DNA:	Deoxyribonucleic Acid
DSI:	Digital Sequence Information
EAC:	East African Community
e-IDSR:	electronic Integrated Disease Surveillance and Response
eLMIS:	electronic Logistics Management Information Systems
EQA:	External Quality Assessment
ERP:	Enterprise Resource Planning
FMD:	Foot and Mouth Diseases
GISAID:	Global Initiative on Sharing All Influenza Data
GMOs:	Genetically Modified Organisms
HIV:	Human Immunodeficiency Virus
HPV:	Human Papillomavirus
HR4SCM:	Human Resources for Supply Chain Management
HSSP V:	Health Sector Strategic Plan V
ICT:	Information and Communications Technology
IMS:	Incident Management System
INES-Ruhengeri:	Institut d'Enseignement Supérieur de Ruhengeri
IQC:	Internal Quality Control
ISO:	International Organisation for Standardisation
LIMS:	Laboratory Information Management Systems
LIS:	Laboratory Information Systems
MINAGRI:	Ministry of Agriculture and Animal Resources
MINALOC:	Ministry of Local Government
MINEDUC:	Ministry of Education

MINEMA:	Ministry of Emergency Management
MININTER:	Ministry of Interior
MoE:	Ministry of Environment
MOH:	Ministry of Health
MVD:	Marburg Virus Disease
NCBI:	National Center for Biotechnology Information
NCDs:	Non-Communicable Diseases
NGS:	Next Generation Sequencing
NGSC:	National Genomics Steering Committee
NISR:	National Institute of Statistics of Rwanda
NRIF:	National Research and Innovation Fund
NRL:	National Reference Laboratory
NST2:	2nd National Strategy for Transformation
PBF:	Performance-Based Financing
PM:	Prime Minister
PPPs:	Public-Private Partnerships
PPR:	Peste des Petits Ruminants
PT: P	Proficiency Testing
QMS:	Quality Management System
RAB:	Rwanda Agriculture and Animal Resources Development Board
RBC:	Rwanda Biomedical Centre
RDB:	Rwanda Development Board
REMA:	Rwanda Environment Management Authority
RFI:	Rwanda Forensic Institute
RIC-R&D:	Rwanda Innovation Challenges for Academia-Industry Research and Development
RMRTH:	Rwanda Military Referral and Teaching Hospital
RMS:	Rwanda Medical Supply
RSV:	Respiratory Syncytial Virus
RVF:	Rift Valley Fever
Rwanda FDA:	Rwanda Food and Drug Authority
SARS:	Severe Acute Respiratory Syndrome
SOPs:	Standard Operating Procedures
SWOT:	Strengths, Weaknesses, Opportunities and Threats
TWGs:	Technical Working Groups
UHC:	Universal Health Coverage
UNAIDS:	United Nations Program on HIV/AIDS
UR:	University of Rwanda
VHFs:	Viral Hemorrhagic Fever
VPDs:	Vaccine-Preventable Diseases
WHO:	World Health Organisation



# 1. Introduction



## 1.1. Country Profile

### Geographical and Demographic Context

Rwanda is a landlocked country in East-Central Africa, bordered by Uganda, Tanzania, Burundi and the Democratic Republic of Congo. It spans a surface area of approximately 26,338 km<sup>2</sup> and is characterised by a mountainous terrain, with the Virunga volcanoes in the north and numerous lakes, including Lake Kivu, in the west. Administratively, Rwanda is divided into four provinces and the City of Kigali is further subdivided into 30 districts (NISR, 2024). The population was estimated at 14.3 million in 2023, with an annual growth rate of 2.3% (World Bank, 2024) and life expectancy at birth (years) of 69.9 (NISR, 2024). Rwanda has a young population, with a median age of 19.7 years and about 78% of the population is under the age of 35.

### Economic and Social Context

Agriculture, services and a growing industrial sector largely drive Rwanda's economy. The country's GDP was estimated at USD14.8 billion in 2023, with a projected growth of 6.2%, driven by public investment, tourism and innovation-led sectors (World Bank, 2024). However, challenges such as fluctuating external funds and climate-related risks persist. Rwanda has made significant progress in social development, particularly in healthcare and education, with universal health coverage reaching over 90% of the population (WHO, 2023).

### Epidemiological Context

Rwanda has achieved substantial progress in reducing communicable diseases, particularly malaria, HIV/AIDS and tuberculosis, through strong health initiatives. However, non-communicable diseases, including cardiovascular diseases, diabetes and cancer, are on the rise (RBC, 2024). Emerging and re-emerging infectious threats, such as the Marburg virus, Ebola virus, Mpox virus and Rift Valley Fever (RVF) virus, also necessitate continued vigilance in public health preparedness (WHO, 2024).

In 2024, Rwanda reported 66 confirmed cases of Marburg virus disease (MVD), including 15 deaths, resulting in a case fatality rate (CFR)

of 23%. Additionally, Rwanda is experiencing an ongoing outbreak of Mpox, with a total of 113 confirmed cases. Furthermore, Tanzania and Uganda have experienced MVD (2024) and Ebola (2025), respectively, which put Rwanda at highest risk of those outbreaks. In 2022, Rwanda experienced an outbreak of RVF, primarily affecting livestock but involving also humans. Rwanda's Health Sector Strategic Plan V (HSSP V) 2025–2029 outlines key milestones achieved in improving public health outcomes. These include significant reductions in maternal and child mortality rates. The maternal mortality ratio decreased from 210 per 100,000 live births in 2014/15 to 105 per 100,000 live births in 2023 and the under-five mortality rate fell from 32 per 1,000 live births in 2014/15 to 28.9 per 1,000 live births by 2022 (Ministry of Health, 2024).

In addition, the HSSPV also highlighted Rwanda's enhanced health security, with strengthened public health surveillance systems and a robust response to health emergencies, including the COVID-19 pandemic. The country's response to the pandemic included coordinated efforts in mass vaccination campaigns, public health guidelines, capacity building and infrastructure development for disease management and to help mitigate the spread and impact of the virus (MoH, 2024).

The country has also made substantial progress in the fight against infectious diseases, with a sharp decline in malaria incidence and mortality. Rwanda has made significant progress towards achieving the UNAIDS 90-90-90 targets, with 83.8% of people living with HIV knowing their status, 97.5% of those on treatment and 90.1% of those on treatment achieving viral suppression (Ministry of Health, 2024).

Rwanda's efforts to address nutrition have been also successful, thanks to the improved livestock and crop breeds, with the prevalence of stunting in children under five dropping from 38% in 2015 to 33% in 2020 (Ministry of Health, 2024). Additionally, the country has made strides in addressing the rise of non-communicable diseases (NCDs), implementing a comprehensive tobacco control policy and increasing the capacity of health facilities to diagnose and manage hypertension and diabetes (Ministry of Health, 2024).

## Health Financing Context

Rwanda's health financing model is built on a combination of both government and partner funding, private sector contributions and community-based mechanisms. A key pillar is the Community-Based Health Insurance (CBHI) scheme, known as Mutuelle de Santé, which provides affordable healthcare access to the majority of Rwandans, particularly in rural areas (Ministry of Health, 2024). The government also invests in performance-based financing (PBF) to improve the quality of healthcare service delivery by incentivising quality care (World Bank, 2023).

In addition to CBHI, health initiatives are co-financed with international health agencies, including the World Health Organisation (WHO), the Global Fund, the Centres for Disease Control and Prevention (CDC) in Atlanta, Africa CDC, Gavi and others. Public health spending focuses on strengthening primary healthcare, disease prevention and maternal and child health services (World Health Organisation, 2024). Despite these efforts, Rwanda still faces challenges in ensuring financial sustainability, reducing out-of-pocket expenses and increasing domestic revenue for health sector resilience (IMF, 2024).

## 1.2. National Genomic Strategy

Effective health outcomes extend beyond data collection and analysis. It necessitates the integration of genomic surveillance, data utilisation and capacity building into existing programs. Genomics is widely recognised as a powerful tool for investigating, managing and monitoring forensics infectious and non-communicable diseases. In Rwanda, significant progress has been made in building genomics capacity to support disease surveillance and forensics. To ensure a long-term impact, it is now essential to sustain and expand these achievements by embedding them within a country-specific surveillance framework.

To ensure a comprehensive realization of genomics in strengthening national public health and justice systems, the strategy integrates forensic genomics as a core pillar. This includes the development of human and non-human DNA analysis and databasing, forensic biobanking, and NGS-based forensic capabilities

within relevant institutions. The strategy will support evidence-based investigations, judicial processes, and national security by enhancing the use of genomics in crime resolution, wildlife protection and conservation enforcement, and post-mortem analysis.

In addition, the National Genomic Strategy will advance precision medicine by enabling widespread access to genomic testing, particularly in oncology and teratology. It will support early cancer detection, diagnosis of genetic disorders, personalized treatment plans, and improved prognosis by integrating genetic data into clinical care. Standardized genomic protocols across healthcare systems will enhance diagnostic consistency and treatment outcomes. The strategy will reduce the burden of cancer and genetic disorders through early detection, monitoring, and treatment.

Aligning the National Genomics Strategy with broader public health initiatives is a key step towards sustainability. The Africa CDC has developed a continental policy framework to guide African Union (AU) Member States in formulating context-specific pathogen genomics strategies. This framework offers recommendations for integrating genomics into clinical and public health functions, promoting regional collaboration and ensuring long-term sustainability.

