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NESTLER
One hEalth SusTainabiLity partnership between EU-AFRICA for food security

One-Health Sustainability Roadmap for EU-Africa Partnership

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Abstract	The NESTLER EU-Africa One Health Sustainable Roadmap presents a strategic framework for advancing One Health implementation through EU-Africa collaboration. Integrating human, animal, and environmental health, the roadmap outlines systemic actions to address shared challenges such as antimicrobial resistance, zoonotic disease emergence, and ecosystem degradation. Rooted in scientific evidence and enriched through inclusive stakeholder engagement, it defines priority areas, fosters cross-sectoral governance, and promotes digital and community-based innovation. Emphasizing equity, resilience, and mutual learning, the roadmap envisions One Health not only as a scientific approach but as a transformative pathway for sustainable development and global health security.

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Executive Summary

The NESTLER *One-Health Sustainability Roadmap for EU-Africa Partnership* offers a structured and forward-looking framework to operationalize the One Health approach in the context of EU-Africa collaboration. Grounded in scientific evidence and guided by participatory engagement, it articulates a multi-level strategy that links health, agriculture, environment, and society. The roadmap is not a static blueprint, but a dynamic guide designed to adapt to evolving risks, stakeholder needs, and political realities. It outlines concrete pathways for strengthening governance, enhancing research and innovation, and building institutional capacity to address health threats at the human–animal–environment interface. With emphasis on inclusivity, resilience, and contextual relevance, the roadmap aspires to bridge global aspirations with local action.

At its core, the roadmap seeks to achieve three interlinked objectives: (1) to promote integrated governance and policy coherence across sectors and borders; (2) to enhance transdisciplinary capacities for surveillance, prevention, and response; and (3) to empower communities and institutions through equitable partnerships and knowledge exchange. Priority areas include antimicrobial resistance, zoonotic disease surveillance, sustainable food systems, and ecosystem restoration. These priorities are informed by both scientific urgency and stakeholder consultations, ensuring relevance to regional needs. Emphasis is placed on systems thinking, participatory methodologies, and digital innovation as tools to translate One Health principles into tangible impact.

The roadmap envisions a future in which EU-Africa cooperation on One Health evolves into a mature, reciprocal partnership rooted in mutual respect, shared knowledge, and co-created solutions. It calls for a paradigm shift from donor–recipient models toward joint innovation ecosystems that harness the unique strengths of both regions. By aligning institutional architectures, investing in regional platforms, and fostering inclusive research networks, this strategic vision aims to build resilience against current and future health threats. Ultimately, the roadmap positions One Health as a catalyst for broader societal transformation, supporting sustainable development, climate adaptation, and health equity on both continents.

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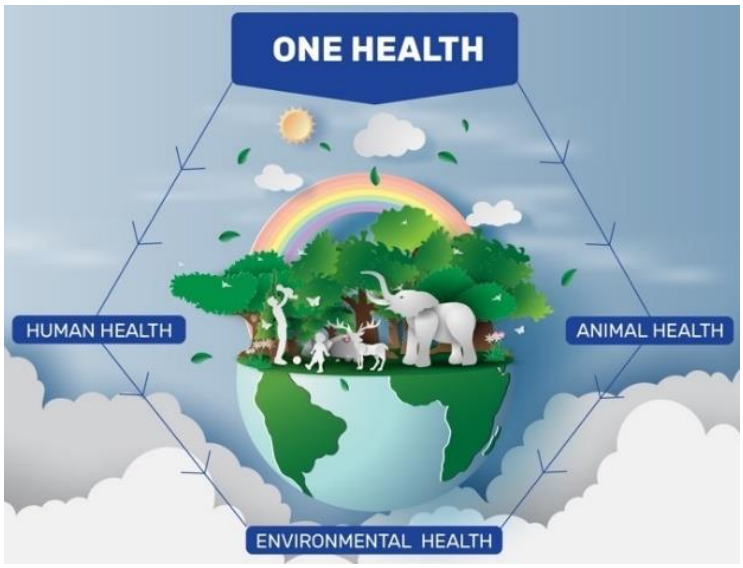
1 Introduction

1.1 Background and Rationale

The emergence and re-emergence of zoonotic diseases, the intensification of environmental degradation, and the accelerating effects of climate change have exposed the vulnerabilities of health systems and underscored the intricate interdependence between human, animal, and environmental health. In particular, the COVID-19 pandemic has highlighted the limitations of siloed responses to global health crises, prompting renewed interest in integrative paradigms such as the One Health approach. This concept recognizes that human health is intimately connected to the health of animals and ecosystems and that sustainable solutions require coordinated, transdisciplinary efforts.



The One Health framework has evolved from a theoretical construct into a practical imperative, endorsed by international institutions such as the ***World Health Organization (WHO)***, the ***Food and Agriculture Organization (FAO)***, the ***World Organisation for Animal Health (WOAH)***, and the ***United Nations Environment Programme (UNEP)***. Their ***Joint Plan of Action (2022–2026)*** [1] has reinforced the call for integrated responses, setting the stage for regional and national actors to operationalize One Health through policies, programmes, and partnerships.

Against this backdrop, the EU-funded NESTLER initiative has been developed to contribute strategically to the implementation of One Health in the context of EU-Africa cooperation. Recognizing the shared challenges across both regions, including the food security threats, the biodiversity loss, and health inequities, NESTLER adopts a systemic perspective. It aims to move beyond traditional disease-centric interventions by addressing the structural drivers of health risk and promoting resilient ecosystems, inclusive governance, and data-driven decision-making.

The rationale for NESTLER is grounded in the need for transformative approaches that align with the ***Sustainable Development Goals (SDGs)***, the ***European Green Deal***, the ***Farm to Fork Strategy***, and the ***African Union's Agenda 2063***. This alignment ensures that One Health is not framed as an isolated domain but as a foundational enabler of broader societal transitions. In doing so, NESTLER also aims to demonstrate how EU-Africa collaboration can serve as a model for bi-regional innovation ecosystems that are equitable, sustainable, and context-sensitive.

1.2 Defining One Health: A Holistic Framework

One Health is an integrated, unifying approach that seeks to sustainably balance and optimize the health of people, animals, and ecosystems. It is based on the recognition that the health of humans, animals (both domestic and wild), and their shared environments are interdependent and influenced by complex socio-ecological systems. As a concept, One Health builds on decades of interdisciplinary thinking, drawing from veterinary science, human medicine, environmental science, public health, and more recently, social sciences and indigenous knowledge systems.

Rather than merely promoting cross-sector collaboration, One Health reconfigures the very architecture of problem framing and solution development. It calls for collaborative governance models, shared knowledge infrastructures, and integrative policy frameworks that cut across institutional boundaries. By doing so, One Health helps address a wide range of challenges, including zoonoses, antimicrobial resistance, food safety, climate-linked health impacts, and biodiversity loss.

In recent years, the operationalization of One Health has gained traction through national platforms, global roadmaps, and regional initiatives. Yet, implementation remains uneven, often constrained by fragmented mandates, insufficient funding, and lack of institutional capacity. A key barrier lies in the inadequate recognition of intersectoral interdependencies and the underutilization of systems thinking in policy and programme design.

NESTLER defines One Health not as a fixed toolkit but as a dynamic, adaptive framework. It emphasizes co-creation with stakeholders, inclusivity, and responsiveness to local contexts. The project recognizes that a truly holistic One Health framework must also account for equity, gender, governance, and ethics—elements often marginalized in technocratic interpretations of the concept. Thus, One Health, as envisioned by NESTLER, becomes both a means and an end: a methodology for integrated problem-solving and a normative vision of sustainable well-being.

1.3 EU-Africa Context and Strategic Importance

The strategic relevance of One Health in the EU-Africa context is both historical and forward-looking. Africa and Europe are connected through deep socio-economic, ecological, and epidemiological ties, and both regions face shared vulnerabilities stemming from climate change, biodiversity loss, disease emergence, and agricultural transformation. At the same time, they possess complementary capacities, experiences, and governance frameworks that—if effectively coordinated—can drive transformative change.

For the African continent, One Health offers a route to addressing persistent development challenges such as food insecurity, zoonotic disease outbreaks, and environmental degradation. National public health systems, often under-resourced and fragmented, stand to benefit from integrative approaches that strengthen surveillance, build human capital, and improve coordination across sectors. The African Union's endorsement of One Health as a continental priority—embodied in the Africa CDC's strategic plans and AUDA-NEPAD programmes—provides a critical policy anchor for such efforts.

On the other hand, within the European Union, One Health has become increasingly institutionalized, particularly in relation to AMR, food safety, and zoonotic risk governance. The EU's Farm to Fork Strategy, Biodiversity Strategy, and Green Deal all embed One Health principles, emphasizing system-wide transitions over isolated fixes.

The NESTLER project leverages this momentum to build a shared EU-Africa roadmap for One Health. It is designed not as a unidirectional transfer of expertise but as a platform for mutual learning and co-development. By identifying synergies between European and African regional initiatives, NESTLER aims to foster bi-regional collaboration in areas such as workforce training, data governance, digital surveillance, and participatory governance.

In doing so, NESTLER contributes to a broader vision of equitable global health governance—one in which Africa is not a passive recipient but an active co-creator of innovation. This is crucial for ensuring that One Health becomes a truly inclusive framework capable of responding to complex global realities.

1.4 Methodology and Stakeholder Engagement

The NESTLER EU-Africa One Health Roadmap is underpinned by a participatory, multi-methodological approach that combines scientific rigour with stakeholder inclusivity. The project adopts a transdisciplinary lens, integrating inputs from public health experts, veterinarians, ecologists, policy-makers, civil society actors, and representatives of indigenous knowledge systems. This methodological pluralism ensures that the roadmap reflects both technical expertise and grounded realities.

A key element of the methodology is **co-creation**, which positions stakeholders not merely as informants but as co-designers of strategies and interventions. This is operationalized through a variety of engagement formats, including focus groups, stakeholder panels, regional workshops, and thematic working groups. Special attention is given to the inclusion of traditionally underrepresented voices, such as smallholder farmers, youth, and women, to ensure that the roadmap is socially grounded and equity-oriented.

Data collection draws on both qualitative and quantitative sources. Literature reviews and policy scans provide a foundational knowledge base, while expert interviews and scenario planning exercises offer contextual insights and future-oriented perspectives. Participatory foresight tools, such as Delphi surveys and back casting, help build consensus around priorities and transition pathways.

The project also incorporates systems mapping and value chain analysis to capture the interdependencies among sectors and stakeholders. These analytical tools support the identification of leverage points for intervention and help define coherent action plans that can be adapted to different governance levels.

Finally, stakeholder engagement is not confined to the design phase. Mechanisms for continuous dialogue and feedback have been built into the project's implementation plan, including digital platforms for collaboration and iterative learning loops. This ensures that the roadmap remains a living document—adaptive to emerging risks, knowledge, and political opportunities.

2 One Health Landscape in Africa and Europe

2.1 Zoonoses and Emerging Infectious Diseases

Zoonotic diseases, which are infectious diseases transmitted between animals and humans, represent a major and persistent public health concern worldwide, particularly relevant within the collaborative context of EU-Africa One Health strategies. Approximately 60% of known human pathogens and around 75% of emerging infectious diseases originate from animal reservoirs, highlighting the interconnectedness of human, animal, and environmental health. Recent global outbreaks, including COVID-19, Ebola virus disease, and the Zika virus, have underscored the potential severity and rapid international spread of zoonotic pathogens, emphasizing the urgency for improved surveillance, early detection, and rapid response capabilities [1]. Environmental disruptions, such as deforestation, urbanization, and intensive agricultural practices, increase human-wildlife interactions, thereby heightening the risk of pathogen spillover events. Wildlife trade and bushmeat consumption also significantly contribute to zoonotic disease emergence, particularly in regions of Africa and Asia [2]. Climate change further complicates these dynamics by altering ecosystems and expanding the geographic range of disease vectors, facilitating the transmission of vector-borne diseases such as Rift Valley fever, West Nile virus, and Lyme disease [3].

Addressing these complexities demands an integrated One Health approach involving cross-sectoral collaboration among veterinary, medical, ecological, and public health disciplines. Strengthening disease surveillance systems by integrating animal and human health data enhances the capacity for early detection and swift containment of outbreaks. Initiatives such as USAID's PREDICT program and the collaborative efforts by WHO, FAO, and WOAH exemplify effective strategies in zoonotic surveillance and prevention, providing frameworks for multisectoral cooperation [4].

