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Laboratory Diagnosis of PPR: A Status Review for the Global Eradication Initiative

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GF-TADS
GLOBAL FRAMEWORK FOR THE
PROGRESSIVE CONTROL OF
TRANSBOUNDARY ANIMAL DISEASES



Outline of Presentation

- ❖ Introduction: Global context - Background
- ❖ Diagnostic Methods
- ❖ Sampling Methods for Diagnosis
- ❖ Evolution of PPR Laboratory Diagnostics (2015–2025)
- ❖ Achievements, Key Contributions and Impact
- ❖ Priorities and Directions Toward PPR-GEP 2030
- ❖ Critical Gaps and Limitations
- ❖ Strategic Alignment with PPR-GEP
- ❖ Conclusion and Roadmap

1. Background - Global Context

- **Global Eradication Framework:** PPR-GEP building on the 2015 GCES, targets disease elimination by 2030, emphasizing **robust diagnostics** for surveillance, vaccination monitoring, and verification of freedom.
- **Since the 2015 GCES launch,** improved serological, molecular and antigen-based tools have enhanced **sensitivity, specificity, and field adaptability.**
- **Diagnostics** are the **cornerstone** of the PPR-GEP: Accurate and accessible diagnostic systems are vital for early detection, outbreak response, verification of disease freedom, and **monitoring progress via the PMAT.**
- **Global Capacity Building:** Between **2015–2025**, FAO, WOAH, and **PPR-GREN** enhanced diagnostic capacity through **protocol harmonization**, reagent provision, laboratory training, and field-level support for outbreak investigations.
- **Challenges & Priorities:** limited validated wildlife assays and field-deployable tools, creating gaps in surveillance and rapid response.



2015-GCES → 2022-Blueprint → 2030-Target Year

2. Why Diagnostics Matter

❑ **Diagnostic Importance:** Rapid, accurate, and field-deployable diagnostic tools- surveillance, control, and eradication, ensuring timely detection and OB response.

❑ **Diagnostic Categories:** Antigen/genomic detection (active infection) and antibody detection (exposure and immunity monitoring).

Diagnostic Methods for PPR



Antigen Detection Methods



- ❑ **Antigen capture ELISA:** From swabs and tissues- cost-effective, but its **sensitivity is moderate** compared to molecular methods.
- ❑ **Molecular Diagnostics:**
 - ✓ **RT-qPCR-** Gold standard for high sensitivity and specificity
 - ✓ **Multiplex PCR-** Detection of **co-infecting pathogens** and PPRV lineages identification.
- ❑ **Isothermal Amplification: LAMP and RPA-** Rapid, low-cost, field-deployable alternatives
- ❑ **Sequencing:** Sanger sequencing and WGS- Molecular epidemiology, lineage tracking, mutation analysis, and tracking transmission pathways.
- ❑ **Virus Isolation:** Confirmatory standard for research and vaccine development
- ❑ **Field-Based Diagnostics:** Lateral flow devices (LFDs), IDvet rapid tests, and portable PCR systems enable on-site detection (75–95% accuracy)
 - ✓ **Non-invasive sampling** (saliva, nasal discharge, feces) for large-scale surveys and wildlife monitoring.