Africa CDC remains committed to supporting Rwanda in developing and implementing a national genomics strategy. By adopting this Strategy, Rwanda can harness the benefits of genomics for public health, strengthen its capacity for early outbreak detection and response and enhance clinical care capabilities.

The National Genomics Strategy will enable the integration of genomics into disease surveillance and forensics, ensuring that the country defines priorities, addresses specific needs and builds resilient health systems. Africa CDC advocates for strategic investments in new technologies to ensure the sustainability and scalability of these efforts, with an ultimate goal of strengthening health security across the continent.

## 2. Vision, Mission, Guiding principles and goal



## 2.1. Vision

To establish a sustainable ecosystem for an integrated National Genomics Strategy for public health action, involving environmental and livestock security, forensics, research and genomic-driven innovations for development.

## 2.2. Mission

To harmonise genomics use in public health, environment, livestock, forensics, research and development.

## 2.3. Guiding Principles

### National Ownership

Rwanda will develop an integrated National Genomic Strategy that ensures ownership but also stakeholder involvement for effective genomics.

### Public Health Focus

The national strategy document will strengthen preparedness, outbreak detection and the tracking of priority pathogens while leveraging genomic tools to ensure effective treatment.

### Multi-disciplinary Partnerships

Partnerships will be strengthened across public and private sectors at local, national, regional and global levels to enhance coordinated and collaborative surveillance efforts.

### Equitability

Resource mobilisation for genomics will be guided by a fair, unbiased and objective approach to ensure equitable access

### Sustainability

Sustained funding and a reliable supply chain, along with long-term forecasting, will establish a robust genomic surveillance infrastructure and resources.

### Data Governance

Clear guidelines for data storage, sharing, accessibility and analysis will be developed in alignment with national policies and regulations.

### One Health Approach

Integrating genomic data from human, animal and environmental health sectors will enhance the response to zoonotic diseases and other cross-species health threats.

### Emergency Preparedness

Rwanda's national genomics strategy aims to integrate genomics into public health systems, enhancing preparedness and facilitating rapid responses to emerging health threats at all levels of the country.

## 2.4. Goal

To strengthen and expand a sustainable National Genomics Strategy.

### 3. Priority Pathogens



Group	Disease or pathogen	Potential genomics use-case	Priority pathogens/use case
	Emerging and re-emerging diseases	Early warning surveillance, outbreak detection, investigation, and appropriate response	<p><b>Viral hemorrhagic fevers (VHFs):</b> Ebola virus, Marburg virus, Crimean-Congo hemorrhagic fever (CCHF) virus, Lassa virus, Rift Valley fever (RVF) virus</p> <p>Influenza-like illness: SARS-CoV-2, Respiratory syncytial virus (RSV), Influenza viruses, Avian influenza virus</p> <p><b>Arboviral diseases:</b> Yellow fever virus, Chikungunya virus, Dengue virus, and Zika virus</p> <p><b>Vaccine-preventable diseases (VPDs):</b> Mpox virus, Poliovirus, Rotavirus, Vibrio cholerae, Bacillus anthracis, Rubeola (Measles) virus, Rubella virus, Yersinia pestis, Salmonella typhi, Enterotoxigenic E. Coli (ETEC), Rabies virus (Rabies lyssavirus), Human papillomavirus (HPV)</p> <p><b>Meningitis:</b> Neisseria meningitidis, Streptococcus pneumoniae, Haemophilus influenzae, Listeria monocytogenes</p> <p><b>Foot and Mouth Diseases (FMD)</b> in livestock</p> <p><b>Peste des petits ruminants (PPR)</b> in livestock</p> <p><b>African Swine Fever (ASF)</b> in livestock</p> <p><b>Tick borne diseases</b> (theileriosis, anaplasmosis, babesiosis, cowdriosis) and tick borne encephalitis (Ixodes ricinus and Ixodes persulcatus)</p> <p><b>Cassava Mosaic Disease</b></p> <p><b>Cassava Brown Streak disease</b></p> <p><b>Coffee Leaf rust</b></p> <p><b>Maize Stalk borers</b></p> <p><b>Banana bacterial wilt</b></p> <p><b>Rice blast</b></p> <p><b>Rice yellow mottle virus</b></p> <p><b>Potato-Phytophthora infestans</b></p> <p><b>Potato-Ralstonia solanacearum</b></p> <p><b>Tomato-Tuta absoluta</b></p>

Group	Disease or pathogen	Potential genomics use-case	Priority pathogens/use case
			<b>Banana Thrips</b> <b>Disease X</b> – detection and investigation of diseases of unknown etiology
II	Antimicrobial resistance (AMR) pathogens	Monitoring the emergence and spread of AMR in Africa	HIV and TB drug resistance. Fungal diseases Pathogens causing neonatal sepsis and hospital acquired infection - Klebsiella pneumoniae, and Escherichia coli, Acinetobacter baumannii, Pseudomonas aeruginosa, Vancomycin-resistant Enterococci, and Staphylococcus aureus (MRSA) Salmonella enterica serovar Typhi, Extended-spectrum $\beta$ -lactamase (ESBL) producing Escherichia coli surveillance in a One health TriCycle framework including human, animal; and the environment sectors
III	Malaria	Monitoring drug, diagnostic, and insecticide resistance; and elucidating transmission dynamics	<b>Parasite:</b> Plasmodium falciparum and Plasmodium vivax <b>Vector:</b> Anopheles mosquito species
IV	Food borne diseases	Outbreak management and surveillance	Salmonella species, Escherichia coli (ETEC, EHEC), Shigella species, Vibrio cholerae, Campylobacter species and Listeria monocytogenes Includes those listed under group II
V	Vaccine preventable diseases	Vaccine efficacy monitoring, transmission dynamics and elimination surveillance	Rotavirus, Rubella, Measles, Poliovirus, Neisseria meningitidis, Salmonella typhi, Vibrio cholerae Includes those listed under group I
VI	Zoonotic diseases		Rift Valley Fever (RVF) Virus, Avian Influenza, Swine Flu, Salmonella, Escherichia coli, Brucella, Campylobacter
VII	Environmental genomics surveillance	Outbreak management and surveillance	Wastewater

## 4. Strategic Objectives



## 4.1. Strategic Objective 1: Expand infrastructure capacity

To meet national priorities and support emerging needs in public health, disease surveillance and precision medicine, Rwanda must expand and maintain a robust genomics infrastructure. This includes strengthening capabilities in Next Generation Sequencing (NGS), bioinformatics and related technologies. The expansion should align with principles spanning public health,

forensic science, environmental monitoring and animal and plant health.

Currently, genomics surveillance for human health is on a positive trajectory but still requires reinforcement. In contrast, other sectors remain underdeveloped, highlighting an urgent need for comprehensive infrastructure development across all domains. Specific areas requiring increased capacity include neonatal genetic disorders, cancer genomics, diagnostics and testing for rare diseases.

### SWOT Analysis

#### Strengths

- Availability of multiple sequencing platforms (e.g., Illumina, Oxford Nanopore, BGI and Genetic Analysers) to support diverse genomic applications in the health sector
- Strong government commitment to investing in infrastructure expansion

#### Weaknesses

- Limited computational infrastructure for genomic data processing and analysis
- Limited laboratory infrastructure, including space and equipment
- Insufficient local capacity for

maintenance and repair of specialised equipment

- Limited biobanking facilities in some sectors
- Lack of automated systems for library preparation

#### Opportunities

- Potential to leverage existing programs to enhance genomics capacity
- Digital health integration

#### Threats

- Limited domestic funding to support genomic infrastructure development.
- High costs associated with genomics equipment, reagents and consumables

### Needs assessment of genomic capacity

To date, Rwanda has not conducted a national assessment of its genomics capacity, a significant gap that will be addressed through the implementation of the National Genomics Strategy.

A comprehensive assessment of national genomics capacity is essential for addressing current challenges and informing effective

strategic planning. Evaluating laboratories involved in genomics will ensure they are adequately prepared and will inform the allocation of resources to strengthen overall capabilities.

This evaluation will focus on key aspects, including the distribution and availability of equipment across laboratories, the number of facilities capable of conducting genomic sequencing and their technical readiness.

By taking a systematic and structured approach, this assessment will lay the groundwork for building a strong and resilient genomics infrastructure, one that supports routine activities and enhances the country's ability to respond effectively to future genomics-related needs.

### Multi-sectoral approach

Adopting a multi-sectoral approach is a strategic pathway to expanding genomics infrastructure capacity cost-effectively and inclusively. By engaging key sectors such as animal health, forensic science, environmental monitoring and precision medicine, in addition to human public health, Rwanda can achieve broader coverage and reduce duplication of infrastructure investments.

This approach promotes shared use of resources, such as laboratory facilities, equipment and data systems, across multiple sectors. It ensures that infrastructure expansion efforts respond to the needs of all genomic applications while maximising return on investment and building resilience in the national system. For instance, current practices, such as transporting samples from collection sites to central testing hubs—highlight the opportunity for multi-sectoral infrastructure upgrades that improve accessibility, efficiency and responsiveness. Through joint planning and shared infrastructure development, Rwanda can strengthen its national genomics capacity more sustainably and comprehensively.