Building workforce capacity and improving infrastructure in diagnostics, surveillance, and outbreak management are equally essential. Enhancing laboratory facilities, training interdisciplinary teams, and investing in research-to-policy initiatives enable countries, especially within Africa, to manage and mitigate risks more effectively [5]. Additionally, harnessing emerging technologies, including genomic sequencing and artificial intelligence for predictive modelling, holds promise for revolutionizing pathogen identification and risk assessment, thereby reducing global vulnerability to zoonotic threats [6].

Strategic EU-Africa collaboration should emphasize joint research investments, technology transfer, and capacity-building initiatives to create resilient health systems capable of addressing current and future zoonotic challenges. Effective communication, community engagement, and evidence-based policy development are integral components that further strengthen collective resilience against zoonotic diseases, ultimately protecting global public health and promoting environmental sustainability.

2.2 Antimicrobial Resistance (AMR)

Antimicrobial Resistance (AMR) is a profound and escalating global health threat that undermines the effectiveness of life-saving treatments, compromises disease control in both human and animal populations, and threatens the sustainability of modern medical, veterinary, and agricultural systems. Within the One Health framework, AMR is a quintessential cross-sectoral challenge, shaped by interactions across human health, animal husbandry, food systems, environmental contamination, and international trade. As such, the EU-Africa One Health partnership must place AMR at the center of its strategic agenda, focusing on integrated surveillance, stewardship, research, and regulatory harmonization.

The emergence and spread of AMR are driven by the overuse and misuse of antibiotics in human and veterinary medicine, unregulated access to antimicrobials, suboptimal infection prevention practices, and the environmental dissemination of resistant organisms and genes. In both Europe and Africa, resistance to

critical antibiotics such as carbapenems, third-generation cephalosporins, fluoroquinolones, and colistin is increasing at an alarming pace. The burden is particularly pronounced in low- and middle-income countries, where limited access to diagnostics, poor pharmaceutical governance, and gaps in veterinary oversight exacerbate the problem [7].

In Africa, studies reveal widespread use of antibiotics in animal production, often without veterinary prescription or adherence to withdrawal periods. Environmental pathways—including the release of pharmaceutical residues into wastewater, run-off from agricultural land, and inadequate sanitation infrastructure—facilitate the spread of resistance genes across ecosystems. Simultaneously, the informal sale of antibiotics in human medicine fosters unsupervised and often unnecessary consumption. In Europe, although stewardship frameworks are more established, cross-border challenges persist, particularly in managing resistance in zoonotic pathogens, foodborne bacteria, and wildlife reservoirs [8].

Addressing AMR requires a robust and integrated surveillance system that captures data across humans, animals, food chains, and the environment. While the EU has made significant progress through the ***European Antimicrobial Resistance Surveillance Network (EARS-Net)*** and the ***European Surveillance of Veterinary Antimicrobial Consumption (ESVAC)***, African surveillance systems remain patchy and under-resourced. Initiatives such as the ***Africa CDC's AMR Surveillance Network*** and the Fleming Fund-supported National Action Plans are important steps toward developing continent-wide data harmonization and laboratory strengthening [9].

Predictive analytics and digital tools can enhance AMR monitoring, allowing for early detection of resistance trends, identification of hotspots, and modeling of transmission dynamics. Whole-genome sequencing (WGS) has emerged as a powerful technique for AMR tracking, enabling precise characterization of resistance determinants, clonal expansion, and interspecies transmission. However, implementing WGS in low-resource settings requires investment in infrastructure, training, and bioinformatics capacity.

Antimicrobial stewardship is a second pillar in addressing AMR. This entails the judicious use of antibiotics through evidence-based guidelines, behavior change interventions, and prescriber accountability. In both EU and African contexts, implementing antimicrobial stewardship programs (ASPs) in hospitals, clinics, veterinary practices, and farms is crucial. Educational campaigns targeting healthcare professionals, farmers, and the general public must be culturally tailored and sustained by policy support.

Legislative action is also needed to regulate antimicrobial distribution, restrict over-the-counter sales, and enforce quality assurance of pharmaceutical products. Substandard and falsified antibiotics contribute not only to treatment failure but also to resistance selection. Harmonizing regulations across the EU and AU regions will improve supply chain oversight, facilitate cross-border response coordination, and ensure compliance with Codex Alimentarius guidelines and WHO's ***AWaRe (Access, Watch, Reserve)*** classification.

From a research perspective, the development of novel antimicrobials, alternatives to antibiotics (e.g., bacteriophages, probiotics, vaccines), and infection prevention technologies must be accelerated. Collaborative EU-Africa research consortia should prioritize context-specific innovations that address regionally relevant pathogens and farming systems. Equally important is socioeconomic research on drivers of antimicrobial misuse and incentives for behavior change. Environmental dimensions of AMR are often overlooked but are critical to containment. Surveillance of antimicrobial residues and resistance genes in water bodies, soils, and effluents from pharmaceutical and agricultural industries must be integrated into national AMR strategies. Nature-based solutions, such as constructed wetlands and green infrastructure, can mitigate environmental contamination while supporting ecosystem services.

Finally, effective governance and cross-sectoral coordination are essential. National AMR coordination

committees must include representatives from ministries of health, agriculture, environment, and education. These platforms should drive policy coherence, ensure accountability, and align with global frameworks such as the Tripartite AMR Action Plan and the Global Antimicrobial Resistance and Use Surveillance System (GLASS).

2.3 Food Systems, Food Safety, and Nutrition

Food systems are a central pillar of the One Health approach, linking human well-being with environmental sustainability, animal health, and economic development. Within the EU-Africa context, food systems are undergoing profound transformation—driven by demographic growth, climate change, urbanization, market integration, and changing dietary patterns. However, this transformation presents both opportunities and challenges. Issues of food safety, nutritional adequacy, ecological resilience, and health equity remain deeply interconnected. A One Health lens allows for a systemic understanding of these dynamics and supports integrated responses that promote human and planetary health simultaneously.

Food safety is foundational to public health. Each year, unsafe food causes an estimated 600 million cases of foodborne illness and 420,000 deaths globally, with Africa and Southeast Asia bearing the greatest burden [10]. Contamination by pathogens such as Salmonella, Listeria, and E. coli, as well as chemical hazards including mycotoxins, heavy metals, and pesticide residues, can have devastating health and economic consequences. In African countries, informal food markets dominate, often characterized by limited regulatory oversight, inadequate infrastructure, and variable hygiene practices. In contrast, the EU maintains rigorous food safety systems, such as those coordinated by the European Food Safety Authority (EFSA), but continues to face challenges in preventing outbreaks linked to global food supply chains.

Strengthening food safety across EU-Africa food systems requires a harmonized approach to risk assessment, standards enforcement, and cross-border collaboration. Capacity building for laboratory diagnostics, food inspection services, and cold chain infrastructure is essential—particularly in resource-constrained settings. Digital technologies such as blockchain, mobile apps for traceability, and AI-enabled food hazard prediction models can enhance transparency and responsiveness. Initiatives like the African Food Safety Index (AFSI) under the African Union's CAADP program offer useful entry points for aligning national strategies with continental benchmarks.

Nutrition security ensures access to diets that are adequate in quantity, quality, and cultural relevance and is considered an equally vital dimension of the One Health-food nexus. Malnutrition, including both undernutrition and obesity, affects millions across both continents. In sub-Saharan Africa, stunting, wasting, and micronutrient deficiencies remain prevalent, while in Europe, non-communicable diseases linked to poor dietary quality are on the rise. Dietary transitions, characterized by increased consumption of ultra-processed foods, sugars, and animal products, have contributed to a double burden of malnutrition and rising ecological footprints.

One Health-informed food policies must bridge health, agriculture, and environmental objectives. Promoting diversified agroecological systems, sustainable livestock practices, and value chains for indigenous crops can improve both nutritional outcomes and ecosystem integrity. For example, biofortification of staple crops, such as vitamin A-enriched maize or iron-rich beans, is a promising strategy to address micronutrient deficiencies in African contexts. In the EU, policies under the Farm to Fork Strategy advocate for reduced pesticide use, animal welfare improvements, and healthy dietary shifts—all of which align with One Health principles.

Food systems are also key vectors in the emergence and spread of zoonotic diseases. Intensive animal farming, wildlife trade, and unsafe food processing conditions create opportunities for pathogen spillover. Strengthening biosecurity in animal production systems, regulating wet markets, and improving food hygiene

practices at all stages of the supply chain are critical prevention strategies. Surveillance systems that integrate veterinary, environmental, and public health data can help detect early warning signs of foodborne or zoonotic outbreaks.

Climate change further complicates the food safety and nutrition landscape. Rising temperatures, erratic precipitation, and extreme weather events disrupt agricultural productivity, alter pathogen dynamics, and increase the risk of mycotoxin contamination. Droughts and floods exacerbate food insecurity and limit access to diverse, nutritious foods. Climate-resilient food systems—based on ecological intensification, improved seed systems, and water-smart technologies—are thus essential to protect both health and livelihoods. Policy coherence across sectors and regions is a cornerstone of effective One Health food governance. National food safety authorities, ministries of agriculture and health, civil society organizations, and research institutions must work in synergy. Mechanisms such as Codex Alimentarius provide global standards, but regional adaptations are necessary to ensure relevance and enforceability. Joint EU-Africa platforms for food systems transformation—such as the AU-EU Agriculture Ministerial Conferences and the upcoming AU-EU Food Security Partnership—can align objectives, pool resources, and coordinate action.

Last bit not least, consumer engagement and food literacy play a crucial role. Empowering communities with knowledge about safe food handling, balanced diets, and environmental sustainability supports informed decision-making and social accountability. School-based nutrition programs, media campaigns, and participatory food policy councils can help foster a food culture that values health, sustainability, and solidarity.

2.4 Environmental Health and Biodiversity

Environmental health and biodiversity are core components of the One Health framework, reflecting the deep interdependence between ecosystems, human well-being, and animal populations. The degradation of natural environments—through deforestation, land-use change, pollution, and climate disruption—directly influences the emergence and transmission of infectious diseases, nutritional security, mental health, and the stability of life-supporting ecosystem services. In both Europe and Africa, preserving biodiversity and strengthening environmental health systems are not only conservation priorities but essential public health strategies.

Biodiversity loss has profound implications for disease ecology. Numerous studies have documented that changes in species composition and ecosystem structure alter host-pathogen dynamics, often increasing the likelihood of zoonotic spillover events. The dilution effect hypothesis, for instance, suggests that greater species richness can buffer pathogen transmission by regulating populations of competent reservoirs or vectors. Conversely, biodiversity loss often results in ecological simplification, creating conditions conducive to disease amplification. In sub-Saharan Africa, deforestation and encroachment into wildlife habitats have been linked to outbreaks of Ebola, yellow fever, and other emerging zoonoses. In Europe, ecosystem fragmentation and climate-driven shifts in vector ranges are reshaping the landscape of tick-borne and mosquito-borne diseases.

Environmental pollution also poses significant threats to One Health. Heavy metals, endocrine disruptors, microplastics, and pharmaceutical residues contaminate soil, water, and food chains, with cascading effects

on reproductive health, developmental outcomes, and immune function in both humans and animals. Agricultural intensification and industrial effluents contribute to eutrophication, biodiversity loss, and the spread of antimicrobial resistance genes in aquatic ecosystems. Inadequate waste management, particularly in urbanizing African regions, further exacerbates the exposure burden and weakens ecosystem resilience.

Mitigating these risks requires integrated environmental surveillance and ecosystem health monitoring. Remote sensing technologies, environmental DNA (eDNA), and geospatial mapping offer powerful tools to detect ecological disturbances, track species loss, and anticipate disease hotspots. Strengthening environmental governance—through protected area networks, ecosystem restoration programs, and pollution control policies—is vital to prevent degradation and promote regeneration. Initiatives such as the European Green Deal and Africa's Great Green Wall exemplify large-scale environmental interventions aligned with One Health goals. Importantly, indigenous knowledge systems and community-based conservation must be recognized as vital components of biodiversity stewardship. Local communities often possess nuanced understanding of ecological dynamics, species behaviour, and land management practices that are essential for sustaining ecosystem services and cultural resilience.