Antibody Detection Methods

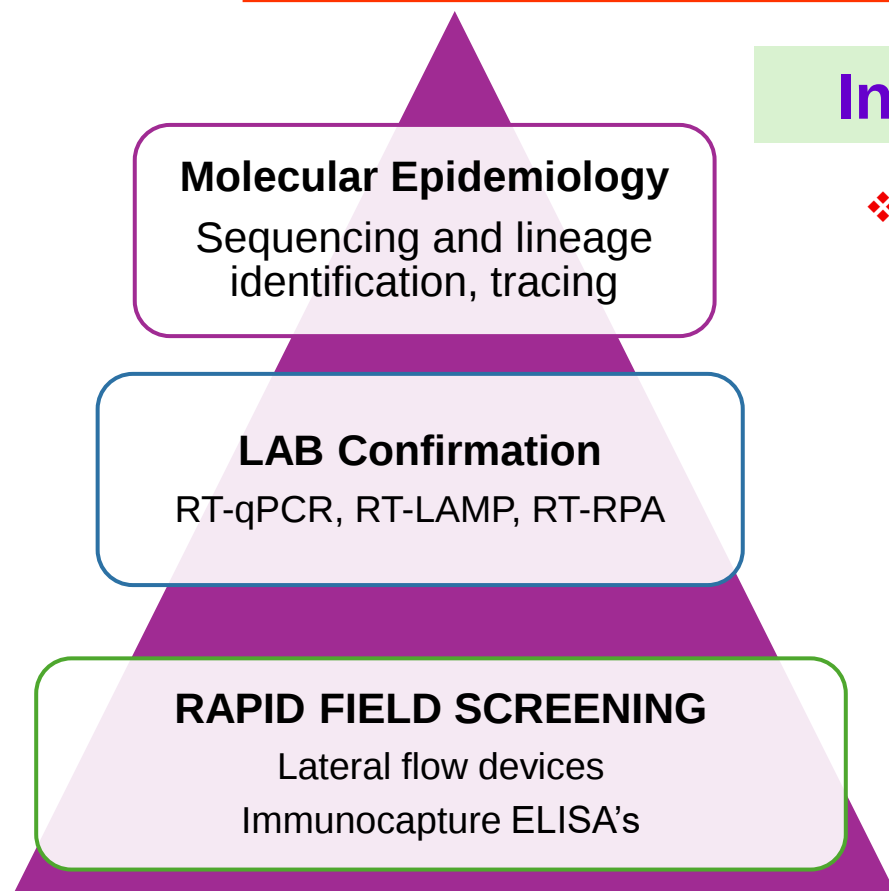


- ❖ **ELISA as Core Tool:** Competitive (cELISA) and blocking (bELISA) formats remain the primary tools for **diagnosis and sero-monitoring**, offering **high sensitivity and specificity** for routine surveillance and vaccination assessment.
 - ✓ **Target Antigens and Applications:** Nucleoprotein (N) (IDvet) or Haemagglutinin (H); H-bELISA (AU-PANVAC), ICAR-IVRI, provides diagnostic performance comparable to VNT, making it ideal for large-scale use.
 - ✓ **Field Insights:** Seroprevalence studies in endemic regions (e.g., Ethiopia, India) using cELISA have revealed widespread virus circulation and informed **vaccine coverage mapping**.
- ❖ **Virus Neutralization Test (VNT):** Gold standard for detecting functional neutralizing antibodies; GFP-based recombinant PPRV simplifies visualization.
- ❖ **Field Antibody Assays and Non-Invasive Tools:** LFA and quantum dot-based LFAs provide rapid, pen-side antibody detection (up to 97.7% sensitivity and 99.5% specificity); non-invasive samples (saliva, milk, feces) expand reach in **wildlife and remote settings**.

Why Diagnostics Matter ?

Integrated Diagnostic Framework

- ❖ Combining **serological** and **molecular** tools across **tiered diagnostic levels** ensures **rapid** screening, **confirmatory** testing, and effective **surveillance** toward eradication goals.



3 Tiers diagnostic levels

Antigen/Genomic Detection



Detects active PPR
virus directly (ELISA,
RT-PCR, RT-qPCR)



Used for outbreak
confirmation and
viral load quantification



Supports genetic typing
through sequencing
(lineage I-IV)

Antibody Detection



Detects immune response
(cELISA, bELISA,
H-bELISA)



Monitors herd immunity
and vaccine effectiveness



VNT confirms protective
antibody titers in
reference labs

3. Sampling Methods

❑ Standardized Sampling:

- ✓ Reliable PPR diagnosis depends on **standardized sampling, handling, and transport protocols**, ensuring accurate surveillance, outbreak investigation, and cross-border data comparability.

❑ Clinical Sampling:

- ✓ **Nasal and ocular swabs:** RT-qPCR or ELISA
- ✓ **Oral and conjunctival swabs:** For rapid field testing using lateral flow immunochromatographic assays
- ✓ **Whole blood (EDTA):** For molecular assays, particularly during early viraemia
- ✓ **Serum:** cELISA, VNT in convalescent or vaccinated animals
- ✓ **Tissue samples:** Spleen, mesenteric lymph nodes, lungs, and intestinal mucosa from freshly deceased or euthanized animals for confirmatory laboratory diagnosis

3. Sampling Methods

Non-Invasive and Wildlife ethical Sampling:

- Environmental samples: Nasal discharge on vegetation, feces, or water from shared drinking sites
- Fecal swabs and environmental wipes: for molecular surveillance- environmental surveillance
- All non-invasive samples should be accompanied by metadata (species, location, date, GPS coordinates) to support epidemiological mapping and traceability

Biosafety and Cold Chain: Field collection must adhere to **WOAH biosafety standards**- use of PPE, disinfection, and cold-chain maintenance of samples.