### Coordination Capacity

Strengthening coordination capacity is key to ensuring that infrastructure investments in genomics are strategic, efficient and interoperable across institutions. Effective coordination among key stakeholders, including public health, animal health, academia and environmental sectors, will reduce infrastructure fragmentation and promote shared use of facilities, technologies and data systems. A centralised consortium will serve as a national coordination hub, enabling laboratories and institutions to align their infrastructure

development plans and avoid duplication. Regular stakeholder meetings, joint planning workshops and harmonised protocols will foster cohesive implementation and scalable infrastructure upgrades.

By establishing clear communication channels and structured feedback mechanisms, Rwanda can ensure that real-time needs and input from multiple sectors guide infrastructure expansion. Continuous training and capacity-building efforts tied to this coordination framework will further reinforce standardised operations and sustainable infrastructure growth.

## 4.2. Strategic Objective 2 – Strengthen workforce development and retention

Rwanda has made commendable progress in genomics, particularly in sequencing emerging infectious agents such as SARS-CoV-2, Mpox and Marburg viruses. This has been made possible through the efforts of key institutions, including the Rwanda Biomedical Centre (RBC), the Rwanda Forensic Institute (RFI), teaching hospitals and higher learning institutions.

While these initiatives have laid a strong foundation for Rwanda's genomic capabilities, they have largely been project-based and time-limited. Additionally, the current number of staff with specialised skills in human genetics, bioinformatics, pathogen, environmental and forensic genomics remains relatively small. Retaining these skilled professionals also is challenging due to the limited career development structures and incentives available.

To build a robust, skilled and sustainable genomics workforce, Rwanda will adopt a multi-faceted approach that strengthens education, training, research, collaboration and retention mechanisms.

## SWOT Analysis

### Strengths

- Availability of various institutions with a skilled workforce in molecular biology
- Availability of training programs to enhance skills
- Government commitment to invest in workforce development

### Weaknesses

- Limited number of personnel in genomic sequencing relative to the workload
- Limited number of personnel with specialised skills in genomics and bioinformatics
- Lack of biomedical engineers trained in the preventive and curative maintenance of genomics equipment
- Absence of a structured framework for continuous education and professional training
- Lack of comprehensive curricula to

develop essential skills in pathogen, human, plant, environmental, animal and forensic genomics

- Brain drain, leading to a loss of skilled professionals

### Opportunities

- Collaboration and training opportunities with academic and research institutions
- Potential for developing local genomic expertise through regional partnerships and cross-border initiatives

### Threats

- Limited control over funding sources, especially from external partners, for workforce development
- Risk of not coping with rapidly advancing genomic technologies
- High risk of brain drain with current lack of special incentives for rare skills

## Workforce capacity and competency

In Rwanda, genomic personnel must be thoroughly trained and proficient in their designated roles. Laboratories should develop job descriptions and competency frameworks for key positions, with annual performance assessments to evaluate staff progress. Based on these assessments, refresher training programs should be provided to ensure continuous skill development. Additionally, Rwandan institutions should design and fund their genomics and bioinformatics curricula, rather than relying solely on external support. This approach will ensure that the national genomic workforce remains sustainable and aligned with the country's evolving needs.

## Training and upskilling the existing workforce

1. Establish continuous professional development (CPD) programs and short courses tailored to specific fields, including human, animal, environmental health, forensics, and policy.
2. Promote local institutional collaboration to optimise resources and ensure the sustainability of training programs.
3. Strengthen international partnerships to develop fellowships and exchange programs for skill enhancement.

## Integrating genomics into university curricula

1. Introduce a comprehensive genomics module anchored in the multi-sectoral approach.

2. Develop specialised undergraduate and postgraduate degree programs in genomics, bioinformatics, and forensic sciences.
3. Align student research projects with National Genomic priorities and practical, real-world challenges.

### Working Environment

To strengthen Rwanda's genomic workforce, it is essential to create adaptable work environments that are tailored to the country's unique context. Leveraging existing Centers of Excellence, such as the African Centers of Excellence (ACE), the African Institute for Mathematical Sciences, the RBC, and university-based research hubs like the Institut d'Enseignement Supérieur de Ruhengeri (INES-Ruhengeri) and the University of Rwanda, can provide dedicated spaces for genomic sequencing, bioinformatics analysis, and training. These hubs will serve as specialised centres for hands-on learning, research, and innovation. By equipping these centres with state-of-the-art sequencing infrastructure, computational resources, and standardized biosafety measures, Rwanda can foster a dynamic ecosystem for workforce development.

Additionally, integrating hybrid and remote work models for bioinformaticians will promote collaboration across institutions and expand the reach of genomic surveillance expertise nationwide.

### Research capacity building

1. Establish dedicated genomics research centres.
2. Promote interdisciplinary research in genomics to address complex health and development challenges.
3. Mobilise funding and grants to support researchers and students specialising in genomics and related fields.
4. Foster industry-academia collaboration to stimulate innovation and entrepreneurship.
5. Support research communication and knowledge dissemination.

### Integration of pathogen genomic surveillance workforce into the national public health policy

A comprehensive genomic program requires the involvement of diverse professionals, including laboratory scientists, bioinformaticians, epidemiologists, clinicians, and data managers.

To ensure sustainability and institutional support, genomics capacity building should be integrated into key national policies, such as:

1. **Health Sector Strategic Plan V (HSSP V) (2024/25–2028/29)** – This plan outlines Rwanda's strategic priorities in healthcare delivery, including strengthening disease surveillance and laboratory systems. Embedding genomic surveillance within HSSP V will support early detection and response to emerging health threats.
2. **National Health Research Agenda and Policy** – Aligning genomics with Rwanda's research priorities will enhance evidence-based decision-making, ensuring that genomic data informs public health interventions.
3. **National Health Sector Policy** – Including genomic surveillance in this policy will institutionalise its role in Rwanda's disease prevention and control strategies.
4. **ICT Sector Strategic Plan (2025-2029)** – Linking genomic data with Rwanda's digital health infrastructure will facilitate real-time data sharing and improve outbreak response.

By embedding genomics capacity building within these frameworks, Rwanda can strengthen inter-agency coordination, improve disease monitoring, and enhance the overall public health response.

Training and development of the workforce  
Building a highly skilled workforce in genome sequencing and bioinformatics requires the establishment of structured national training programs aligned with both regional and international standards. Partnerships among universities, research institutions, RFI, health institutions, and global health organisations

will be vital in building capacity in sequencing technologies, bioinformatics, and data interpretation. Offering continuous professional development, including hands-on training, in-service education, and mentorship programs, will ensure Rwanda's workforce remains skilled, adaptive, and capable of meeting emerging genomic challenges. Encouraging cross-sector collaboration, particularly between public health institutions, academic institutions, and the private sector, will further enhance Rwanda's genomic capacity and ensure that workforce development is not only effective but also sustainable.

#### Strengthening institutional partnerships and research networks

1. Establish a National Genomics Consortium to coordinate research, policy implementation, and data sharing.
2. Enhance collaboration between universities, national laboratories, and international institutions.
3. Encourage public-private partnerships to support advancements in genomic medicine and biotechnology.

#### *Retaining skilled professionals*

1. Develop clear career pathways and incentives to attract and retain genomic scientists in academia, healthcare, forensics and industry.
2. Establish professional recognition frameworks and performance-based advancement mechanisms.

### **4.3. Strategic Objective 3 – Enhance coordination, governance and leadership**

Currently, genomic activities in Rwanda operate in silos, lacking a formal mechanism to coordinate diagnostic and research surveillance across the human, animal, environmental and forensic sectors. While functional structures are in place to advocate for large-scale genomic surveillance, a unified framework is still needed to ensure comprehensive coordination.

Rwanda has established a multi-ministerial coordination approach involving key ministries and agencies. This approach facilitates the management of public health emergencies, where the most relevant ministry takes the lead during specific events and reports to a task force steering committee. The activation of this system flows from the steering committee down to district-level task forces and community-based implementing entities.

Each ministry has an organisational structure that channels guidance and policies from central bodies to local community organisations, including Community Health Workers (CHWs) agricultural and livestock mentors. Central governance communications are relayed through peripheral leadership to reach the community level. Additionally, district command posts coordinate public health emergency management within their respective areas.

The electronic community event-based surveillance system has achieved nationwide coverage across all 30 districts, with at least two community healthcare workers in each district trained to report events via mobile phones. Public health emergency operations have been decentralised from the national to the provincial level to enhance emergency preparedness and response. Despite these advancements, a gap remains in integrating the National Genomic Strategy within existing health and governance systems. To address this, there is a clear need to establish a National Genomic Consortium. This consortium would bring together key ministries, technical implementing institutions and experts involved in genomic surveillance to ensure coordinated efforts and effective leadership in genomic activities nationwide.

The National Genomic Consortium will serve as a national platform for technical expertise, facilitating the scaling-up of genomics activities at all levels. It will ensure the integration of genomic science within existing institutional systems, promoting sustainability and strengthening Rwanda's overall genomic surveillance capabilities.