2.5 Climate Change and Health

Climate change is a defining threat to global health, with direct and indirect consequences across human, animal, and environmental systems. Rising temperatures, altered precipitation patterns, sea level rise, and the increased frequency of extreme weather events are disrupting ecological balances, reshaping disease dynamics, and threatening the resilience of health systems worldwide. The One Health approach provides an integrative lens to understand and address these cascading impacts, particularly in the context of the EU-Africa partnership, where climate vulnerability and health disparities often intersect.

One of the most immediate consequences of climate change is the altered distribution and intensity of vector-borne diseases. Warmer temperatures and changing rainfall patterns have expanded the habitat ranges of vectors such as mosquitoes and ticks, contributing to the spread of malaria, dengue, chikungunya, Zika, and Lyme disease. In Africa, highland areas previously free from malaria are now experiencing outbreaks, while in Europe, the Aedes albopictus mosquito has facilitated the re-emergence of arboviral diseases. Predictive climate-health models suggest further geographic expansion and increased intensity of such outbreaks if mitigation efforts are not accelerated.

Climate change also exacerbates food and water insecurity, with downstream effects on nutrition and health. Droughts, floods, and soil degradation reduce crop yields and livestock productivity, heightening the risk of undernutrition, micronutrient deficiencies, and foodborne illnesses. In Africa, climate shocks have disproportionately affected subsistence farming communities, while in Europe, extreme weather events are straining agricultural supply chains. Moreover, water scarcity and contamination contribute to diarrheal diseases and other waterborne infections, particularly among vulnerable populations. Mental health impacts are increasingly recognized as a major concern. Climate-induced displacement, loss of livelihoods, and ecological grief are contributing to psychological distress, depression, and anxiety. Health systems are often ill-prepared to respond to these less visible but deeply felt consequences. Health infrastructure itself is under threat. Heatwaves and flooding can damage healthcare facilities, interrupt service delivery, and increase demand for emergency care. In both African and European contexts, resilient health systems must include climate-adaptive infrastructure, emergency preparedness protocols, and sustainable energy solutions.

Addressing climate-related health risks requires multisectoral coordination, early warning systems, and climate-resilient development policies. Investments in surveillance networks that integrate meteorological, ecological, and epidemiological data are essential. Health impact assessments must become standard components of national adaptation plans. In parallel, mitigation actions—such as decarbonizing health

systems, promoting sustainable transport, and enhancing green urban planning—can generate co-benefits for health, equity, and the environment.

2.6 Socio-Economic Determinants of Health

Socio-economic determinants of health, including as income, education, employment, housing, and social protection, shape the conditions in which people are born, grow, live, and age. These determinants critically influence health outcomes, access to healthcare, and vulnerability to diseases. Within the One Health framework, addressing socio-economic disparities is essential for building resilient and equitable health systems across the EU and Africa.

Poverty remains a major driver of health inequities. In low-income settings, limited access to nutritious food, clean water, sanitation, and medical services exacerbates exposure to communicable diseases and impairs recovery from illness. Informal labor conditions, especially in agriculture and animal husbandry, often lack occupational health protections and increase exposure to zoonotic and environmental risks. In urban settings, overcrowding, air pollution, and inadequate housing create conditions conducive to both chronic and infectious diseases.

Education, particularly of women and girls, is a powerful determinant of health. Higher levels of education are consistently associated with better health behaviors, increased healthcare utilization, and improved child and maternal health outcomes. Similarly, stable employment and income security contribute to better access to services and reduced psychosocial stress.

Addressing socio-economic determinants requires integrated policies that span health, education, labor, social welfare, and urban planning. The EU-Africa One Health agenda must prioritize inclusive development strategies, social protection schemes, and targeted interventions for marginalized communities to ensure that health gains are both equitable and sustainable.

3 Strategic Priorities and Thematic Pillars

3.1 Strengthening Surveillance and Early Warning Systems

An effective surveillance and early warning system (EWS) lies at the heart of a resilient One Health strategy for both Europe and Africa. The capacity to detect emerging health threats early before they escalate—depends on multi-sectoral integration, community engagement, infrastructure, and data-driven technologies. This section delves into critical aspects of building robust systems that connect human, animal, and environmental health domains.

3.1.1 Integrated, Multi-Level Surveillance Architecture

A One Health EWS transcends traditional siloed models by interlinking veterinary, medical, environmental, and wildlife surveillance systems. Scientific evidence supports that coordinated systems are more effective in detecting zoonotic outbreaks. Integrated surveillance frameworks—such as the European MediLabSecure initiative covering Mediterranean, Black Sea, and Sahel regions—have demonstrated comprehensive monitoring of arboviruses like West Nile and Dengue by harmonizing human, vector, and veterinary data sources [11] [12]. Similarly, Africa CDC's event-based surveillance (EBS) framework assists member states in gathering real-time outbreak signals from diverse sources, reinforcing early detection capabilities [13].

At the national level, One Health surveillance enables structured disease prioritization. For instance, Burkina Faso's anthrax monitoring system reflects stakeholder engagement and institutional cooperation across veterinary and public health sectors, facilitating early warning in hotspot regions [14]. Yet, tangible challenges persist: fragmented data streams, uneven infrastructure, and low interoperability hinder cross-sectorial responsiveness.

3.1.2 Event-Based and Community-Inclusive Surveillance

Early warning fundamentally relies on capturing signals from the ground—before they escalate into full-scale outbreaks. Event-based surveillance (EBS) actively gathers information from informal sources such as community reports, media, and frontline workers. This "bottom-up" model, central to the One Health Early Warning and Response System (OH-EWRS), emphasizes grassroots engagement, encouraging NGOs, private veterinarians, and community healers to report anomalies in animal or human health [15].

As detailed in this framework, OH-EWRS expands conventional "push" approaches through active participation of community informants, strengthening risk detection in remote or underserved areas. Cross-border EBS initiatives within Africa CDC's new frameworks also demonstrate that local surveillance enhances detection of signals before pathogen spillover [11].

3.1.3 Technological Innovations in Detection and Prediction

Technological integration markedly enhances early detection. Genomic surveillance and real-time data platforms expedite the identification and characterization of pathogens. For example, sequencing wastewater samples for SARS-CoV-2 and influenza has provided geographically broad, cost-effective surveillance for emerging pathogens. In Africa, AI-enhanced analytics have demonstrated value in public health surveillance through pattern recognition in complex datasets, optimizing outbreak detection, resource allocation, and predictive intelligence [16].

Satellite imagery and environmental indicators also support ecosystem-based alert systems—such as forecasting drought via vegetation indices in pastoral regions, helping prevent disease outbreaks associated with ecological stressors (e.g., zoonotic pathogens linked to land use change) . Moreover, autonomous sensor networks and robotic monitoring systems offer scalable environmental surveillance solutions, relevant to biosecurity and vector control (arxiv.org).

3.1.4 Laboratory Networks and Data Interoperability

Early detection becomes actionable only when testing infrastructure supports rapid confirmation. Strengthening laboratory networks—especially at Points of Entry (PoEs) is a core part of EWS strategies. Africa CDC's frameworks specify digitalized EWS linked to labs at borders to ensure swift pathogen identification.

Data interoperability enhances surveillance efficacy. Harmonization of digital platforms through standards like the FAO-WHO-WOAH Tripartite Zoonosis Guide promotes transparent, replicable, and secure data exchange. In Europe, platforms such as the French animal health epidemiological surveillance system (ESA) achieve early warning through eco-epidemiological data pipelines integrating GIS, bioinformatics, and veterinary field data.

3.1.5 Governance, Coordination, and Capacity Strengthening

Governance structures underpin the operational success of EWS. Regional mechanisms—like MediLabSecure, Africa CDC, and EU Health Threat Unit—provide blueprints adaptable to EU–Africa collaboration [12]. Successful cross-border surveillance relies on formal information-sharing agreements, joint training, and harmonization of emergency reporting protocols.

Capacity building must align with operational goals—from frontline health workers to epidemiologists and data analysts. Studies of national capacity-building efforts show that continuous training in data triangulation, cross-sector interpretation, and rapid response translates into sustained institutional gains.

3.2 Enhancing Research and Innovation

Enhancing research and innovation within the One Health framework is pivotal for generating context-specific, actionable knowledge that bridges science, policy, and practice. In the EU-Africa context, fostering collaborative R&I ecosystems is not only a strategic necessity but a shared responsibility in addressing complex health, agricultural, and environmental challenges that transcend borders. Emerging infectious diseases, antimicrobial resistance (AMR), food insecurity, and biodiversity loss are deeply interwoven. Yet, research funding and infrastructure remain unevenly distributed between the continents. Africa accounts for approximately 15% of the global population but produces less than 1% of global research output [17]. This asymmetry limits the continent's ability to generate data, design interventions, and lead innovation adapted to its ecological and socio-cultural realities.

Joint EU-Africa research programmes, such as those under Horizon Europe and the European & Developing Countries Clinical Trials Partnership (EDCTP), offer promising platforms for co-developing solutions. Priority areas should include disease ecology, climate-health interactions, digital agriculture, indigenous knowledge integration, and responsible AI for health surveillance. Importantly, innovation should extend beyond

technologies to include institutional mechanisms that enable adaptive governance, co-creation with communities, and gender-responsive research design.

Investing in regional centres of excellence, open data platforms, and equitable intellectual property frameworks can amplify African leadership in One Health science. Ultimately, innovation must be driven by local relevance, equity, and transdisciplinary. By moving from technology transfer to true knowledge co-production, EU and African actors can cultivate a resilient, anticipatory science-policy interface—capable of preventing the next health crisis before it begins.

3.3 Building Workforce Capacity and Training

Building workforce capacity and training are essential components in successfully implementing a One Health approach, particularly in the context of EU-Africa collaboration. A proficient, multidisciplinary workforce equipped with relevant skills is necessary to effectively address the complex interactions among human health, animal health, and ecosystem integrity. Training programs must prioritize not only technical and scientific knowledge but also interdisciplinary collaboration, critical thinking, and problem-solving skills necessary for tackling emerging health threats and environmental challenges.

Educational curricula should integrate One Health principles across human medicine, veterinary sciences, environmental health, public health, and agricultural sectors. This comprehensive educational strategy ensures that professionals understand and appreciate the interconnectedness of these disciplines, thereby fostering collaboration and coordinated response in health crises and sustainability initiatives. Specialized training programs and certification courses should further address priority areas such as zoonotic disease management, antimicrobial resistance (AMR) stewardship, biodiversity conservation, and climate resilience.

Moreover, capacity-building initiatives must emphasize continuous professional development and experiential learning, including practical field training, collaborative research projects, and exchange programs between European and African institutions. Digital technologies, such as virtual learning platforms, webinars, and simulation-based training, offer scalable and accessible methods to reach diverse and geographically dispersed professionals. Additionally, mentoring and fellowship programs are critical for building leadership capacities, particularly among youth and women, thereby ensuring inclusivity and sustainable knowledge transfer.

Strategic partnerships among academia, governmental agencies, private sector stakeholders, and international organizations are vital to leverage resources and expertise effectively. Investment in workforce training enhances institutional resilience and preparedness, directly contributing to improved public health outcomes, ecosystem sustainability, and socio-economic stability across Europe and Africa. Through dedicated, targeted capacity-building efforts, both continents can cultivate a skilled, versatile, and responsive workforce prepared to meet present and future One Health challenges.

3.4 Digital Health and Data Interoperability

Digital health and data interoperability are essential pillars of an integrated EU-Africa One Health strategy. The exponential growth of health and environmental data, ranging from genomics and epidemiology to climate and agricultural systems, demands robust digital infrastructures that facilitate secure, ethical, and real-time data sharing. Interoperability ensures that data generated by laboratories, hospitals, veterinary services, and environmental monitoring systems across both continents can be harmonized, interpreted, and mobilized for timely decision-making.

A core challenge lies in aligning data standards, governance frameworks, and digital capacities across diverse contexts. This requires co-developing interoperable platforms that respect data sovereignty while enabling cross-border collaboration for disease surveillance, antimicrobial resistance tracking, and health system

resilience. Artificial intelligence and predictive analytics offer significant opportunities for early warning systems, but they must be underpinned by quality-assured, contextually relevant datasets.