Virus preservation medium to conserve samples where cold storage capacity is limited

Shipment Guidelines:

- **National Shipment Protocols:** WOAH-recommended **triple packaging system** for domestic transport
- **International Shipment & Collaboration:** **UN3373 regulations** govern cross-border transport to **FAO/WOAH reference labs** with necessary permits, documentation, and cold-chain validation
- ✓ WOAH fast-track registration allows transfer of biological samples from CITES-listed species between reference laboratories.



4. Evolution of PPR Laboratory Diagnostics

Traditional and Conventional Techniques:

- ✓ Early assays such as AGID, CIE, and HI laid diagnostic foundations but lacked sensitivity
- ✓ ELISA formats (IDScreen® cELISA, H-bELISA) improved surveillance and vaccine monitoring across endemic regions.

Transition to Molecular and Field-Deployable Diagnostics

- ✓ RT-PCR and RT-qPCR targeting conserved N, F, and H genes became the gold standards for sensitive detection.
- ✓ Multiplex PCR and Duplex qPCR enhanced efficiency and co-pathogen detection.
- ✓ **Field-Deployable Innovations:** Development of RT-LAMP, and lateral flow tests (LFTs) enabled rapid, reliable, on-site diagnosis-offering comparable accuracy to laboratory PCR with turnaround times under one hour.

Commercial and Technological Collaborations: Partnerships between CIRAD and IDvet produced standardized kits-



ID GENE® Duplex qPCR



ID Screen® Antigen Capture Sandwich ELISA



ID RAPID® Immunochromatographic Dipstick



ID Screen® PPR Competitive ELISA

- ✓ Pirbright / ICAR-IVRI: *Advancing DIVA-compatible vaccines* and training (TOT) for diagnostic deployment.

4. Evolution of PPR Laboratory Diagnostics

❖ Diagnostic Transformation (2015-2025)

- ✓ **Rapid, reliable diagnostics are the backbone of the PPR GEP**
- ✓ **PPR diagnostics** have evolved from lab-bound assays to portable, digital, and One Health–aligned systems driving global eradication efforts.

Culture → ELISA → PCR → LAMP → Field Kit → AI Device

❖ Diagnostics advances (2021–2025) - Future Directions:

- ❑ **Nanotechnology**-based biosensors and microfluidic “lab-on-chip” systems
- ❑ **Oxford Nanopore** MinION for real-time field sequencing
- ❑ **Multiplex qPCR** enabling simultaneous detection of PPR, Pasteurella, Capripox, Mycoplasma
- ❑ **ISO-accredited training & harmonization** by WOA and FAO expanded quality diagnostics across regions.

5. Achievements, contributions and Impact

- Enhanced Diagnostic Reach
- Partnerships & Capacity Building
- WOAHA and FAO Reference Laboratory Leadership
- Global Research Coordination
- Impact on Eradication Goals



Global Enhanced Diagnostic Reach

Strengthening PPR Diagnostics and Surveillance Ecosystems

- **Global coordination:** FAO, WOAH, and reference laboratories shifted PPR surveillance from fragmented, lab-based testing to a **coordinated global diagnostic network**, advancing the 2030 eradication goal.
- **Rapid field detection:** Lateral flow tests and RT-LAMP assays enabled **on-site detection in endemic regions, expanding coverage and shortening outbreak response times**, supporting timely vaccination campaigns.
- **Standardized validated tools:** qPCR, cELISA, antigen ELISA, and rapid dipsticks now provide **reliable, globally harmonized diagnostics** for outbreak confirmation and post-vaccination evaluation (PVE).
- **Expanded surveillance:** Harmonized sampling and sero-monitoring protocols cover **domestic and wild ruminants across Africa and Asia**, improving turnaround time and field coverage.
- **Impact:** These advances in diagnostics form a **cornerstone of global PPR eradication efforts**, enabling faster, more accurate decision-making.