## SWOT Analysis

### Strengths

- Established governing organs and structures from the central level to the community
- Good governance
- National command post to coordinate public health concerns and report to the Prime Minister's office
- Existing sample referral system for medical laboratory testing

### Weaknesses

- The absence of an official platform to

link researchers, academicians and other technical institutions

- Institutions with genomic activities planning and working in siloes

### Opportunities

- Prioritisation of genomics in Government plans

### Threats

- The risk of disease threats, such as pandemics impacting operations

## National health strategic policies and plans

### Leadership and Governance (HSSP-V)

1. HSSP-V emphasises a robust Leadership and Governance component, aiming to achieve strategic priorities through effective coordination structures (e.g., Health Sector Working Groups and Technical Working Groups)
2. The framework ensures alignment among government, development partners, civil society organisations and the private sector during strategic plan development, implementation and performance reviews
3. It highlights health security and public health management
4. Promotes a smart, integrated One Health System
5. Advocates for multi-pathogen genome sequencing to identify potential health threats

### One Health Integration

While a “One Health” approach is present at the policy level, specific genomic

surveillance activities across the human, animal, environmental and forensic sectors have not been fully integrated into institutional planning and operations.

### Joint surveillance and standardised regulations

1. The policy encourages joint disease surveillance, response and standardised healthcare regulations.
2. While surveillance systems are a priority under HSSP-V, genomic surveillance is not explicitly detailed within the framework.
3. The Ministry of Emergency Management (MINEMA) incorporates risk mitigation strategies and the national contingency plan, which could support the endorsement of the national genomic strategy
4. The Ministry of Environment oversees implementing the Biosafety Law, especially on Genetically Modified Organisms (GMOs).

### Networks

#### Ministerial Collaborations

Coordination among key ministries, including the Ministry of Health (MOH), Ministry of

Local Government (MINALOC), Ministry of Agriculture (MINAGRI), Ministry of Emergency Management (MINEMA), Ministry of Environment (MoE), Ministry of Interior (MININTER), Ministry of Education (MINEDUC) and Rwanda Development Board (RDB), ensures a unified approach to public health emergencies.

### ***Expert and technical working groups***

A consortium comprising national Technical Working Groups (TWGs) and specialised expert groups (covering human, animal, environmental and forensic sectors) provides enhanced technical and strategic guidance.

### **Regional Collaboration**

Engagement with regional expert groups supports knowledge sharing and collective regional actions and initiatives.

## **Implementation of a continuous improvement strategy**

### ***1. Regular Technical Meetings:***

- Scheduled meetings for TWGs and expert groups, under defined Terms of Reference, ensuring continuous dialogue and strategy alignment
- A broader consortium meeting structure is also established to harmonise efforts across all groups

### ***2. Integration with existing systems:***

The genomic surveillance sample transportation system is incorporated into the current national infrastructure, enhancing operational efficiency

### ***3. Horizon Scanning:***

To identify and analyse emerging trends, risks and opportunities that could impact an organisation or industry in the future, enabling proactive decision-making and risk management

## **Use of research and information in strategic decision-making**

### ***Surveillance reports and interventions***

Expert/TWG reports are utilised to guide national genomic surveillance interventions and health research.

### ***Leveraging existing platforms***

Field epidemiology, surveillance and response platforms, as well as testing laboratories, are integrated into the genomic surveillance framework to strengthen data-driven decision-making.

### ***Governance and Coordination***

Since the One Health approach is central to the development and implementation of Rwanda Genomic Strategy, its coordination will be managed by the One Health governing framework (Figure 1). However, the actual implementation will be carried out by TWGs comprising members from public health disease control and emergency response.

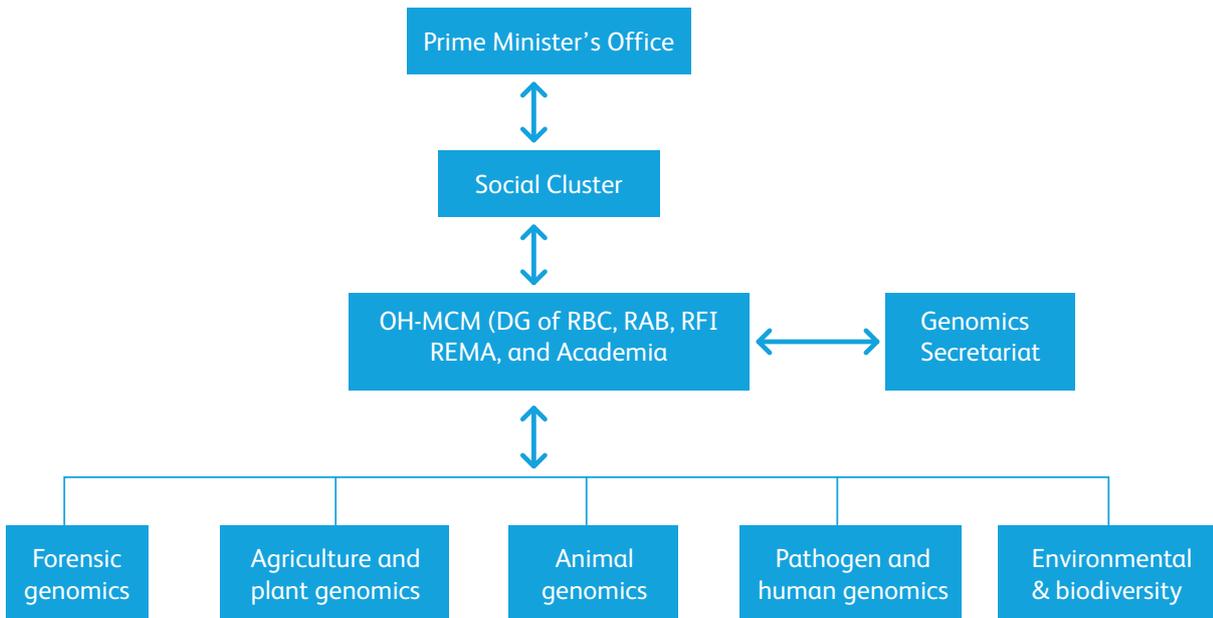


Figure 1 Proposed Governance and Coordination

The social cluster of the National Genomic Strategy comprises the Ministry of Health (MoH), the Ministry of Agriculture and Animal Resources (MINAGRI), the Ministry of Environment (MoE), the Ministry of Justice (MINIJUST) and the Ministry of Education (MINEDUC). This cluster shall be responsible for providing policy direction of Genomic Strategy and the MoH is the lead Ministry for the social cluster as per the One Health Policy.

### **One Health Multi-Sectoral Coordination Mechanism**

This shall be the inter-institutional leadership and coordination level composed by RBC, RAB, REMA, RFI and Academia. Its main function shall be support, coordination, collaboration, and communication among sectors at the leadership level, and shall advocate for a multi-sectoral One Health approach to policy making, strategic planning, fundraising and resource allocation. The One Health Multi-Sectoral Coordination Mechanism (OH-MCM) shall report and advise the social cluster of line Ministries bi-annually or more times depending on the need to inform or advice government on special issues.

### **Technical Working Groups (TWGs)**

These shall be expert fora that provide technical

expertise for tackling Genomic matters, enhance mutual accountability and collaboration among the sectors and promote greater efficiencies in Genomics management.

The following shall be key areas of focus for technical working groups (although others may be chosen by the OH-MCM):

- a) Forensic genomics
- b) Agriculture and plant genomics
- c) Animal genomics
- d) Pathogen and human genomics
- e) Environmental and biodiversity genomics

Technical aspects of program implementation shall be fully integrated into the appropriate operating units of key implementing partners through their sector specific policies and action plans. The number of TWGs and their specific terms of reference shall be determined by the OH-MCM.

Genomic secretariat shall be set up to assist the OH-MCM with the mandate to monitor on regular basis all the activities carried out under the integrated genomic strategy and shall be

hosted by the RBC. The Genomic Secretariat shall also be responsible for fiduciary aspects and for preparing quarterly and annual consolidated technical and financial reports that shall be submitted to the OH-MCM for review and approval.

#### 4.4. Strategic Objective 4 – Improve Quality Management Systems (QMS) in genomics

The government of Rwanda has established a quality management system for medical laboratories. Currently, four medical laboratories, including three public (NRL, CHUB, RMRTH) and one private (Legacy Clinics), are accredited under ISO 15189 for quality and competence in medical laboratories. An

External Quality Assessment (EQA) program has been initiated in these medical laboratories, as well as at the Rwanda Forensic Institute (RFI), which utilises the ISO 17025 standard. The NRL continues to provide training for staff in ISO 15189 standards to support the accreditation process to increase the number of accredited medical laboratories. Additionally, the Genomics Laboratory has developed and implemented standard operating procedures (SOPs) and testing protocols, spanning from sample collection to bioinformatics analysis.

In human health, the NRL is planning to become a Proficiency Testing (PT) provider. In line with this plan, a quality improvement initiative has been established to provide staff training on ISO 17043 standards.

### SWOT Analysis

#### Strengths

- Existing Quality Management Systems (QMS) in several medical laboratories.
- ISO 15189 accreditation was achieved by four medical laboratories in Rwanda.
- Active participation in proficiency testing (PT) for medical laboratories and in forensic applications for human identification.
- An operational sample transportation system for medical laboratories.

#### Weaknesses

- No established quality management system (QMS) specific to genomics laboratories.
- Limited QMS frameworks specifically tailored to genomics.
- Insufficient number of personnel trained in QMS related to genomics.
- Absence of certified institutions capable of producing genomic PT panels.
- Lack of ISO-accredited laboratories for animal, environmental and forensic sciences.

- Absence of a national accreditation body in Rwanda for genomics-related standards.