Investments in open-source tools, capacity building, and connectivity, especially in rural and underserved regions, are critical to bridge the digital divide. EU-Africa cooperation can accelerate the development of shared digital health architectures, guided by FAIR (Findable, Accessible, Interoperable, Reusable) data principles and the One Health approach. Ultimately, digital interoperability strengthens health security, enhances transparency, and fosters innovation across sectors and regions.

3.5 Sustainable Food and Agricultural Systems

Sustainable agricultural and food systems are foundational to the One Health framework, harmonizing human, animal, and ecosystem health. Given the interconnectedness of these domains, promoting sustainable agriculture is essential to addressing food security, environmental protection, and socio-economic stability in both Europe and Africa.

Agroecological and regenerative agricultural practices, including diversified cropping systems, crop rotations, conservation tillage, agroforestry, and integrated pest management (IPM), play a pivotal role in creating resilient and productive food systems. These practices enhance soil organic matter, reduce erosion, and improve water retention, thereby enhancing climate resilience and mitigating greenhouse gas emissions [18]. Regenerative agriculture, for example, leverages biological processes and biodiversity to reduce chemical inputs, restoring ecosystem functions and soil fertility while safeguarding biodiversity [19].

Agrobiodiversity further contributes significantly to sustainability, facilitating robust ecosystem services such as pollination, biological pest control, nutrient cycling, and resilience to environmental stresses. Diversified agricultural systems also support nutritional diversity, food security, and improved livelihoods, particularly important in rural African contexts where agriculture directly sustains millions of households [20].

European strategies such as the EU Farm to Fork and the Common Agricultural Policy (CAP) increasingly emphasize sustainable agriculture and environmental stewardship, encouraging eco-schemes and innovation in sustainable farming practices. African initiatives, including agroecology-driven approaches endorsed by the Nairobi Declaration, prioritize indigenous knowledge and localized solutions for sustainable intensification and soil restoration, balancing productivity with ecological preservation [21].

Digital agriculture, incorporating precision farming techniques such as sensor-based irrigation, drone-assisted monitoring, and data-driven nutrient management, further advances sustainability goals by optimizing resource use efficiency, enhancing traceability, and reducing environmental footprints [22]. These technological innovations, when equitably disseminated, bridge productivity gaps between rural and urban agricultural sectors, promoting inclusivity and economic stability.

Together, these combined approaches form a comprehensive, science-based model that addresses food security challenges, promotes environmental sustainability, enhances public health, and fosters socio-economic resilience in alignment with EU-Africa strategic development priorities.

3.6 Environmental Protection and Climate Adaptation

Environmental protection and climate adaptation are foundational to the One Health approach, recognizing that human and animal health are inseparably linked to the health of ecosystems. In both the EU and African contexts, accelerating climate change, biodiversity loss, land degradation, and water insecurity are not only environmental crises—they are profound health threats. Climate-induced shifts in disease vectors, food system stability, and ecosystem functioning are already reshaping the risk landscape for zoonotic spillovers, malnutrition, and waterborne diseases [23].

In Africa, recurrent droughts, floods, and habitat fragmentation have intensified pressure on ecosystems and increased human-wildlife contact, raising the risk of emerging infectious diseases. Meanwhile, Europe faces intensifying forest fires, heatwaves, and pollution-linked chronic diseases. Effective One Health policy must therefore integrate environmental surveillance and climate risk modelling into early warning systems, land-use planning, and health preparedness frameworks.

Nature-based solutions—such as forest conservation, wetland restoration, and agroecological farming—offer co-benefits for biodiversity, carbon sequestration, and public health. These strategies align with both the EU Green Deal and Africa's Agenda 2063, offering a shared platform for climate-resilient health systems. However, implementation requires bridging policy silos and ensuring community involvement in environmental stewardship, particularly in marginalized and climate-vulnerable regions.

Cross-continental cooperation should prioritize investments in ecological monitoring networks, climate-resilient infrastructure, and transboundary watershed governance. Climate adaptation must be informed by local ecological knowledge, supported by open data, and integrated across sectors. By embedding environmental protection within One Health, EU and African stakeholders can strengthen resilience to cascading risks—and foster a future where ecosystems and societies thrive together.

3.7 Community Engagement and Risk Communication

Community engagement and risk communication are indispensable pillars of an effective One Health strategy. In both African and European contexts, communities are not merely recipients of health interventions, they are active agents in the detection, prevention, and management of health risks. Particularly in regions where formal surveillance infrastructure may be limited, communities often serve as the first line of defense against emerging zoonoses, environmental hazards, and food safety threats.

Effective risk communication involves timely, transparent, and culturally sensitive dissemination of information before, during, and after health events. Trust is central: misinformation, especially during outbreaks like Ebola and COVID-19, has repeatedly shown that lack of trust can undermine public health responses and exacerbate vulnerabilities [24]. Risk communication must therefore move beyond top-down messaging to incorporate community voices, traditional knowledge systems, and local leadership in shaping public health narratives.

Community-based surveillance systems—such as those piloted in Nigeria, Uganda, and Mali—demonstrate that empowering local actors to detect and report early warning signs significantly enhances outbreak

responsiveness and legitimacy [11], [25]. Similarly, participatory risk mapping and co-designed educational campaigns have proven effective in tailoring One Health messages to diverse linguistic and cultural contexts.

EU–Africa cooperation can reinforce these systems through joint training initiatives, digital platforms for two-way communication, and inclusive governance structures that integrate community representatives in planning and evaluation. Ultimately, risk communication is not only a tool for crisis response, but a cornerstone of resilience-building. By fostering social cohesion, equity, and mutual accountability, community engagement enhances the legitimacy, reach, and effectiveness of One Health interventions—ensuring that science is translated into action with, not just for, the people most affected.

3.8 Policy Coherence and Regulatory Alignment

Achieving policy coherence and regulatory alignment is a cornerstone of an effective and operational One Health strategy. The interconnected challenges of zoonotic disease prevention, antimicrobial resistance (AMR), climate adaptation, food safety, and biodiversity conservation span multiple sectors and jurisdictions as it necessitating harmonized policy frameworks that bridge institutional silos and geopolitical boundaries.

Across Europe and Africa, a key obstacle remains the fragmentation of legal and regulatory instruments governing human health, veterinary medicine, environmental management, and food systems. This regulatory disjunction undermines preparedness and response capacities, particularly during health emergencies that require rapid, coordinated action. For instance, divergent standards on antimicrobial use in livestock production complicate cross-border disease control and trade agreements [18].

The Tripartite Plus collaboration (WHO–FAO–WOAH–UNEP) has offered guiding frameworks such as the *One Health Joint Plan of Action (2022–2026)* [26], which urges governments to integrate One Health principles into national legislation and budgetary planning. Additionally, the EU's *Farm to Fork Strategy*, the *Green Deal*, and Africa's *One Health Coordinating Mechanism* under Africa CDC present opportunities to align regional priorities and promote mutual recognition of standards.

However, coherence must go beyond formal regulatory harmonization. It requires inclusive policy dialogues, shared monitoring tools, and inter-agency task forces that facilitate real-time coordination. Joint EU–Africa platforms, such as the African Medicines Agency (AMA) and European Medicines Agency (EMA), can also support convergence on pharmaceutical regulation, vaccine approval, and pathogen surveillance protocols.

Embedding One Health in national legal frameworks, supported by intersectoral governance mechanisms, enhances resilience, reduces duplication, and builds trust across institutions and borders. Coherent policy is not merely an administrative goal; it is a mechanism of accountability, efficiency, and collective health security.

4 Partnerships and Stakeholder Engagement

4.1 Institutional Framework and Stakeholder Roles

A successful EU-Africa One Health partnership depends not only on technical expertise but also on a robust and inclusive institutional architecture. Such a system must facilitate coordinated actions across sectors and governance levels, while remaining responsive to the complexities at local, national, and cross-border scales. Although the One Health framework has evolved significantly, challenges persist in aligning mandates, workflows, and financing mechanisms among diverse actors. Ministries of health, agriculture, environment, and education form the backbone of this architecture, but their coordination often remains fragmented and externally driven. To ensure sustainability, there is a need to establish permanent One Health structures equipped with legal authority, dedicated funding, and cross-sectoral mandates.

At the continental level, African Union bodies such as **Africa Centres for Disease Control and Prevention (Africa CDC)** [27, 11], the **African Union Inter-African Bureau for Animal Resources (AU-IBAR)** [28], and the **African Union Development Agency (AUDA-NEPAD)** [21, 29] play a strategic role in shaping common agendas and convening member states. Their engagement should extend beyond policy guidance to active implementation monitoring and policy harmonization.

In the European Union, intra-EU collaboration on One Health is more institutionalized through agencies such as the **European Centre for Disease Prevention and Control (ECDC)**, the **European Food Safety Authority (EFSA)**, and the **European Medicines Agency (EMA)** [30]. These institutions coordinate extensive cross-country surveillance of human and animal diseases, food safety hazards, and pharmaceutical regulation. For instance, **ECDC's *Epidemic Intelligence Information System (EPIS)*** supports real-time information exchange on emerging outbreaks across EU member states, while EFSA contributes to joint risk assessments involving animal and environmental health interfaces [31].

The success of the EU-Africa One Health partnership relies not only on scientific innovation or technical capacity, but fundamentally on a coherent and inclusive institutional architecture. Such a framework must enable coordinated action across administrative levels and sectors, while remaining responsive to complex realities at local, national, and transboundary scales. Institutional arrangements for One Health have evolved considerably, yet challenges persist in aligning mandates, operational workflows, and funding streams across diverse actors. Ministries of health, agriculture, environment, and education remain the core governmental pillars, but their coordination is often ad hoc or dependent on external funding. Institutionalizing multisectoral collaboration requires moving from informal inter-ministerial task forces to permanent One Health units with dedicated budgets, legal mandates, and horizontal authority across domains.

Stakeholders from civil society, private sector, and regional networks serve equally critical roles. Farmers' cooperatives, wildlife conservation groups, food industry actors, and community health organizations are not peripheral but embedded within the operational ecosystem of One Health. Their early engagement is vital—not only for implementation but for priority-setting and legitimacy. Mechanisms such as stakeholder advisory councils, joint programme boards, and regional dialogues must be structurally embedded within institutional design, ensuring that non-state actors contribute beyond consultation phases.

Universities and research institutions, too, must be situated as institutional actors, not merely service providers. Their roles include co-leading surveillance systems, training personnel, developing policy-relevant research, and facilitating community engagement. Academic consortia with policy influence, such as the One Health High-Level Expert Panel (**OHHLEP**) [32], exemplify how science can be structurally embedded into governance.

A mature institutional framework for One Health is neither overly centralized nor fragmented. It depends on trust, clearly delineated responsibilities, interoperable mandates, and above all, accountability mechanisms. This entails not just formal structures but relational capital, including relationships of cooperation, respect, and transparency between sectors and stakeholders. Moving forward, capacity development should prioritize institutional agility: the ability to adapt governance practices to emerging risks, evolving knowledge, and shifting political landscapes.

4.2 Regional and Intra-African/Intra-EU Collaboration

Robust intra-regional collaboration is foundational to operationalizing the One Health approach both within Africa and the European Union. Within each continent, intra-regional synergies are essential not only for aligning technical capacities and regulatory frameworks but also for building collective resilience to cross-border health threats, including zoonoses, antimicrobial resistance (AMR), and climate-linked disease emergence.

In Africa, intra-continental collaboration has gained momentum through platforms such as the **Africa CDC** and the **African Union One Health Coordination Mechanism (AU-OHCM)**. These institutions have been instrumental in promoting integrated disease surveillance, developing national One Health platforms, and supporting harmonized action plans across member states. Notably, Africa CDC's *Framework for One Health Practice in National Public Health Institutes* emphasizes regional knowledge sharing, workforce development, and joint outbreak response mechanisms across health, veterinary, and environmental agencies [9, 27]. Regional economic communities such as the **Economic Community of West African States (ECOWAS)** play a complementary and often catalytic role. ECOWAS has supported member states in developing regional early warning and emergency response systems, notably through the ***West African Health Organization (WAHO)***, which promotes joint public health responses and workforce development. Similar mechanisms within ***Intergovernmental Authority on Development (IGAD)***, a regional organization comprising eight East African countries, namely Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan, and Uganda and ***Southern African Development Community (SADC)*** have facilitated veterinary harmonization, transboundary animal disease control, and integration of environmental indicators into public health planning. These regional bodies offer important platforms for collective action where national systems are fragmented or under-resourced. For example, the ***IGAD Sheikh Technical Veterinary School (ISTVS)*** has become a regional hub for cross-border veterinary education and applied One Health research in the Horn of Africa.