Global Partnerships and Capacity Building

Building Diagnostic Capacity Through Global Collaboration

➤ Collaborative Infrastructure:

❖ FAO/WOAH Reference Laboratory:

- ✓ **CIRAD (France):** Global leader in diagnostic validation & non-invasive tools.
- ✓ **Joint FAO/IAEA:** Diagnostics, Molecular Multiplex.
- ✓ **Pirbright (UK):** DIVA vaccine R&D & pen-side molecular diagnostics.
- ✓ **CAHEC (China):** Regional reference for Asia-Pacific. molecular diagnostics and molecular epidemiology
- ✓ **ICAR–NIVEDI (India):** WOAH Reference Lab (Since 2024), Surveillance and monitoring and integrating AI & GIS for risk mapping.
- ✓ **AU–PANVAC (Ethiopia):** Vaccine quality control for Africa.

❖ WOAH Laboratory Network for PPR: 22 + Labs Across Globe

❖ CIRAD–IDvet partnership – standardised global diagnostic kits:

- ✓ *ID GENE qPCR, ID Screen ELISA, ID RAPID dipstick.*

❖ FAO/IAEA VETLAB Network – connects 75 + laboratories across -60+countries for training, reagent access, and molecular diagnostics

Global partnerships have transformed diagnostics into a harmonized, quality-assured, and globally accessible system- **the foundation of the PPR Global Eradication Programme.**

➤ Global Coordination:

❖ PPR-GREN (Since 2018): Aligns global research on diagnostics, vaccine improvement, and disease modeling.

❖ PPR-GEP Blueprint (2022): Defines the operational roadmap toward 2030 eradication, integrating *surveillance, diagnostics, and vaccination.*

WOAH and FAO Reference Laboratory Leadership

Global PPR Reference Laboratories – Roles & Contributions

22+ network labs coordinating diagnostics, surveillance, and eradication efforts



WOAH

Reference Laboratory
Network for PPR

1. CIRAD (France)



1. Diagnostics, vaccines, molecular epidemiology
2. Standardized qPCR, ELISA, rapid tests
3. Non-invasive sampling & training

2. Pirbright Institute (UK)



1. DIVA vaccines & pen-side RT-LAMP
2. Reference reagents & strain characterization

3. FAO/IAEA VETLAB Network



Training, assay development, proficiency testing

4. CAHEC (China)



1. Asia–Pacific surveillance & vaccine monitoring
2. ELISA/qPCR testing & sequencing
3. CRISPAR-Cas

5. ICAR–NIVEDI (India)



1. Regional diagnostics & molecular epidemiology
2. AI/GIS-based risk mapping
3. ICAR–IVRI PPRV Diagnostics & vaccine development- c-ELISA and s-ELISA

7. AU–PANVAC (Ethiopia)



1. Vaccine quality, safety, standardization, b-ELISA
2. Supports Pan-African PPR Eradication Programme

Coordinated lab network strengthens assay standardization, genomic data sharing, outbreak monitoring, and global PPR eradication target

Global Research Coordination

Global PPR Eradication Framework

PPR Global Eradication Programme (GEP)

- Jointly coordinated by FAO & WOA
- Guided by the **2022 Blueprint**
- Focuses on **surveillance, vaccination, diagnostics, and socio-economic interventions**
- Supports the **2030 eradication target**



PPR Global Research & Expertise Network (PPR-GREN)

- Established 2018 to align research agendas
- Links **virologists, epidemiologists, socio-economists, etc.**
- Focus: epidemiology, diagnostics, vaccines, socio-economics, disease modeling



GEP ↔ PPR-GREN

- Harmonizes research, diagnostics, and knowledge sharing
- Translates innovations (NGS, multiplex assays, molecular surveillance) into **field applications**

Strategic Priorities in PPR Diagnostics

Category	Highlights
Diagnostic Innovations	Lateral flow, RT-LAMP, RT-RPA, MinION sequencing, multiplex PCR
Commercial Collaboration	CIRAD–Innovative Diagnostics kits; The Pir Bright Institute-DIVA vaccine; ICAR-IVRI- DIVA Vaccine and Diagnostics
Capacity Building	VETLAB network, training programs, technical expansions- all WOAHA and FAO labs.
Reference Laboratories	Multi-modal diagnostic services, surveillance & training capabilities
Global Coordination	PPR-GEP Blueprint, PPR-GREN network
Challenge and Gaps	Sensitivity, wildlife testing, infrastructure, test integration
Future Focus	AI-enhanced diagnostics, scalable capacity, integrated surveillance

6. Critical Gaps and Limitations in PPR Diagnostics

Challenges in PPR Diagnostics and Surveillance

Incomplete Validation Across Species- Wildlife/atypical hosts

- Current ELISA and RT-qPCR assays optimized for domestic small ruminants.
- Non-invasive sampling (feces, nasal secretions, environment) is promising but **under-validated**.
- Wildlife reservoir role remains poorly defined, hindering risk-based interventions.