#### Opportunities

- Strong government commitment to establishing genomic laboratories with robust QMS.
- Potential collaborations with diverse partners to support QMS initiatives.
- Capacity-building opportunities focused on genomic-specific QMS.
- Opportunity for the Rwanda NRL to obtain ISO 17043 accreditation for producing genomic PT panels.
- Opportunity for the Rwanda Forensic Institute to pursue ISO 17025 accreditation.
- Opportunity to achieve ISO 15189 accreditation for animal health laboratories.

#### Threats

- Dependence on external laboratories for genomic PT production.

## Standards, accreditation and regulations

Through the national genomic Strategy, the Government of Rwanda aims to establish genome sequencing and bioinformatics guidelines aligned with internationally recognised standards, including biosafety and biosecurity regulations. For instance, the REMA has developed a National Strategy for the Implementation of Biosafety Framework for Genetically Modified Organisms (GMOs). Genomic laboratories in Rwanda will adhere to ISO 15189:2022 for medical and animal health laboratory quality and competence, as well as ISO 17025 for forensic laboratories. To facilitate the accreditation process, the laboratory network will be integrated into the Africa Pathogen Genomics and Bioinformatics Network Operational Framework.

Key institutions are committed to strengthening partnerships with public and private molecular biology laboratories, research institutions, universities and scientific industries. Additionally, the country will promote regional collaboration with institutions such as the African Society for Bioinformatics and Computational Biology and enhance coordination with national regulatory authorities involved in genomic oversight.

### Laboratory standardisation processes and methodologies

To ensure standardisation, Rwanda will develop standard operating procedures (SOPs) for genomic sequencing, data analysis and reporting, ensuring alignment with manufacturers' instructions and national and international best practices. Validation of test kits will be conducted for each new batch or lot using well-characterised reference specimens.

The equipment management system will include scheduled calibration and maintenance. Laboratory staff will be adequately trained and regularly assessed for competency in specimen handling, genomic workflows and the operation of equipment.

## Quality control and quality assurance

A national genomic quality assurance system will be established, incorporating a robust external quality assurance (EQA) program across the laboratory network. An inter-laboratory comparison system will be implemented to ensure consistency, reliability and accuracy of genomic test results.

Internal quality control (IQC) procedures will be implemented in line with laboratory policies and manufacturer protocols. Rwanda's genomic laboratories will also actively participate in External Quality Assessment (EQA) schemes to benchmark their performance to ensure consistency. These measures will support Rwanda's vision of establishing a reliable and sustainable genomic quality assurance system aligned with global best practices.

### 4.5. Strategic Objective 5 – Address supply chain and access bottlenecks

Rwanda's health supply chain has made significant advancements in recent years, particularly in enhancing efficiency, infrastructure and workforce capabilities. From 2020 to 2023, the rate of stock orders increased from 85% to 95% and the availability of essential medicines rose from 79% to 87%—a testament to improved logistics and inventory management.

Maintaining a reliable cold chain remains a critical component, especially for the storage and distribution of genomic reagents and other temperature-sensitive medical products. To address this need, Rwanda established a central cooling hub in Kigali, which serves as a platform to test and deploy innovative cold chain technologies. This initiative ensures the viability of genomics reagents and strengthens the resilience of the broader health supply chain.

Despite this progress, challenges persist—particularly in workforce capacity, with a shortage of skilled professionals in supply chain management. To address this gap,



Rwanda has adopted the Human Resources for Supply Chain Management (HR4SCM) Theory of Change, a strategic framework that identifies key workforce preconditions and supports performance optimisation through targeted interventions. However, continued investment is required in infrastructure, digital systems and workforce development to ensure a robust, reliable and sustainable genomic supply chain.

Other challenges include:

1. Non-standardised and non-interoperable electronic Logistics Management Information Systems (eLMIS): This hinders real-time visibility, coordination and decision-making across supply chain tiers. A new electronic system, i.e. Enterprise Resource Planning, has been introduced to improve supply chain management.

2. Incidents of substandard products: Cases of poor-quality equipment, reagents and consumables highlight the need for rigorous quality control measures and supplier vetting processes.

For the genomic Strategy to function optimally, it is essential to harmonise and streamline platforms used in genomic diagnostics and surveillance. Platform selection should be centralised and standardised, focusing on quality, cost-effectiveness and ease of maintenance.

Furthermore, procurement and equipment maintenance for genomic laboratories, including those serving human, animal, forensic and environmental health, must be coordinated and efficiently managed.

### *Strengths*

- Government commitment and policy framework: Supportive health logistics policies
- Centralised supply chain
- Innovation through technology (e.g., ZIPLINE)
- Cold chain infrastructure
- Regular supply chain performance evaluations
- Regulatory oversight by Rwanda FDA

### *Weaknesses*

- Unreliable funding to support supply chain management
- Lack of local manufacturing capacity

- Lack of buffer stock
- Lack of coordinated forecasting and procurement

### *Opportunities*

- Emerging local pharmaceutical companies
- Engagement of private sector stakeholders
- Direct engagement between RMS and manufacturers

### *Threats*

- Supply chain disruptions (Geopolitical conflicts, pandemics and natural disasters)
- Reliance on external suppliers

## Strengthening supply chain management

To enhance the effectiveness of supply chain operations, a harmonised and interoperable system, i.e. the Enterprise Resource Planning (ERP), should be implemented. The unified platform (ERP) would streamline logistics processes, including the management of genomics laboratory supplies, reagents and equipment.

In parallel, strengthening management practices is also critical for ensuring sustainable commodity availability. Furthermore, the procurement of laboratory equipment should be governed by agreements that include provisions for regular maintenance, thereby ensuring longevity, reliability and timely replacement.

## Quantification of laboratory commodities and security strategy

The Ministry of Health, through a Coordinated Procurement and Distribution System (CPDS), conducts annual quantification exercises to forecast and plan for health commodity needs. This includes programmatic laboratory commodities and supports the development of annual supply plans. Expanding this practice to encompass genomic surveillance commodities will allow for more accurate forecasting and resource allocation. Aligning the procurement of genomics-related laboratory supplies with the national Quality Management System (QMS) ensures the acquisition of the correct quantities at the right time and optimal cost, thereby enhancing the effectiveness of genomic sequencing.

Strengthening public-private partnerships through RMS will also be key to securing long-term collaborations that ensure consistent access to high-quality genomic reagents and consumables.

## 4.6. Strategic Objective 6 – Establish financing and sustainability models

Rwanda's vision for genomics aligns with its broader goals in healthcare innovation, biotechnology and digital transformation. A sustainable financing model must leverage government funding, international partnerships, public-private collaboration and innovative financing mechanisms to ensure long-term success. The Rwanda financing mechanisms for this strategy should ensure the sustainability, advancement and sector's ownership of genomic services in place and in line with the following financing mechanisms:

**Budget Allocations for Genomics Commodities and Training:** Rwanda has various budget lines dedicated to supporting the procurement of medical supplies, including genomics commodities. These budget allocations also support staff training in sequencing and bioinformatics, ensuring the continuous development of capacity in genomic services.

**Collaboration initiatives for Genomics Research:** There are existing partnership agreements between the local agency (i.e., RBC) and private agencies for collaborative research projects, including genomics initiatives. Strengthening these partnerships with both local (including RAB, RFI, REMA and RDB) and international organisations/institutions (BGI, Ginkgo, EAC, ...) will enhance Rwanda's capabilities in genomic research and sustainability.

## SWOT Analysis

### Strengths

- Government commitment
- Multiple Co-investment Resources (Pandemic Fund, Fleming Fund, World Bank, EAC, ...)
- Bilateral partnership between Rwanda and other countries

### Weaknesses

- Reliance on External Funding
- Lack of comprehensive Strategy for resource mobilisation
- Genomics is still in its infancy to attract funders

### Opportunities

- Leveraging on existing genomics facilities to attract further investments
- Publication and conferences-Driven Collaboration

### Threats

- Changes in Global Funding Policies
- Limited domestic budget allocation

## Sustainable health financing

Rwanda aims to integrate genomic surveillance into its health systems, prioritising local resource generation for long-term sustainability. Continuous monitoring and assessment will be crucial to ensure the system's effectiveness and adaptability

The Rwanda Health Sector Strategic Plan V (HSSPV) has established objectives for mobilising sustainable funds to achieve Universal Health Coverage (UHC) while ensuring efficient resource allocation. It prioritises financial sustainability under the following strategic objectives:

### 1. Resource Mobilisation

- Allocate government funds to support genomic research infrastructure and integrate genomics into National plans such as Vision 2050 and NST2.
- Encourage Public-Private Partnerships (PPPs) to attract private investment in

health infrastructure and direct health commodity supply.

- Establish co-financing agreements with pharmaceutical companies interested in vaccine and drug research.

### 2. Grant Schemes

Innovation Challenges: The National Council for Science and Technology has established a Rwanda Innovation Challenges for Academia-Industry Research and Development Collaboration Grant (RIC-R&D), co-funded by the National Research and Innovation Fund (NRIF) and the private sector. Special emphasis is placed on promoting knowledge transfer partnerships between industry, the private sector and academia, which could extend to genomic diagnostics, therapeutic interventions and pathogen genomics solutions.

## 4.7. Strategic Objective 7 – Strengthen data governance culture

Rwanda is progressively developing a robust data governance culture, particularly in the health sector, to support evidence-based decision-making and ensure the responsible handling of personal and genomic data. The enactment of Law No. 058/2021 on the protection of personal data and privacy, published in the Government Gazette on October 15, 2021, marks a critical step in establishing a comprehensive legal framework. This law provides clear guidance for the collection, processing, storage and sharing of personal health data, safeguarding individual privacy across public health systems.