Policy coherence within the EU has also been advanced through the **Farm to Fork Strategy**, the **European Green Deal**, and the **One Health European Joint Programme (OHEJP)**, which unites over 40 public health, food safety, and veterinary institutes. These mechanisms have enabled joint training, data harmonization, and co-funded research projects, serving as replicable models for African regional blocs.

Strengthening intra-regional collaboration requires investing in interoperability frameworks, regional centres of excellence, and sustained policy dialogue platforms. Critically, both Africa and Europe must foster decentralized cooperation models, supporting subnational institutions and civil society organizations in translating One Health strategies into action at the local level.

4.3 Public-Private Partnerships

Public-private partnerships (PPPs) represent a critical yet often underutilized mechanism in advancing One Health implementation. Across both EU and Africa regions, the scale and complexity of One Health challenges, ranging from zoonotic spillovers to food system sustainability and antimicrobial resistance, necessitate collaborative models that transcend the boundaries of state-led governance. When designed with transparency, equity, and shared accountability, PPPs can catalyze innovation, accelerate technology transfer, and bridge implementation gaps across sectors.

In the **health and pharmaceutical domain**, PPPs have demonstrated their value in vaccine development, diagnostic innovation, and the deployment of digital surveillance systems. African initiatives such as the ***Partnership for Aflatoxin Control in Africa (PACA)*****,** supported by AU and private agrifood actors, showcase how coordinated action between regulatory agencies, farmer cooperatives, and food companies can reduce exposure to foodborne toxins while improving market access. Similarly, public-private initiatives like the ***GALVmed consortium*** have expanded the availability of veterinary vaccines and diagnostics in underserved rural regions, aligning market incentives with public health goals.

The **European Union** has promoted PPPs in areas including digital agriculture, AMR stewardship, and environmental biosecurity, through funding mechanisms such as Horizon Europe and the **European Innovation Council (EIC)**. Programs such as ***IMI AMR Accelerator***, which is a partnership between the EU and pharmaceutical companies, demonstrate how high-risk, high-cost research into new antimicrobials and alternatives (e.g., phage therapy or microbiome modulation) can be de-risked through co-investment. These experiences are particularly relevant for Africa, where limited access to capital and R&D infrastructure hinders health innovation pipelines.

In the **agriculture and food systems sectors**, digitalization has opened new avenues for PPPs. Satellite imaging firms, mobile data platforms, and fintech companies have begun collaborating with ministries of agriculture and environment to support early warning systems, disease mapping, and adaptive farm management. For instance, initiatives in East Africa involving agri-tech start-ups, telecom operators, and national veterinary services have enabled SMS-based livestock disease reporting and AI-enhanced epidemiological modeling.

However, the success of PPPs hinges on more than financial co-investment. Institutional trust, regulatory clarity, and shared value creation must form the foundation. Governments must establish robust frameworks for governance, data ownership, intellectual property, and risk sharing to ensure that public interests are safeguarded. Equity considerations are paramount: PPPs must avoid reinforcing market asymmetries or bypassing public sector priorities. African smallholder farmers, informal traders, and community health workers must not be reduced to passive beneficiaries but should be actively engaged in partnership design and benefit-sharing mechanisms.

4.4 Involvement of NGOs, Academia, and Indigenous Knowledge Systems

The implementation of One Health principles cannot be effective without the meaningful involvement of non-state actors, especially non-governmental organizations (NGOs), academic institutions, and holders of indigenous and local knowledge. These actors function as connective tissue across communities, disciplines, and sectors filling operational gaps, contextualizing scientific knowledge, and ensuring the social legitimacy of health and environmental interventions

Particularly at the community level, NGOs often act as first responders in areas where state capacity is limited. Their proximity to local populations allows for early identification of atypical health events, facilitation of risk communication, and the delivery of culturally competent health services. Organizations

such as ***ALERT Africa*** [33] and ***RECONCILE*** **(Kenya)** [34] have worked on wildlife-human conflict resolution, zoonosis education, and ecosystem restoration, providing real-time community feedback into national early warning systems. International NGOs, including ***VSF International*** **and** ***Health in Harmony*** [35], play critical roles in supporting One Health implementation in fragile ecosystems, especially in post-conflict or climate-stressed regions. However, NGO contributions are frequently under-documented in formal policy processes, limiting their visibility and integration into regional One Health strategies.

Beyond its conventional role in knowledge generation, academia is also central to creating transdisciplinary bridges that are still rare in institutional structures. Universities in both Africa and Europe have been instrumental in incubating cross-sectoral research, piloting co-designed interventions, and training hybrid professionals who can navigate between veterinary, medical, and ecological domains. Importantly, academia also serves as a mediator between science and policy. Networks such as the *Global One Health Network* and *COST Action NEOH* have demonstrated how academic consortia can standardize One Health metrics, develop interoperability frameworks, and inform ethical governance models for cross-border data sharing. To enhance impact, academic institutions must shift toward open science models, emphasizing participatory research and community-engaged scholarship.

Moreover, indigenous knowledge systems (IKS) such as the **Africa Indigenous knowledge system** [36] hold deep understanding of ecological patterns, disease symptoms in animals and plants, and the cultural logic that underpins land and resource use. EU-Africa collaboration provides an opportunity to elevate these actors beyond consultation into co-design and governance roles. Multi-stakeholder platforms should institutionalize the participation of civil society, universities, and traditional authorities in setting priorities, shaping curricula, and evaluating impact. Only by integrating these complementary knowledge systems and networks can One Health become more inclusive, adaptive, and contextually grounded.

5 Digital Transformation and Data Governance

5.1 Digital Infrastructure for One Health

Robust digital infrastructure forms the backbone of a functional One Health ecosystem, enabling seamless data exchange, real-time surveillance, predictive analytics, and cross-sectoral collaboration. For the EU-Africa One Health initiative, digital infrastructure is not only a technological asset but a strategic enabler for coordinated action across human, animal, and environmental health systems. However, significant asymmetries exist between and within regions, demanding a concerted effort to both upgrade existing digital systems and co-create new architectures that are interoperable, inclusive, and ethically sound.

5.1.1 Exiting Digital Infrastructure

In Europe, several mature digital health and surveillance platforms already operate at national and regional levels. Systems such as the EU's Early Warning and Response System (EWRS), the European Surveillance System (TESSy), and the Animal Disease Notification System (ADNS) are linked through secure networks that support automated alerts, case tracking, and epidemiological modeling. These platforms are backed by robust data governance frameworks, standardized protocols, and strong institutional mandates. They serve as foundational assets that can inform and support South-North knowledge transfer.

In Africa, digital health systems are expanding rapidly, but remain fragmented and uneven. Several countries have adopted platforms such as DHIS2 (District Health Information System 2) for routine health reporting, and initiatives like SORMAS (Surveillance Outbreak Response Management and Analysis System) and REDISSE (Regional Disease Surveillance Systems Enhancement) are helping to unify surveillance efforts. However, challenges remain in ensuring interoperability between sectors, data completeness, system sustainability, and equitable digital access—particularly in rural or underserved regions.

5.1.2 Moving towards 2030

To build a cohesive digital infrastructure for One Health, several key elements must be prioritized. Initially, **interoperability standards** must be agreed upon across human, animal, and environmental sectors. This includes shared data dictionaries, harmonized metadata frameworks, and open APIs that allow different platforms to communicate securely and efficiently. Moreover, **investments in broadband connectivity, cloud computing, and distributed data centers** are essential to support real-time data processing and storage, especially in regions with limited technical capacity.

On the digital tools approach, **user-centered design** should guide the development ensuring platforms are accessible, adaptable to local contexts, and responsive to the needs of frontline health workers, veterinary officers, and environmental stewards. Language localization, mobile compatibility, offline functionality, and low-bandwidth optimization are critical features for inclusion. Moreover, **strong governance mechanisms** must underpin digital infrastructure, with clear policies on data ownership, privacy, ethical use, and accountability. Cross-border data sharing agreements—especially between EU and African partners—should balance public health benefits with individual and community rights. Existing frameworks such as the WHO's guidance on digital health, the EU General Data Protection Regulation (GDPR), and the African Union's Digital Transformation Strategy offer useful starting points.

It should also be underlined that **digital capacity-building** must be embedded at all levels. This includes technical training for system administrators, data analysts, and developers, as well as digital literacy programs for local users and decision-makers. Building local ownership and long-term maintenance capabilities is key to avoiding dependency on external vendors or short-term pilot projects.

Last bit not least, **digital innovation ecosystems** should be fostered across the EU and Africa to encourage homegrown solutions. Incubators, research labs, and start-up accelerators focused on digital health, veterinary technologies, and environmental monitoring can drive context-specific innovation. Collaborative R&D platforms and open innovation calls can further bridge EU-Africa partnerships in digital One Health technology.

5.2 Data Sharing, Sovereignty, and Ethics

In the context of One Health, data is not merely a technical asset, but a shared societal good. Timely, accurate, and interoperable data underpin early warning systems, policy decisions, epidemiological models, and transdisciplinary research. However, data also carries significant implications for sovereignty, privacy, trust, and equity. As the EU-Africa One Health partnership advances, the frameworks governing data sharing, ownership, and ethics must evolve to reflect a balance between openness and control, utility and rights, science and justice.

5.2.1 The Strategic Value and Complexity of One Health Data

One Health data spans human health records, veterinary reports, genomic sequences, environmental metrics, climate indicators, and socio-economic variables. Each domain operates under different governance logics, standards, and regulatory mandates. Combining these data sources across sectors and borders introduces complex questions: Who owns the data? Who benefits from it? Who decides how it is used, stored, or shared?

In Europe, data governance benefits from relatively mature frameworks, including the EU's General Data Protection Regulation (GDPR), which sets high standards for personal data privacy, user consent, and data portability. The GDPR applies not only to human health data but increasingly to datasets involving digital phenotyping, environmental monitoring, and AI analytics. The upcoming European Health Data Space (EHDS) seeks to further harmonize access to health data for research, policy, and innovation across the EU.

In Africa, data ecosystems are more fragmented. While countries like Rwanda, Kenya, and South Africa have made strides in developing digital health and agricultural data policies, many nations lack comprehensive legislation or digital infrastructure. The African Union's Digital Transformation Strategy (2020–2030) provides a guiding vision, calling for data sovereignty, regional interoperability, and ethical AI. However, implementation across diverse legal traditions, technical capacities, and geopolitical contexts remains a challenge.

5.2.2 Data Sovereignty and Equity in EU-Africa Collaboration

Data sovereignty, defined as the right of a country or community to govern the data generated within its territory, is central to the EU-Africa partnership. Historically, data extraction from African institutions to support global research or commercial models has often occurred without fair benefit sharing, reinforcing North-South asymmetries. Ensuring data sovereignty means recognizing African stakeholders as co-owners of data, with the right to control access, define terms of use, and receive equitable returns from data-driven products and insights.

Sovereignty also has a communal dimension. For instance, indigenous ecological knowledge, traditional livestock systems, or community-level biosurveillance data cannot be treated as raw data devoid of cultural and political context. Ethical data governance must embed principles of Free, Prior and Informed Consent (FPIC), respect for cultural heritage, and protection of collective rights.

At the same time, data sovereignty must be balanced with the imperative for regional and global data sharing. Pathogens do not respect borders; neither should the information needed to detect and contain them. Cross-border data flows—governed by mutually agreed protocols—are essential for early warning, coordinated response, and scientific collaboration. Regional data trusts or federated data spaces could offer an institutional mechanism to facilitate controlled data sharing while maintaining national autonomy.