Field Test Limitations:

- Point-of-care assays (LFIA) improve on-site detection but have **lower sensitivity/specificity**.
- Lack of **DIVA capability** limits post-vaccination monitoring.

Digital Surveillance and Data Integration Gaps:

- **Digital surveillance platforms** like mobile reporting tools and WOA's WAHIS are **poorly integrated** with diagnostic laboratory data, resulting in **delayed real-time analysis** and slower decision-making.
- Poor connectivity, limited data management, and incompatible databases slow reporting and information sharing, especially in **remote pastoral regions with high animal movement**.

Diagnostic, operational, and infrastructural gaps still limit effective surveillance, control

6. Critical Gaps and Limitations in PPR Diagnostics

Field Implementation Barriers

- Weak cold chain, reagent shortages, sample degradation (virus preservation medium to conserve samples where cold storage capacity is limited)
- Limited staff training in biosafety and sample handling
- Co-infections complicate detection and reporting, reducing the scalability and consistency of surveillance.

Molecular and Sequencing Gaps

- Lack of access to RT-qPCR and sequencing capacity
- Limited access to equipment, reagents, and skilled personnel hinder detection of new PPR lineages
- High cost slows adoption of portable sequencing technologies

Lack of Standardisation and Quality Assurance Gaps

- **Variability in diagnostic protocols and limited participation in inter-laboratory proficiency testing** undermine result consistency and reliability.
- Need for harmonized guidelines and accreditation (e.g., ISO/IEC 17025)

Laboratory Network & Infrastructure Gaps:

- Many labs lack BSL facilities.
- Reliance on reference labs causes delays and increases costs.

7. Future Priorities and Directions Toward PPR Eradication

- ❖ Achieving the 2030 PPR eradication goal requires coordinated global efforts.
- ❖ GEP enters its final phase, improving diagnostic tools, standardization, and accessibility is critical.

Non-Invasive Diagnostic Methods

- Develop validated assays for **saliva, feces, nasal swabs, and environmental samples.**
- Enable ethical, stress-free sampling of **wildlife and atypical hosts.**
- Integrate into One Health–aligned **wildlife and ecosystem surveillance**

Point-of-Care and Next-Generation Diagnostics

- Develop **DIVA-capable diagnostics** to distinguish vaccinated from infected animals.
- Advance **lab-on-a-chip, digital LAMP, digital PCR, and nanobody-based LFDs** for access in remote areas
- Leverage **AI-assisted imaging and mobile sequencing (MinION)** for rapid outbreak confirmation.
- Genomic surveillance tracks viral evolution & cross-border transmission.



Digital PCR

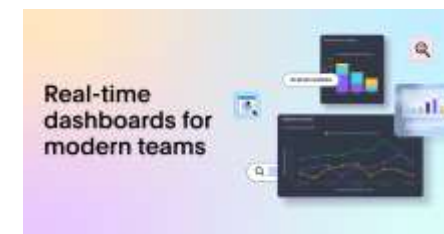


MinION

7. Future Priorities and Directions Toward PPR Eradication

Digital Outbreak Reporting & Data Integration

- Link laboratory results to **real-time digital dashboards and WAHIS**.
- Use **AI and big data analytics** for predictive modeling and hotspot identification.
- Integrate **diagnostic, vaccination, and post-vaccination evaluation (PVE)** systems for data-driven response.



Laboratory Capacity Building & Equity

- Expand the **FAO/IAEA VETLAB Network** into under-represented regions.
- Strengthen national labs for **confirmatory molecular testing** and rapid response.
- Foster **twining, proficiency testing, and reagent access** to ensure diagnostic sustainability.



Standardization & Quality Assurance

- Harmonize **sampling, testing, and data reporting protocols** across regions.
- Conduct **routine proficiency testing** and inter-lab comparisons led by WOA reference labs.
- Promote **ISO/IEC 17025 accreditation** and consistent SOP implementation.