Efforts are also underway to expand this legal landscape. A draft Ministerial Order is being developed to establish a GeneBank for preserving and managing the genetic content of flora and fauna, while the Law on Biosafety, coordinated by REMA, reinforces safety and regulatory measures for biological materials.

Although Rwanda currently lacks a dedicated digital system specifically for genomic data management, existing platforms such as the Electronic Integrated Disease Surveillance and Response System (e-IDSR), Laboratory Information Systems (LIS) and the Viral

Hemorrhagic Fever (VHF) Digital System offer a solid foundation for integration. At the Rwanda Forensic Institute (RFI), systems such as Laboratory Information Management Systems (LIMS) and comprehensive DNA databases are already in use for forensic profiling, underscoring the country's capacity to manage sensitive genetic data. Furthermore, the National Incident Management System (NIMS) also plays a pivotal role in coordinating outbreak responses. It includes a command post structure with a designated lead overseeing strategic information and ensuring coordinated data analysis and sharing during public health emergencies. Complementing this, RFI is currently developing a formal data governance document to guide cross-institutional standards and practices.

Despite these advances, there remains a gap in the standardisation of genomic data access and sharing across key institutions, such as RFI, RAB and REMA. While local bioinformaticians actively conduct analyses and contribute data to global platforms like NCBI and GISAID, the absence of a unified framework limits the full utilisation of data for national public health planning. Developing and institutionalising a clear and standardised framework for genomic data governance will be vital for promoting collaboration, protecting data integrity and unlocking the full potential of genomics in Rwanda.

## SWOT Analysis

### Strengths

- Availability of Law No. 058/2021 on the protection of personal data and privacy
- Existence of various digital systems (e-IDSR, LIS, LIMS)

### Weaknesses

- Lack of a Genomic Data Guideline
- Limited data infrastructure
- Limited human resources
- Susceptibility to data security breach when using cloud solutions
- Lack of a Genomic Data Centre
- Lack of integration of existing digital systems

### Opportunities

- Existing interministerial, regional and international coordination and collaboration
- Growing academic and research programs
- Availability of free online genomic data processing tools

### Threats

- Staff Attrition
- Global funding shifts based on priorities

## Standardisation of data guidelines

1. Establish and enforce standardised protocols for genomic data. This includes developing clear guidelines for metadata requirements and easy data sharing across local, national, regional and global health networks.
2. Collaborative efforts with regional and global entities to promote best practices and ensure compatibility with global initiatives.
3. REMA is looking at ways to regulate genomic data from biological diversity flora and fauna used for access and benefit sharing (such as DSI and NAGOYA protocol).

## Data sharing and publication

1. Develop a data-sharing framework that

outlines policies and procedures for accessing and publishing data securely and effectively. This framework should ensure that all data sharing adheres to ethical guidelines, respects privacy concerns and complies with intellectual property laws. Encouraging transparency and the timely release of pathogen genomic data will enhance collaboration with global health networks and maximise the impact.

2. Engage relevant ministries to establish a legal framework for data sharing and publication.

## Data storage, control and ownership

1. Establish a governing policy for data ownership and sharing by relevant institutions.
2. Put in place measures for safe access and secure storage of genomic data.



# 5. Monitoring and Evaluation



## GOAL: EXPAND AND STRENGTHEN GENOMICS INFRASTRUCTURE

### Strategic Objective 1. Expand infrastructure capacity

Strategic Actions and Activities	Output Indicators	Means of Verification	Assumptions and Risks
<b>Strategic Action 1.1. Equitable distribution of resources</b>			
Conduct comprehensive needs assessment in genomics capacity	Needs assessment conducted Number of institutions assessed	Need assessment reports	<ul style="list-style-type: none"> <li>Laboratories at different institutions have different capacities</li> <li>Reluctance in sharing data</li> </ul>
Hold multi-stakeholder engagement meetings to expand infrastructure capacity, including space allocation	Number of stakeholder engagement meetings held	Meeting reports	<ul style="list-style-type: none"> <li>There is no established genomics technical working group or consortium</li> <li>Conflicting interests among stakeholders</li> </ul>
Mobilise resources through multi-stakeholder grant applications	Number of grant proposals to support genomic sequencing submitted Number of commitments received	Grant applications and budget allocation	<ul style="list-style-type: none"> <li>There is inadequate funding support for genomic sequencing</li> <li>Delays in adhering to set deadlines</li> </ul>

Procure laboratory genomics and biobank equipment according to the institutional needs	Number of equipment procured	Delivery note Codifying Inventory database	<ul style="list-style-type: none"> <li>• There exist varying levels of laboratory equipment in different institutions</li> <li>• Delays in procurement</li> </ul>
Procure IT equipment according to the institutional needs	Number of equipment procured	Delivery note Codifying Inventory database	<ul style="list-style-type: none"> <li>• There are IT equipment in different institutions with different capacities</li> <li>• Misalignment between procured equipment and actual user</li> </ul>

## GOAL: EXPAND AND STRENGTHEN GENOMICS WORKFORCE

### Strategic objective 2. Strengthen workforce development and retention

Strategic Actions and Activities	Output Indicators	Means of Verification	Assumptions and Risks
<b>Strategic Action 2.1. Training and upskilling the current workforce</b>			
Conduct a multi-sectorial workshop to develop CPD training/Short courses for animal, human, environmental and forensic professionals for Genomics	Workshop conducted	Workshop report	<ul style="list-style-type: none"> <li>• They exist CPD/training programs in different institutions</li> <li>• Developed CPDs may not cover all domains</li> </ul>
Conduct a workshop to develop short courses for policymakers, epidemiologists, laboratory scientists, supply chain and data managers	Workshop conducted	Workshop report	<ul style="list-style-type: none"> <li>• Institutions have developed similar short courses</li> <li>• Developed courses may not meet the expectations</li> </ul>
Hold multi-stakeholder meetings to discuss opportunities involving international collaboration to establish fellowship programs (e.g. MMed molecular pathology, bioinformatics)	Number of stakeholder engagement meetings held	Meeting reports	<ul style="list-style-type: none"> <li>• Available fellowship programs in different institutions</li> <li>• The demand may exceed the available fellowships</li> </ul>
Conduct short courses training of in-service workforce, including Laboratory scientists, Supply Chain, Data Scientists, Bioinformaticians and Biomedical Engineering	Training conducted	Number of certificates issued	<ul style="list-style-type: none"> <li>• There is a gap in the knowledge and skills of the current in-service workforce</li> <li>• Unsatisfactory performance</li> </ul>

Strategic Action 2.2 Increase the number of skilled workforce			
Conduct a need assessment for the genomics workforce	Needs assessment conducted Number of institutions assessed	Needs assessment report	<ul style="list-style-type: none"> <li>• Workforce capacities vary among different institutions</li> <li>• Overloading institutions with high capacities</li> </ul>
Hold multi-stakeholder meetings to develop MSc and PhD programs in genomics	Multi-stakeholder meetings held	Meeting reports	<ul style="list-style-type: none"> <li>• Institutions have developed MSc. and PhD programs related to genomics</li> <li>• Limited resources</li> </ul>
Conduct a multi-stakeholder workshop to develop undergraduate (UG) core modules on pathogen and human genomics	Workshop conducted Number of genomics core modules integrated into undergraduate curricula	Workshop report	<ul style="list-style-type: none"> <li>• There exist genomics-related modules</li> <li>• Limited skills in genomics among fresh graduates</li> </ul>
Conduct a multi-stakeholder workshop to align students' research projects with national genomic priorities and real-world applications	Workshop conducted Number of research topics developed	Workshop report	<ul style="list-style-type: none"> <li>• Students align their research projects with national genomic priorities and real-world applications</li> <li>• Limited funds</li> </ul>
Organise consultative meetings with genomic stakeholders to assess the needs and requirements for the development of training programs for biomedical engineers	Consultative meetings conducted	Meeting reports	<ul style="list-style-type: none"> <li>• There exist training programs for biomedical engineers</li> <li>• Limited hands-on practical skills</li> </ul>
Strategic action 2.3. Research capacity building			
Hold multi-stakeholder engagement meetings to establish research centres on genomics, epidemiology and bioinformatics	Number of stakeholder engagement meetings held	Meeting reports	<ul style="list-style-type: none"> <li>• There exist research centres</li> <li>• No innovative research in genomics</li> </ul>
Hold multi-stakeholder meetings for fund mobilisation	Meeting conducted Number of awarded grants	Meeting reports	<ul style="list-style-type: none"> <li>• Institutions have mobilised funds</li> <li>• Insufficient mobilised funds</li> </ul>