5.2.3 Ethical Foundations for One Health Data Use

Ethical data governance in the context of One Health is underpinned by four fundamental principles: transparency, justice, beneficence, and accountability. ***Transparency*** ensures that all stakeholders clearly understand how data is collected, processed, and used. It requires that communities are informed about who accesses their data and for what purposes, fostering informed participation and trust. ***Justice*** calls for a fair distribution of both the risks and benefits associated with data use. This includes equitable involvement in data governance processes, mechanisms for fair benefit-sharing, and the safeguarding of vulnerable populations from potential harm or exploitation. ***Beneficence*** emphasizes that data should be used in ways that demonstrably advance the public good, such as through improved disease prevention, environmental stewardship, and sustainable development. ***Accountability*** entails the establishment of oversight mechanisms to ensure compliance with ethical norms, enable redress for grievances, and facilitate the adaptation of practices in light of emerging challenges.

The increasing reliance on artificial intelligence (AI) and machine learning (ML) within One Health data systems adds a further layer of ethical complexity. Algorithmic bias, non-transparent decision-making, and a lack of explainability can deepen existing inequities and erode public confidence. To mitigate these risks, ethical AI frameworks must be integrated into the design and governance of data systems. This includes conducting regular audits, ensuring human oversight, and engaging communities in participatory governance to align technological innovations with societal values and needs.

5.2.4 Legal Instruments and Emerging Frameworks

Several international instruments provide essential normative guidance for ensuring ethical and lawful data sharing within the One Health context. The **Nagoya Protocol**, established under the Convention on Biological Diversity, sets critical rules for access to genetic resources and emphasizes equitable benefit-sharing—particularly relevant for the international exchange of pathogen genomic data. Complementing this, the **International Health Regulations (IHR 2005)** outline binding legal obligations for countries to report public health events in a timely manner, although they offer limited detail on the governance of specific data flows.

Meanwhile, the **FAIR Data Principles**—which promote data that is Findable, Accessible, Interoperable, and Reusable—advocate for responsible open science. However, applying these principles to sensitive health and biosecurity data requires careful contextualization and safeguards. The **OECD's 2017 Recommendation on Health Data Governance** also plays a key role, proposing a framework for cross-border health data sharing that prioritizes transparency, trust, and the protection of individual rights. Within the African context, the **African Union Convention on Cyber Security and Personal Data Protection**, also known as the Malabo Convention, offers a continental legal architecture to harmonize cybersecurity and data privacy laws among member states.

As the EU-Africa One Health partnership matures, there is a timely opportunity to co-develop a joint *Code of Practice on One Health Data Governance*. Such a document could serve as a dynamic and context-sensitive framework aligning legal, ethical, and technological principles across both regions. It would define shared standards for informed consent, access control, data minimization, anonymization, and equitable benefit-sharing—supporting the development of a just, transparent, and interoperable data ecosystem.

5.2.5 Pathways Forward: Operationalizing Ethical and Sovereign Data Sharing

To move from principle to practice, we propose the following concrete steps, that we believe should be implemented:

1. **Build data stewardship capacity** in both regions. This includes training local data managers, ethicists, and legal experts in data governance frameworks.
2. **Establish federated data infrastructure** where sensitive datasets remain in local institutions but can be queried under secure, controlled conditions.
3. **Adopt open-source digital tools** with built-in privacy safeguards, audit trails, and differential access rights.
4. **Foster inclusive governance structures**, ensuring that community representatives, civil society, and underrepresented groups participate in decision-making.
5. **Develop joint EU-Africa data sharing agreements**, grounded in reciprocal benefit, accountability, and transparency.

The future of One Health relies not only on the data we collect but on how we govern it. By embedding data sovereignty, ethical integrity, and legal accountability into the digital architecture of One Health, the EU and Africa can set a global benchmark for collaborative, equitable, and responsible health innovation.

5.3 AI and Predictive Analytics in Disease Prevention

Artificial Intelligence (AI) and predictive analytics are revolutionizing the landscape of disease prevention, offering unprecedented opportunities to detect, forecast, and respond to health threats before they escalate. In the context of the EU-Africa One Health initiative, the integration of AI-driven technologies into disease surveillance and risk modeling systems can transform reactive responses into proactive interventions. When combined with interoperable data systems, community-based reporting, and genomic surveillance, AI holds the potential to strengthen public health infrastructure, enhance veterinary services, and safeguard ecosystems.

5.3.1 Understanding AI and Predictive Analytics in a One Health Context

AI refers to computational systems that can mimic human intelligence, such as learning from data (machine learning), reasoning, decision-making, and pattern recognition. Predictive analytics uses statistical algorithms, data mining, and machine learning techniques to identify trends and make forecasts based on historical and real-time data.

In a One Health framework—where human, animal, and environmental health data must be integrated. AI facilitates the processing of vast and diverse datasets, identifying complex relationships across disciplines. This capability is essential for tracking emerging infectious diseases, mapping antimicrobial resistance (AMR), predicting zoonotic spillover events, and optimizing resource allocation.

5.3.2 Applications in Early Detection and Outbreak Forecasting

One of the most transformative uses of AI in disease prevention is early outbreak detection. Algorithms trained on multi-source data, including clinical records, veterinary health logs, weather patterns, satellite imagery, and social media, can identify anomalies that signal the emergence of disease. For example, tools like HealthMap and BlueDot have used AI to detect disease outbreaks days or even weeks before official announcements.

In Africa, AI-enhanced platforms like the Surveillance Outbreak Response Management and Analysis System (SORMAS) are being expanded to improve real-time monitoring and automate response triggers. Similarly, environmental sensors, mobile health data, and livestock tracking systems can feed into predictive models that identify high-risk zones for Rift Valley Fever, Ebola, or Avian Influenza, enabling early interventions and targeted vaccination campaigns.

For the EU, systems such as the Early Warning and Response System (EWRS) and the European Centre for Disease Prevention and Control (ECDC)'s Epidemic Intelligence (EI) program are increasingly integrating AI tools to improve timeliness and accuracy in assessing transboundary threats.

5.3.3 Predictive Modeling for Zoonotic Spillover and AMR

Predictive analytics also plays a vital role in identifying conditions conducive to zoonotic spillover. Machine learning models trained on ecological, socio-economic, and climatic variables can estimate the likelihood of pathogen emergence in specific regions. For instance, predictive models developed by EcoHealth Alliance have mapped global hotspots for bat-related viral spillover, helping inform wildlife surveillance strategies.

Similarly, AI can forecast patterns of antimicrobial resistance by analyzing data from prescription records, wastewater analysis, and bacterial genomic databases. These models can guide stewardship programs, regulate antibiotic use in agriculture, and anticipate the spread of resistant strains across borders.

5.3.4 Optimizing Resource Allocation and Logistics

AI-driven tools are increasingly used to optimize the deployment of health resources during both preparedness and response phases. For example, predictive analytics can identify communities most vulnerable to disease outbreaks, allowing for targeted distribution of vaccines, personal protective equipment, and testing kits. Algorithms can also assist in determining optimal locations for mobile clinics, laboratory support, and community health interventions.

During the COVID-19 pandemic, AI models helped forecast ICU demand, guide lockdown policies, and assess the effectiveness of non-pharmaceutical interventions. In future pandemics or regional outbreaks, similar tools could support dynamic, data-driven decision-making for EU and African public health authorities.

5.3.5 AI in Genomic Surveillance and Pathogen Discovery

Next-generation sequencing (NGS) has become a cornerstone of disease surveillance. AI accelerates the analysis of genomic data, helping identify novel pathogens, monitor mutations, and trace transmission chains. In Africa, the African Centre of Excellence for Genomics of Infectious Diseases (ACEGID) in Nigeria uses AI tools to analyze pathogen genomes in near-real time, contributing to regional and global pathogen intelligence.

In the EU, AI-based pipelines for genomic analysis are integrated into platforms like GISAID and Nextstrain, enhancing the speed and granularity of disease tracking. By applying AI to One Health genomic datasets—from human, animal, and environmental samples—researchers can uncover new insights into pathogen evolution and interspecies transmission dynamics.

5.3.6 AI in the context of Ethical and Practical Considerations

Despite its potential, the use of AI in disease prevention must be governed by ethical principles and practical safeguards. Key concerns include data privacy, algorithmic bias, explainability, and equitable access.

AI systems trained on biased or incomplete data may reinforce existing health disparities. For example, if rural areas in Africa lack sufficient health data inputs, predictive models may underperform in these regions, leading to unequal resource allocation. To address this, AI development must include diverse, high-quality datasets from both continents.

Transparency and explainability are also essential. Health authorities and frontline workers must be able to understand and trust AI-generated recommendations. Investing in human-in-the-loop systems—where algorithms augment rather than replace human judgment—can enhance accountability and user confidence.

Equally important is ensuring that AI tools are accessible to low-resource settings. Mobile-based solutions, cloud-hosted platforms, and open-source tools can help democratize access and promote South-South innovation.

5.3.7 Toward a Predictive and Preventive Health Ecosystem

Looking ahead, AI and predictive analytics will become integral to the broader transition from reactive to preventive health systems. In a mature One Health ecosystem, AI will not be a standalone tool but part of an integrated decision-support architecture spanning surveillance, diagnostics, logistics, risk communication, and governance.

To get there, the EU-Africa One Health partnership must invest not only in digital infrastructure but in trust, interoperability, and institutional readiness. Ethical and locally grounded AI will be central to this vision—ensuring that data becomes intelligence, and intelligence becomes action, in the service of shared health security and planetary well-being.

6 Capacity Building and Education

6.1 One Health Curricula and Certification Programs

Developing structured One Health curricula and certification programs is a strategic priority for the EU-Africa One Health partnership. These educational frameworks must reflect regional health priorities, foster transdisciplinary collaboration, and ensure the continuous development of a skilled workforce equipped to manage the interdependencies between human, animal, and environmental health.

Across Europe and Africa, institutions are increasingly adopting integrated One Health training approaches, facilitated through both formal education and professional development pathways. In Africa, notable examples include the ***Africa One Health University Network (AFROHUN)*** [37], formerly ***OHCEA*** (One Health Central and Eastern Africa), which operates in multiple countries including Uganda, Ethiopia, Kenya, Cameroon, and Rwanda. AFROHUN develops contextualized One Health curricula that address zoonotic disease management, antimicrobial resistance, ecosystem health, and climate adaptation. These programs emphasize field-based training, systems thinking, and leadership skills, often implemented in collaboration with ministries of health, agriculture, and environment.

Similarly, the ***ASPIRE*** (*Afrique One*) consortium, funded by the Wellcome Trust[1] supports PhD and postdoctoral training in One Health research across East and West Africa, with a focus on zoonotic disease ecology, animal-human-environment interfaces, and capacity strengthening in under-resourced academic environments. These programs also promote equitable South-South and South-North partnerships, ensuring knowledge flows in all directions. Moreover, ASPIRE initiative supports institutions such as ***Makerere University*** (Uganda), ***Sokoine University of Agriculture*** (Tanzania), and the ***University of Pretoria*** (South Africa), which pioneer regional One Health training hubs and integrate field's epidemiology, veterinary public health, and ecological health studies.

In Europe, One Health is embedded in a growing number of master's and doctoral programs supported by initiatives such as the ***Erasmus Mundus Joint MSc Degrees*** and the **EU-FORA Fellowship Programme** administered by the European Food Safety Authority (EFSA). The Erasmus+ funded "One Health European Joint Programme" (One Health EJP) has connected over 40 public health, food safety, and veterinary institutes from 19 countries, delivering interdisciplinary training modules and harmonized certification pathways.

Furthermore, the ***Med-Vet-Net Association***, a pan-European network of excellence in veterinary public health, provides capacity-building and continuing professional development (CPD) opportunities for researchers and policy professionals [38]. In addition, *the One Health European Joint Programme Summer School*, and the *European Joint Doctorate in One Health Microbiology*, are exemplary educational models promoting transdisciplinary learning across borders.