Innovation, integration, and inclusivity will define the final phase of global PPR eradication

8. Strategic Alignment with PPR GEP 2030

- ❖ **Strategic Alignment of all** diagnostic and capacity-building **with GEP Blueprints**
- ❖ **Sustaining Eradication Momentum:** Track milestones, foster synergy, and apply research in the field.
- ❖ Adopt an **episystem approach**, integrating molecular, ecological, and socio-economic data in surveillance
- ❖ **Research to Action:** Use of **PPR GREN** to turn research into field strategies.- The **PPR GREN** bridges *research* → *field application*, ensuring that diagnostic innovations and vaccine advances reach end-users through training and policy translation.
- ❖ **Data-Driven and Predictive Tools:** Integration of **remote sensing, migratory mapping, and socio-economic indicators** enhances predictive modeling, supporting *risk-based vaccination and movement control strategies*.
- ❖ **Sustainable Global Investment:** **Achieving 2030 eradication** requires continuous global investment in **diagnostic innovation, digital integration, and institutional capacity**- creating a **resilient surveillance ecosystem** for future transboundary disease threats.

9. Conclusion - Path Toward PPR Eradication

- ❑ **Global PPR Impact & Eradication:** Highly contagious transboundary disease causing significant global economic losses. PPR-GEP building on the **2015 GCES**, targets disease **elimination by 2030**
- ❑ **Diagnostic Progress since launch of GCES (2015–2025):**

Culture → ELISA → PCR → LAMP → Field Kit → AI Device

- ❑ **Key achievements:**
 - Leadership and standardization by **WOAH/FAO Reference Laboratories**.
 - Expansion of diagnostic reach through the **WOAH/ FAO/IAEA VETLAB Network**.
 - Commercialization of field tests--- **Lateral Flow** and **LAMP** assays.
 - These innovations have **strengthened global surveillance, outbreak response, and diagnostic harmonisation**.
- ❑ **Remaining Challenges:** Limited sustainability in endemic regions, **lack of wildlife assays**, incomplete genomic data, and logistical constraints.
- ❑ **Eradication Priorities:** Deploy next-generation diagnostics, scale lab/field capacity, and integrate multidisciplinary digital surveillance (epidemiology, socio-economics, ecology).
- ❑ **Global Coordination:** Sustained investment and harmonized networks like PPR GREN under PPR GEP Blueprints are critical to achieve 2030 eradication goals.

Critical Gaps Remain

- ❑ **Limited diagnostic sustainability in endemic regions.** Lack of validated wildlife assays and Applicability of DIVA-compatible tools. Incomplete genomic data and limited sequencing capacity. Logistical and cold-chain constraints in low-resource settings
- ❑ **Molecular and sequencing inequity:** Several national labs still lack RT-qPCR reagents, sequencing tools, and bioinformatics capacity, restricting genomic tracing and early warning of new lineages.
- ❑ **Inconsistent standardization and proficiency testing:** Variability in diagnostic protocols and low participation in inter-laboratory comparisons (ILCs) undermine data reliability.
- ❑ **Many labs lack BSL-** containment, cold-chain systems, and trained staff, causing delays and dependency on reference labs. Sustained investment and regional twinning laboratory are vital for self-sufficiency.
- ❑ **Need for harmonized** ISO/IEC 17025-based accreditation and routine proficiency testing. Infrastructure and capacity gaps

Way Forward — Priorities for the Phase (2025–2030)

- ❑ **Deploy next-generation**, validated diagnostics to every endemic region.
- ❑ **Strengthen laboratory** and field capacity through training and VETLAB expansion.
- ❑ **Integrate multidisciplinary** digital surveillance, linking epidemiology, socio-economics, and ecology.
- ❑ **Foster sustained investment** and coordinated action through PPR-GREN and FAO–WOAH GEP Blueprints.
- ❑ **Priorities:** Achieving eradication requires a **tiered diagnostic framework**, enhanced **laboratory capacity**, **standardized validation**, and **affordable, field-deployable tools** for both domestic and wildlife surveillance.



Implementation Roadmap 2025–2030

Translating Diagnostic Innovation into Global Action

Focus Area	2025–2027	2028–2030	Expected Impact
Non-Invasive Diagnostics	Validation across species & regions	Integration into wildlife surveillance	Expanded coverage, ethical sampling
DIVA & Next-Gen Tools	Prototype field validation	Global deployment under GEP	Reliable PVE & rapid outbreak tracing
Digital Integration	National dashboards & mobile apps	Linked to global WAHIS	Real-time decision-making
Lab Capacity & QA	Training & twinning programs	Regional ISO accreditation	Sustained diagnostic equity
Protocol Standardization	Harmonized SOPs & proficiency testing	Universal compliance	Credible global reporting



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