Conduct multi-stakeholder engagement meetings to foster industry-academia collaboration	Meeting conducted Several industry-academia partnerships were established	Meeting reports	<ul style="list-style-type: none"> <li>• Institutions have established collaborative partnerships with industries</li> <li>• A limited number of industries specialised in genomics</li> </ul>
Conduct a symposium for research findings dissemination	Symposium conducted	Symposium report	<ul style="list-style-type: none"> <li>• Institutions have put in place means for research communication and dissemination</li> <li>• Research findings without impact on the community</li> </ul>
<b>Strategic Action 2.4. Strengthening institutional partnerships and research networks</b>			
Convene stakeholder meetings to establish a national genomics consortium, aiming to streamline efforts in research, policy implementation and data sharing.	Stakeholder meetings conducted	Meeting report	<ul style="list-style-type: none"> <li>• There exist similar consortiums to streamline efforts in research, policy implementation and data sharing</li> <li>• Fragmented and duplicated research</li> </ul>
<b>Strategic Action 2.5. Retaining skilled professionals</b>			
Conduct multi-stakeholder meetings for need and requirement assessment to create clear career pathways and incentives for genomic scientists	Multi-stakeholder meetings conducted	Meeting conducted	<ul style="list-style-type: none"> <li>• Institutions have means to retain their skilled professionals</li> <li>• High turnover of skilled staff</li> </ul>

## GOAL: ENHANCE COORDINATION, GOVERNANCE AND LEADERSHIP OF GENOMIC STRATEGY IN RWANDA

Strategic Objective 3.1. Establish a National Genomic Governance Platform composed of Researchers, Academicians and other technical Institutions

Strategic Actions and Activities	Output Indicators	Means of Verification	Assumptions and Risks
<b>Strategic Action 3.1. Establishment of Governing Bodies</b>			
Conduct a workshop to establish a multi-sectoral genomic governing organigram	Number of workshops and institutions conducted	Workshop report	Institutions understand the role of having a Multi-sectoral coordination approach Lengthy procedures in approving and implementing structure
Conduct a workshop to develop terms of reference and the guidelines for multi-sectoral genomic governing body	Workshop conducted	Workshop report	<ul style="list-style-type: none"> <li>Leveraging from existing similar organigrams</li> <li>Developed ToRs not meeting expectations</li> </ul>
<b>Strategic Action 3.2. Collaborative framework between institutions</b>			
Conduct twice-yearly institutional network workshops for capacity, expertise and data sharing	Number of workshops conducted	Workshop reports	<ul style="list-style-type: none"> <li>Institutions are working in silos, resource-scattered and underutilised</li> <li>Lack of efficiency and limited productivity</li> </ul>
Identify existing facilities at different level for an effective use of existing infrastructure and a coordinated planning	Existing infrastructure identified at different level	Identified missing infrastructure and plan for purchase	<ul style="list-style-type: none"> <li>Leveraging from existing similar policies and procedures</li> <li>Time constraints for developing policies Clearly identified needs for building a centralized center for the consortium</li> <li>Conflict of interest</li> </ul>

Conduct workshops to develop policies and procedures strengthening the collaborative framework			
Strategic Objective 3. 2 Establish collaboration, information sharing and reporting through a multi-sectoral genomic approach			
Strategic Action 3.3. Establish and functionalise TWGs, Steering committees and establish the consortium			
Quarterly meeting of TWGs	Number of meetings conducted	Meeting report	<ul style="list-style-type: none"> <li>• TWGs are committed to attend</li> <li>• Irregular TWGs meeting</li> </ul>
Bi-annual meeting for steering committee	Number of meetings	Meeting report	<ul style="list-style-type: none"> <li>• The steering committee will meet as planned</li> <li>• Inconsistent attendance due to conflicting agenda</li> </ul>
Conduct meeting for the genomic Governing board	Number of meetings	Meeting report	<ul style="list-style-type: none"> <li>• The governing board shall meet</li> <li>• Conflicting national priorities</li> </ul>

**GOAL: ENHANCE COORDINATION, GOVERNANCE AND LEADERSHIP OF GENOMIC STRATEGY IN RWANDA**

Strategic Objective 3.1. Establish a National Genomic Governance Platform composed of Researchers, Academicians and other technical Institutions

Strategic Actions and Activities	Output Indicators	Means of Verification	Assumptions and Risks
Conduct annual genomic conference	Conference conducted	Conference report	<ul style="list-style-type: none"> <li>Sharing research findings and experience</li> <li>Limited funds and low attendance</li> </ul>

**GOAL: ESTABLISH AND STRENGTHEN AN ACCREDITED QUALITY MANAGEMENT SYSTEM (QMS) FOR INTEGRATED GENOMIC SERVICES IN RWANDA**

Strategic Objective 4. Improve Quality Management Systems (QMS) on genomics

Strategic Actions and Activities	Output Indicators	Means of Verification	Assumptions and Risks
Conduct a multi-stakeholder workshop to develop and adopt national QMS guidelines tailored for genomics, including a roadmap	National Genomic QMS Guidelines developed and approved	Approved and published QMS guideline documents	<ul style="list-style-type: none"> <li>There is institutional support for national QMS implementation</li> <li>Delays in administrative approvals</li> </ul>
	Roadmap for QMS implementation across sectors developed and validated	Roadmap plan document	
Conduct onsite assessment for readiness to adopt genomics QMS	Assessment conducted	Assessment report	<ul style="list-style-type: none"> <li>There are medical laboratories with QMS</li> <li>Limited funds to address the identified non-conformities</li> </ul>

**Strategic Action 4.2. Strengthen human resources capacity for genomics QMS**

Provide in-service training on Genomics QMS	Number of personnel trained Training report		<ul style="list-style-type: none"> <li>A limited number of personnel are trained on different aspects of QMS</li> <li>Low attendance</li> </ul>
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**Strategic Action 4.3. Strengthen External Quality Assurance (EQA) and Proficiency Testing (PT) mechanisms**

Conduct training of staff for PT production	Number of staff trained	Training report and certificate	<ul style="list-style-type: none"> <li>Some staff have participated in PT production training</li> <li>Limited funds and low attendance</li> </ul>
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Strategic Action 4.4. Facilitate laboratory accreditation and recognition in genomics			
Conduct assessment and mentorship for the implementation of Genomics QMS Accreditation by a recognised body	Number of laboratories assessed	Assessment and Mentorship Report Accreditation certificate	<ul style="list-style-type: none"> <li>• Some laboratories are at different stages of accreditation</li> <li>• Lack of qualified assessors</li> </ul>
Strategic Action 4.5. Establishing Rwandan-based accreditation and PT provider			
Conduct training on PT production	Training conducted	Training report	<ul style="list-style-type: none"> <li>• There are some ongoing activities for PT production</li> <li>• Limited funds for training</li> </ul>
Conduct multi-stakeholder meetings to establish a National accreditation body	Meeting conducted	Meeting report	<ul style="list-style-type: none"> <li>• Key stakeholders are willing to establish an accreditation body</li> <li>• Lack of ownership</li> </ul>
Benchmarking with other accredited PT provider institutions	Benchmarking visit conducted	Benchmarking visit report	<ul style="list-style-type: none"> <li>• There exist accredited PT provider institutions with best practices</li> <li>• Difficulties in meeting PT production requirements</li> </ul>
PT production of selected genomic tests	Number PTs produced	Accreditation for PT production	<ul style="list-style-type: none"> <li>• Requirements for PT production are in place</li> <li>• Lack of sustainability</li> </ul>

## GOAL: STRENGTHEN THE SUPPLY CHAIN TO CATER FOR GENOMICS SEQUENCING IN RWANDA

### Strategic Objective 5. Address supply chain and access bottlenecks

Strategic Actions and Activities	Output Indicators	Means of Verification	Assumptions and Risks
<b>Strategic Action 5.1. Harmonisation of procurement for equipment and laboratory commodities for genomic laboratories and maintenance</b>			
Train the supply chain team on Genomics commodities	Training conducted	Training report	<ul style="list-style-type: none"> <li>Some staff have been trained on supply chain</li> <li>Limited mastery due to irregular practice</li> </ul>
Registration of multiple suppliers	Number of registered suppliers	Number of suppliers certified	<ul style="list-style-type: none"> <li>There exist local suppliers for genomics reagents and equipment</li> <li>Reluctance of suppliers due to low demand</li> </ul>
<b>Strategic Action 5.2. Integrating laboratory reagents, consumables and equipment into the existing CPDS (Coordinated procurement and distribution system)</b>			
Annual quantification exercise for genomic reagents across the human, animal, forensic and environmental sectors	Annual quantification conducted	Annual quantification report	<ul style="list-style-type: none"> <li>Relevant stakeholders are committed to annual quantification</li> <li>Increased expiries</li> </ul>
Conduct a meeting to review the quarterly supply plan for genomic reagents across multi-sectors	Meeting conducted	Meeting report	<ul style="list-style-type: none"> <li>There exists stock out and expiries</li> <li>Low participation</li> </ul>

Strategic objective 6. Establish financing and sustainability models			
Strategic Actions and Activities	Output Indicators	Means of Verification	Assumptions and Risks
<b>Strategy Action 6.1: Mobilise domestic and international funding</b>			
Conduct a multi-stakeholder meeting to develop a collaboration document for Genomics partnerships	Number of Meetings conducted	Meeting report	<ul style="list-style-type: none"> <li>All key stakeholders are committed</li> <li>Institutional priorities differ among stakeholders</li> </ul>
Conduct workshops for grant writing	Number of workshops conducted	Grant proposals developed	<ul style="list-style-type: none"> <li>There are available grants for application</li> <li>A limited number of awarded grants</li> </ul>
Engage in PPPs between stakeholders and private sectors	Number of PPPs established	MoUs, contracts.	<ul style="list-style-type: none"> <li>Private sectors align with national priorities</li> <li>Limited funds committed to PPP initiatives</li> </ul>
<b>Strategy Action 6.2: Strengthen financial governance and accountability</b>			
Appoint financial managers from relevant institutions	Technical Managers appoints	Appointment letters	<ul style="list-style-type: none"> <li>Accountants are available in institutions</li> <li>No motivation to carry additional tasks</li> </ul>
Hire a consultant/software agency to develop a Resource Tracking Tool (RTT) for genomics activities resources	Percentage of genomic resources tracked; discrepancies identified/resolved	RTT dashboards, audit reports	<ul style="list-style-type: none"> <li>Consultant/software agencies have the necessary expertise and experience in developing an RTT</li> <li>Companies do not bid for published tenders</li> </ul>
Deploy and use the Resource Tracking Tool (RTT)	Usage percentage	Dashboard	<ul style="list-style-type: none"> <li>Expenditure.</li> <li>The RTT will capture the use of genomic resources across all relevant programs</li> <li>Underutilisation of the tool</li> </ul>