Certification frameworks in the EU and Africa are increasingly aligned with the ***Tripartite One Health Competency Framework*** (formally titled the *COHFE, Competencies for One Health Field Epidemiology*) framework, co-developed by WHO, FAO, and WOAH [39]. This framework sets out core competencies in collaborative leadership, surveillance, risk assessment, and outbreak response, ensuring that training outcomes meet global benchmarks. FAO's regional One Health training program for Central Asia and Eastern Europe, which includes hybrid learning and practical case studies, can be adapted for similar use across the African context through capacity-building hubs. The framework also outlines guidance on mentorship

[1] Wellcome Trust is a politically and financially independent global charitable foundation, funded by a £38.2 billion investment portfolio. Their strategy includes grant funding, advocacy campaigns and partnerships to find solutions for today's urgent health challenges (link)

models, evaluation methods, and certification pathways, making it a valuable resource for academic institutions and training providers seeking to align their curricula with international standards

The African Union's endorsement of One Health under the Africa CDC's strategy has also spurred the development of regional guidelines for One Health workforce training. Pilot programs led by the ***African Union Inter-African Bureau for Animal Resources (AU-IBAR)*** are now translating these strategies into formal curricula across veterinary and medical institutions, with an emphasis on accreditation and mutual recognition of qualifications across member states.

Globally, academic institutions have begun to introduce specialized One Health training modules. For instance, the University of Washington offers a **Graduate Certificate in One Health** that focuses on zoonotic disease transmission, environmental risk analysis, and collaborative intervention strategies [40]. Similarly, the University of Arizona has developed an **Online Graduate Certificate in One Health**, designed for both current professionals and graduate students. This program provides foundational courses in epidemiology, environmental health, and systems thinking, allowing credits to be transferred toward advanced public health degrees [41]. Certification programs, whether academic or professional, offer essential validation of competencies and enable practitioners to pursue specialized roles in governmental, non-governmental, and international institutions. For example, the **University of Florida's One Health Certificate** integrates systems science, One Health policy, and applied fieldwork experiences. Students who complete the program are eligible for advanced positions in public health departments, agricultural ministries, and research organizations [42]. In-service professionals also benefit from modular learning formats and continuing professional development (CPD) schemes. The **FAO-WHO-WOAH One Health Training Program for Europe and Central Asia**, for instance, uses e-learning and hybrid modules to train mid-career professionals in One Health approaches, with an emphasis on real-world problem-solving and intersectoral collaboration [43].

Crucially, One Health education should not be confined to siloed disciplines. Interdisciplinary approaches and systems thinking must be embedded in curricula to allow professionals to recognize and act on the interdependence of biological, ecological, and social systems. A 2021 report by the National Academy of Medicine emphasized that educational programs should incorporate experiential learning opportunities, such as case-based learning, simulations, capstone projects, and field placements in real One Health contexts [44].

It is our opinion EU-Africa collaboration should foster joint certification mechanisms and mutual recognition agreements to advance standardization and recognition. Universities and professional bodies could collaborate in developing joint One Health diplomas, dual-degree programs, and co-branded certificates that hold value across continents. These mechanisms would enhance mobility, create shared professional identity, and deepen the institutional alignment between African and European educational ecosystems. Curriculum development must also be adaptive and responsive to emerging challenges such as antimicrobial resistance, climate change, digital health, and food system transformation. Regular curriculum reviews, stakeholder consultations, and partnerships with research institutions are essential to maintain the relevance and impact of One Health education.

6.2 Institutional Strengthening in Public Health and Veterinary Services

Institutional strengthening in public health and veterinary services is a cornerstone of effective One Health implementation, especially within the EU-Africa context where systemic capacity disparities persist. Strengthening these institutions ensures the operationalization of integrated surveillance, coordinated outbreak response, and sustainable health interventions. It encompasses infrastructure investment, human resource development, governance reform, intersectoral collaboration, and digital modernization.

Public health and veterinary institutions function at the intersection of disease prevention, food safety, environmental health, and population resilience. However, many of these systems remain under-resourced, particularly in low- and middle-income countries where fragmented governance, limited laboratory capacity, and inadequate workforce training constrain their effectiveness. Bridging these structural gaps requires both financial investment and policy innovation. For example, the Africa Centres for Disease Control and Prevention (Africa CDC) and national public health institutes (NPHIs) have begun spearheading efforts to establish regional laboratory networks, harmonize health data standards, and train rapid response teams.

A first step in institutional strengthening is **infrastructure development**. Modernizing laboratories and veterinary diagnostic centers ensures timely detection of zoonotic and foodborne pathogens. Investments in biosafety and biosecurity, including the adoption of ISO standards for lab operations, are essential to maintaining both scientific integrity and public trust. Veterinary services must be equipped with mobile diagnostic units and field laboratories to service rural and remote areas, where emerging zoonoses often originate. Equally important is developing cold chain systems and logistics capacity to support vaccine delivery and outbreak response.

Human resource capacity is another critical pillar. Building a skilled, multidisciplinary workforce requires systematic training in epidemiology, laboratory science, veterinary medicine, public health policy, and bioinformatics. Regional One Health training hubs should offer both pre-service education and in-service training, integrating field epidemiology programs with One Health competencies. Joint training exercises—combining human, animal, and environmental health professionals—strengthen operational collaboration and emergency preparedness. Cross-continental fellowship and exchange programs between African and European institutions will reinforce shared standards and foster long-term institutional partnerships.

Governance structures must also evolve to support intersectoral coordination. Institutional reforms should embed One Health coordination units within Ministries of Health and Agriculture, supported by legal mandates and sustainable financing. Multi-agency task forces, involving public health authorities, veterinary services, environmental agencies, and local governments, should be empowered to jointly assess risks, allocate resources, and implement interventions. Successful models, such as Uganda's One Health Platform and the integrated zoonotic disease units in Kenya and Ethiopia, illustrate how structural coordination mechanisms can transform fragmented efforts into unified response systems.

Digital transformation is a key enabler of institutional integration. Developing interoperable information systems for disease surveillance, laboratory reporting, and supply chain management enables timely, data-driven decision-making. Open-source platforms like DHIS2 and EMPRES-i, when customized for One Health, can support integrated reporting across sectors. Cloud-based dashboards, geospatial analysis tools, and mobile applications facilitate real-time data sharing and visualization, improving outbreak detection and response. However, digitalization must be coupled with investments in cybersecurity, data privacy frameworks, and digital literacy programs for frontline workers.

Institutional strengthening must also address regulatory capacity. Veterinary and public health authorities require updated legal frameworks aligned with international standards, such as the International Health Regulations (IHR), WOAH Performance of Veterinary Services (PVS) Pathway, and Codex Alimentarius food safety standards. Regulatory harmonization across countries—particularly in areas like antimicrobial stewardship, food safety inspections, and animal movement controls—enhances cross-border disease control and trade facilitation. Strengthened inspection and enforcement mechanisms, backed by trained personnel and risk-based protocols, are essential to regulatory credibility.

Importantly, **institutional strengthening** should be inclusive and community centered. Decentralizing authority to district and local levels enables tailored health interventions, while enhancing the

responsiveness of veterinary and public health services to local needs. Community health workers, animal health auxiliaries, and local surveillance agents should be integrated into institutional frameworks and supported with training, incentives, and clear reporting lines. This approach fosters trust, facilitates early detection, and ensures interventions are culturally appropriate and locally owned.

Sustainable financing is fundamental. Institutional strengthening cannot depend solely on donor cycles or emergency funding. National governments and regional bodies must allocate dedicated budget lines to One Health operations, laboratory maintenance, workforce development, and outbreak preparedness. Public-private partnerships can complement public funding, especially for digital tools, vaccine delivery systems, and innovation hubs. Financial planning should include contingency reserves, insurance mechanisms, and pooled procurement strategies to enhance institutional resilience.

Monitoring and evaluation (M&E) systems are essential to track institutional performance, identify gaps, and promote continuous improvement. Indicators should measure infrastructure functionality, workforce capacity, coordination effectiveness, response times, and community satisfaction. Tools such as Joint External Evaluations (JEE) and the State Party Self-Assessment Annual Reporting (SPAR) under the IHR framework provide structured mechanisms for assessing national public health capacities. Benchmarking veterinary service performance against WOAH's PVS assessments offers similar value for the animal health sector.

Finally, **institutional culture and leadership development** are key. Strengthening institutions goes beyond structures and systems—it also involves fostering leadership, accountability, and adaptive learning. One Health leaders must be trained to manage complexity, build consensus, and navigate political and technical challenges. Embedding One Health values into institutional missions, standard operating procedures, and evaluation frameworks promotes coherence and long-term commitment.

6.3 Gender Equity and Youth Empowerment

Gender equity and youth empowerment are foundational elements for achieving sustainable and inclusive outcomes in the One Health strategy. Recognizing that gender disparities and youth disenfranchisement limit the potential of entire communities, targeted capacity-building initiatives must prioritize equitable participation and meaningful empowerment. Addressing gender and youth inclusivity directly enhances the effectiveness, legitimacy, and sustainability of health interventions across Europe and Africa.

Gender equity involves not only increasing representation and participation of women across health, scientific, and environmental sectors but also transforming institutional structures and cultural norms that perpetuate inequalities. Women, often disproportionately affected by health crises, frequently bear significant responsibilities in healthcare, agriculture, and community resilience efforts. Capacity-building strategies must, therefore, explicitly address gender-based barriers, promoting equitable access to education, training opportunities, leadership roles, and decision-making processes. Gender-sensitive curricula, mentoring programs, and dedicated scholarships can significantly enhance women's participation, leadership, and innovation within One Health fields.

Youth empowerment constitutes another critical pillar, harnessing the transformative potential and innovative capabilities of young people. Africa, in particular, has one of the youngest populations globally, representing an enormous demographic dividend if effectively leveraged. Youth must be actively involved in shaping health interventions, policies, and research agendas, offering fresh perspectives and driving technological and social innovations. Capacity-building programs tailored for youth, including targeted educational pathways, youth-led research initiatives, innovation incubators, and internships, enable young professionals to actively contribute to health security, climate adaptation, and sustainable development.

Educational institutions and professional organizations across Europe and Africa should collaborate in designing and implementing inclusive training and mentorship programs that address gender equity and youth empowerment explicitly. Exchange programs and networks for young professionals and women leaders can promote intercultural dialogue, mutual learning, and collaborative problem-solving, enhancing cross-continental cooperation and shared understanding.

Monitoring and evaluation frameworks must incorporate gender- and youth-specific indicators, systematically tracking progress in achieving equity and empowerment objectives. Transparent reporting, accountability mechanisms, and continuous stakeholder engagement are essential to ensure sustained progress and adapt strategies responsively.

7 Roadmap to 2030 and Beyond

7.1 Phased Implementation Plan (Short, Medium, Long Term)

Effective implementation of the One Health roadmap requires a strategic, phased approach designed to manage complexity, optimize resource allocation, and enhance adaptability across short-, medium-, and long-term horizons. This phased implementation plan outlines actionable priorities, strategic milestones, and adaptive management considerations to ensure sustainable progress toward overarching One Health objectives.

7.1.1 Short-Term Implementation (0-3 Years)

In the initial short-term phase, the immediate focus is establishing foundational systems, building institutional capacity, and initiating critical interventions. This stage emphasizes rapid actions that yield tangible early wins, establishing confidence and momentum among stakeholders. Key actions include strengthening surveillance infrastructures by implementing integrated early warning systems capable of identifying emerging zoonotic diseases. Such systems require harmonizing data collection standards, establishing interoperable platforms, and fostering cross-sectoral collaboration.

Community engagement must commence early, utilizing existing social and community networks to foster awareness and proactive participation in surveillance and early detection efforts. Pilot community-based surveillance programs should be initiated in high-risk regions, supported by targeted education campaigns addressing misinformation and promoting transparent risk communication.

Research and innovation in this phase focus on rapid diagnostics, vaccine development, and risk modeling technologies. Short-term EU-Africa research partnerships can initiate joint pilot projects that develop and test diagnostic tools and innovative disease management approaches. Establishing regional research hubs, particularly within African countries, promotes equitable distribution of research capabilities and accelerates innovation transfer.

Policy coherence and regulatory alignment in the short term involve preliminary mapping of existing regulatory frameworks and identifying key discrepancies and harmonization opportunities. Early dialogue platforms should be established, encouraging stakeholder engagement across public health, veterinary, environmental, and agricultural sectors, laying groundwork for integrated legislative frameworks.

7.1.2 Medium-Term Implementation (3-6 Years)

The medium-term phase consolidates and expands upon early achievements, systematically scaling initiatives and embedding deeper institutional integration. Surveillance systems will transition from pilot projects into national and regional networks characterized by enhanced interoperability and real-time data sharing capabilities. AI-powered predictive modeling and genomic surveillance systems should be expanded, providing advanced analytical capabilities that significantly enhance the prediction and early management of outbreaks.