<b>GOAL: Ensure Timely Standardised Data Analysis And Sharing For Public Health Decision-Making</b>			
<b>Strategic Objective 7. Strengthen data governance culture</b>			
<b>Strategic Actions and Activities</b>	<b>Output Indicators</b>	<b>Means of Verification</b>	<b>Assumptions and Risks</b>
<b>Strategic Action 7.1. Standardisation of data</b>			
Develop a standardised tool for the collection of metadata for genomic testing across sectors	Standardised tool developed	Available tool in using a	<ul style="list-style-type: none"> <li>• There exist available and similar tools</li> <li>• Resistance to adopting a new tool</li> </ul>
Conduct a workshop for standardisation/curation of generated genomic data quality	Workshop conducted	Workshop report	<ul style="list-style-type: none"> <li>• Key experts and stakeholders will participate in the workshop</li> <li>• A limited number of curators</li> </ul>
<b>Strategic Action 7.4. Data sharing and publication</b>			
Hold a multi-stakeholder workshop to develop a data-sharing policy for genomic data	Workshop conducted	Workshop report	<ul style="list-style-type: none"> <li>• All relevant stakeholders are willing and available to participate in the workshop</li> <li>• Divergent stakeholder interests and legal interpretations</li> </ul>
<b>Strategic Action 7.5. Data storage, control and ownership</b>			
Hold a multi-stakeholder meeting to develop guidelines for data access, storage, control and ownership centralisation	Meeting conducted	Meeting report	<ul style="list-style-type: none"> <li>• Stakeholders agree on the centralised control and security measures for genomic data</li> <li>• Leakage of stored data</li> <li>• Lack of backup system</li> </ul>

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# Annexes



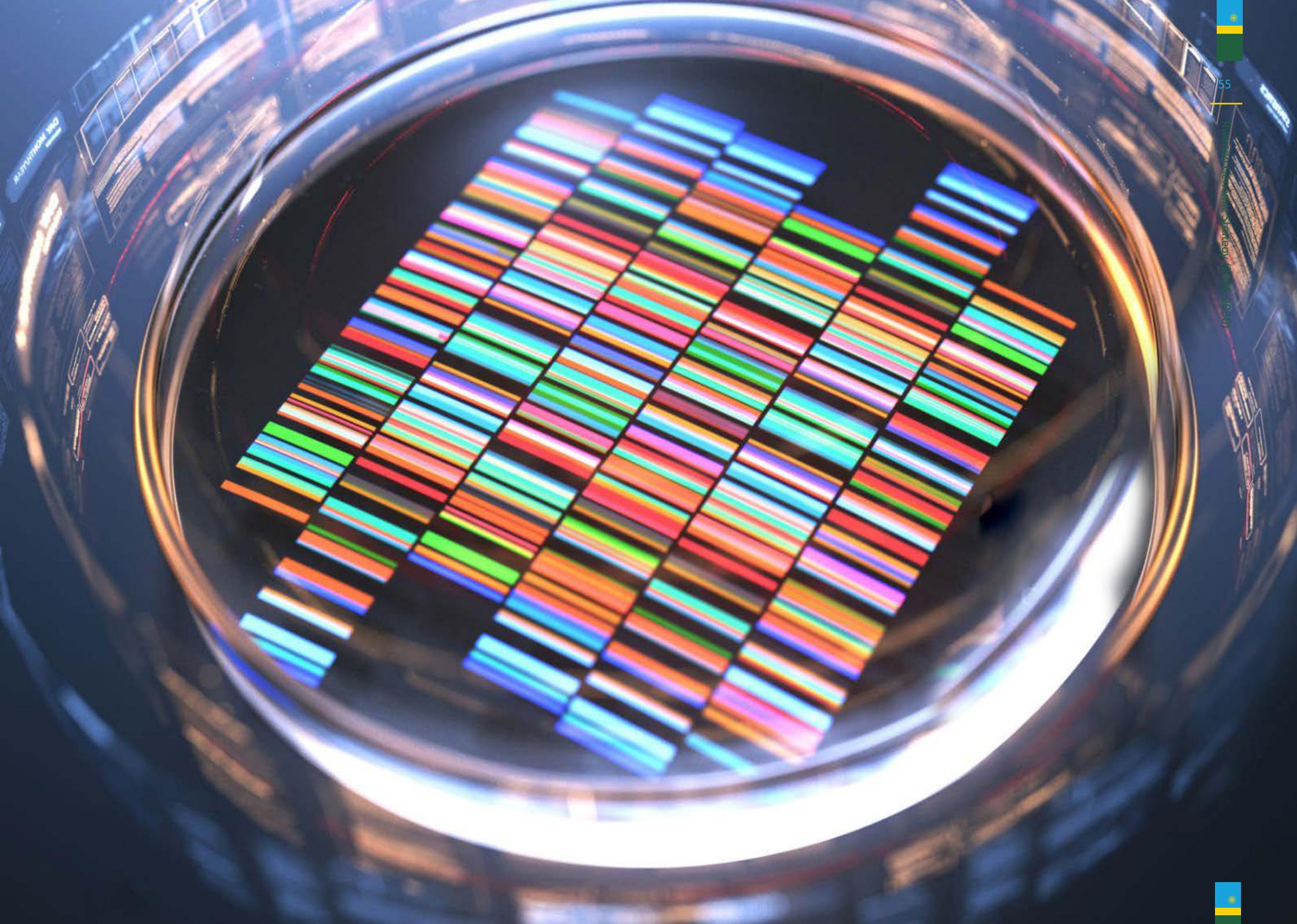


Hold multi-stakeholder meetings to discuss opportunities involving international collaboration to establish fellowship programs (e.g. MMed molecular pathology)	1,269,958	1,269,958	1,269,958	1,269,958	1,269,958	6,349,790
Conduct short courses training of in-service workforce including Laboratory scientist, Supply Chain, Data Scientist, Bioinformaticians and Biomedical Engineering	32,244,528	32,244,528	32,244,528	32,244,528	32,244,528	161,222,640
Conduct a need assessment for genomics workforce	411,600	411,600	411,600	411,600	411,600	2,058,000
Hold multi stakeholder meetings to develop MSc and PhD programs in genomics	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
Conduct a multi stakeholder workshop to develop undergraduate (UG) core modules on pathogen and human genomics	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
Conduct a multi stakeholder workshop to align students' research projects with national genomic priorities and real-world applications	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
Organize consultative meetings with genomic stakeholders to assess the needs and requirements for the development of training programs for biomedical engineers	1,269,958	1,269,958	1,269,958	1,269,958	1,269,958	6,349,790





	2026	2027	2028	2029	2030	Total
Annual quantification exercise for genomic reagents across the human, animal, forensic, and environmental sectors	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
Conduct a meeting to review quarterly supply plan for genomic reagents across multi-sectors	621,958	621,958	621,958	621,958	621,958	3,109,790
<b>Strategic Objective 6: Establish financing and sustainability models</b>	<b>109,690,476</b>	<b>109,690,476</b>	<b>109,690,476</b>	<b>109,690,476</b>	<b>109,690,476</b>	<b>548,452,380</b>
Conduct a multi-stakeholder meeting to develop collaboration document for Genomics partnerships	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
Conduct workshops for grant writing	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
Engage in PPPs between stakeholders and private sectors	621,958	621,958	621,958	621,958	621,958	3,109,790
Appoint financial managers from relevant institutions	81,600,000	81,600,000	81,600,000	81,600,000	81,600,000	408,000,000
Hire a consultant /software agency to develop a Resource Tracking Tool (RTT) for genomics activities resources	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	50,000,000
<b>Strategic Objective 7: Strengthen Data Governance Culture</b>	<b>34,937,036</b>	<b>34,937,036</b>	<b>34,937,036</b>	<b>34,937,036</b>	<b>34,937,036</b>	<b>174,685,180</b>
Develop a standardized tool for collection of metadata for genomic testing across sectors	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
Conduct a workshop for standardization/ curation of generated genomic data quality	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
Hold a multi-stakeholder workshop to develop a data sharing policy for genomic data	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
Hold a multi-stakeholder meeting to develop guidelines for data storage, control and ownership centralization	8,734,259	8,734,259	8,734,259	8,734,259	8,734,259	43,671,295
<b>Total per year</b>	<b>4,589,562,317</b>	<b>4,589,562,317</b>	<b>4,589,562,317</b>	<b>4,589,562,317</b>	<b>4,589,562,317</b>	<b>4,589,562,317</b>
<b>Total Cost</b>						<b>22,947,811,585</b>





## Partners and Collaborators