Workforce capacity-building moves beyond foundational training, emphasizing continuous professional development and interdisciplinary education. Establishing One Health-focused curricula within medical,

veterinary, environmental, and agricultural educational institutions ensures sustainability of the knowledge base. Exchange programs between European and African institutions are essential for reciprocal knowledge transfer and capacity strengthening, developing leadership and collaborative competencies critical to sustained partnership success.

Research during the medium-term phase intensifies around solutions-oriented innovation. Research efforts should prioritize the development of sustainable agricultural practices, novel antimicrobials, and integrated approaches to manage antimicrobial resistance. Transdisciplinary research collaborations, under frameworks such as Horizon Europe and African research consortia, should receive sustained funding to support comprehensive, long-term studies addressing regional priorities.

Community engagement in this period becomes more systematic, transitioning from awareness-building to sustained participation in local One Health initiatives. Integrative communication platforms enabling two-way dialogue between communities, policymakers, and researchers should be institutionalized, fostering local ownership and legitimacy of interventions. Participatory risk mapping and scenario planning exercises facilitate community preparedness and adaptive resilience.

Regulatory alignment efforts become more formalized, characterized by bilateral and multilateral agreements aimed at harmonizing standards related to disease reporting, antimicrobial use, environmental protection, and cross-border public health measures. The establishment of transboundary regulatory coalitions and regional agencies facilitates structured coordination, providing governance frameworks that support integrated implementation.

7.1.3 Long-Term Implementation (6-10 Years and Beyond)

Long-term implementation of the One Health roadmap emphasizes consolidation, sustainability, and adaptability. Surveillance and early warning infrastructures are expected to reach full maturity, functioning seamlessly across sectors and regions with high levels of digital integration, interoperability, and predictive accuracy. At this stage, surveillance systems should integrate comprehensive environmental and climate data to support ecosystem-based health monitoring, identifying long-term health risks linked to climate change and biodiversity loss.

Workforce development and training will reflect fully institutionalized One Health principles, with educational frameworks deeply embedded within curricula and professional standards. Continuous knowledge renewal mechanisms will ensure the workforce remains adaptable to evolving health threats and technological advancements. Leadership training and mentorship programs must support ongoing institutional resilience, emphasizing gender equity, youth participation, and indigenous knowledge integration.

Long-term research priorities shift towards system-level innovation, resilience-building, and addressing emerging challenges anticipated through comprehensive forecasting models. Robust funding mechanisms, shared research infrastructures, and equitable intellectual property frameworks will ensure sustained research productivity and innovation capacity in Africa and Europe alike. Research outcomes should continuously inform policy decisions, with institutionalized mechanisms for research-policy translation ensuring that evidence-based interventions remain relevant and effective.

Community engagement in the long term transcends participation, achieving deep community empowerment and co-governance of local health initiatives. Institutionalized community advisory councils, representative governance bodies, and collaborative monitoring frameworks will sustain accountability and responsiveness of One Health strategies. Long-term risk communication frameworks will remain dynamic, adapting to changing societal contexts and maintaining high levels of public trust and transparency.

Finally, policy coherence and regulatory alignment reach full integration, reflected in harmonized legislative frameworks, unified standards, and structured mechanisms for transboundary cooperation. Policy implementation should undergo regular review and adaptive refinement, supported by rigorous monitoring and evaluation frameworks. Governance mechanisms established in earlier phases must remain flexible and responsive, capable of adapting to new health threats, scientific advances, and societal shifts.

Through deliberate, phased implementation, the EU-Africa One Health roadmap will build resilient, interconnected health systems capable of responding effectively to present and future challenges. Each phase provides foundational successes and lessons to inform subsequent stages, ultimately fostering sustainable health security, environmental stewardship, and socio-economic resilience across both continents.

7.2 Strategic Milestones

In our analysis and strategic roadmap, strategic milestones will serve as essential benchmarks to measure progress, ensure accountability, and guide adaptive management throughout the implementation of the One Health roadmap. These milestones reflect clear, measurable outcomes across short-, medium-, and long-term phases, providing tangible evidence of progress and facilitating ongoing stakeholder engagement and resource mobilization.

We may define the following **Short-Term Milestones (0-3 Years)**

M1.1. Establishment and operationalization of integrated surveillance pilot projects in key hotspot regions, demonstrating real-time data sharing and early detection capabilities.

M1.2. Launch of foundational community engagement initiatives, evidenced by increased public awareness and active participation rates in community-based surveillance and risk communication activities.

M1.3. Development and launch of initial One Health training programs and capacity-building workshops, achieving measurable increases in trained interdisciplinary personnel across veterinary, medical, and environmental sectors.

M1.4. Initiation and establishment of pilot EU-Africa research partnerships, with at least two major collaborative projects addressing diagnostics, vaccine development, or disease prediction technology.

M1.5. Completion of regulatory mapping exercises, clearly identifying gaps and discrepancies across national and regional policies and establishing preliminary coordination frameworks.

Moving towards **Medium-Term Milestones (3-6 Years)**

M2.1. Expansion and institutionalization of national and regional surveillance networks, demonstrating improved predictive capacity and response times to outbreaks, verified by simulation exercises and real-world event responses.

M2.2. Implementation of continuous professional development curricula within key educational institutions, measurable by increased graduation rates of One Health-trained professionals and active knowledge exchange between European and African institutions.

M2.3. Achievement of significant research outputs from collaborative projects, including new diagnostic tools, antimicrobial agents, or agricultural technologies, validated through field trials and peer-reviewed publications.

M2.4. Integration of community advisory groups within local governance structures, evidenced by consistent community-driven inputs into health policy and intervention designs.

M2.5. Formal establishment of bilateral and multilateral regulatory agreements, facilitating standardized practices and harmonized disease reporting across EU-Africa jurisdictions.

Final Long-Term Milestones (6-10 Years and Beyond) include:

M3.1. Comprehensive maturity of integrated surveillance systems, verified by seamless interoperability across sectors, real-time cross-border data sharing, and routine integration of environmental and climate indicators.

M3.2. Full institutionalization of One Health educational frameworks and professional standards, measurable by stable workforce retention, leadership succession plans, and sustainable knowledge renewal programs.

M3.3. Sustained outputs and systemic impacts from long-term research initiatives, reflected in policy integration of research outcomes, commercialization of innovations, and demonstrable health, agricultural, and environmental improvements.

M3.4. Empowered community governance structures, achieving co-ownership and sustained local management of One Health programs, regularly validated by community satisfaction and participatory evaluations.

M3.5. Robust regulatory coherence and policy integration at national and regional levels, evidenced by streamlined governance frameworks, reduced legislative discrepancies, and established transboundary cooperation mechanisms.

7.3 Risk Management and Contingency Plan

Effective risk management and contingency planning are critical components of the One Health implementation process, ensuring that potential threats and uncertainties are systematically identified, evaluated, and mitigated. Given the interconnectedness of human, animal, and environmental health, comprehensive risk management approaches must incorporate multidimensional assessments and adaptive strategies to prepare for, respond to, and recover from potential crises.

7.3.1 Risk Identification and Assessment

Risk management begins with robust and comprehensive risk identification, a systematic process that considers diverse sources of potential threats, vulnerabilities, and uncertainties inherent in the One Health approach. Key risk categories include epidemiological threats (e.g., zoonotic diseases and antimicrobial resistance), environmental hazards (e.g., climate-induced disasters, biodiversity loss), socio-economic challenges (e.g., inadequate infrastructure, poverty-driven behaviors), and technological vulnerabilities (e.g., data breaches, system failures).

Interdisciplinary risk assessment methodologies such as hazard mapping, scenario analysis, and quantitative modeling are essential tools for understanding the likelihood and potential impacts of identified risks. Scenario planning, in particular, allows stakeholders to simulate various outbreak events or environmental disruptions, evaluating system readiness, resource availability, and community resilience. Such exercises provide actionable insights, allowing stakeholders to prioritize resources and interventions effectively.

7.3.2 Risk Mitigation and Preparedness

Risk mitigation focuses on proactive strategies designed to reduce the probability of adverse events and minimize their potential impacts. A multi-layered preparedness framework is crucial, involving measures at community, institutional, national, and regional levels. Within the One Health context, these measures

include strengthening surveillance and early warning systems, enhancing laboratory diagnostic capabilities, and establishing rapid response teams capable of multidisciplinary coordination during health crises.

Preparedness initiatives must prioritize infrastructure resilience, such as reinforcing health facilities, laboratories, and communication networks. Technological preparedness includes maintaining robust digital platforms that ensure real-time data sharing, interoperable communication systems, and secure databases. Implementing redundancy systems and backup measures reduces the risk of technological failures disrupting critical health services.

Community-level preparedness involves targeted risk education, capacity-building activities, and active participation in local contingency planning. By fostering local awareness and empowering communities with knowledge and tools, preparedness initiatives significantly enhance grassroots resilience and response effectiveness.

7.3.3 Contingency Planning and Response

Effective contingency planning establishes clear, structured protocols and operational guidelines for managing crises when preventive measures fall short. Contingency plans must be detailed, actionable, and tailored to diverse scenarios such as disease outbreaks, natural disasters, or food safety incidents. Key components of effective contingency plans include clearly defined roles and responsibilities, communication strategies, resource allocation guidelines, and decision-making frameworks.

Rapid response protocols must include clearly delineated coordination mechanisms that integrate medical, veterinary, environmental, and emergency management teams. Cross-sector collaboration, supported by joint training exercises and simulation drills, ensures that response teams can swiftly mobilize, operate cohesively, and communicate effectively across sectors.

Effective communication strategies are critical during crisis response, emphasizing transparency, accuracy, and timeliness. Communication plans must outline clear channels for information dissemination, community engagement strategies, and mechanisms for addressing misinformation and public anxiety. Leveraging digital platforms, community leaders, and trusted local institutions ensures that critical information reaches all affected populations promptly and effectively.

7.3.4 Recovery and Resilience-Building

The recovery phase emphasizes restoring community and institutional functions to pre-crisis levels, coupled with systematic improvements to enhance future resilience. Recovery plans should include strategies for immediate post-crisis rehabilitation, as well as longer-term restoration of affected services, infrastructure, and community livelihoods. Within the One Health framework, recovery interventions must holistically address human health, animal health, and environmental restoration.

Recovery strategies should integrate mental health support, socio-economic assistance, and community capacity-building programs designed to mitigate long-term impacts. Effective recovery involves comprehensive evaluations of crisis responses, identifying successes and failures, and translating lessons learned into improved preparedness and mitigation strategies.

Building resilience involves systematic enhancements in infrastructure, policy frameworks, community engagement, and workforce capacity, ensuring better preparedness and adaptive response to future risks. Resilience-building measures emphasize integrated governance, strengthened health systems, diversified agricultural practices, and sustainable ecosystem management, ultimately creating a robust foundation for long-term sustainability and health security.

7.3.5 Monitoring, Evaluation, and Adaptive Management

Continuous monitoring and evaluation (M&E) are indispensable for effective risk management and contingency planning, providing evidence-based assessments of preparedness, response effectiveness, and resilience outcomes. Structured M&E frameworks should include clearly defined metrics and indicators capable of capturing multidimensional impacts, efficiency, and effectiveness across all phases of crisis management.

Regular evaluations, incorporating feedback from diverse stakeholders, including frontline workers, community members, policymakers, and scientists, facilitate adaptive management by identifying critical gaps, emerging threats, and opportunities for improvement. Adaptive management involves regularly revising contingency plans, updating risk assessments, refining preparedness measures, and enhancing resource allocation strategies based on M&E outcomes.

Institutionalizing adaptive management ensures that the risk management framework remains dynamic, responsive, and capable of addressing evolving threats and uncertainties effectively. By embedding continuous learning and adaptation into governance structures and operational protocols, stakeholders enhance institutional resilience and readiness to navigate complex health, environmental, and socio-economic challenges.

8 Conclusions & Vision for Post-2030 EU-Africa Health Security

The Post-2030 vision for EU-Africa health security embraces a future where human, animal, and environmental health are seamlessly interconnected and sustainably managed, reflecting the highest aspirations of the One Health approach. By 2030 and beyond, health security in both regions will have transcended traditional boundaries, integrating cutting-edge science, resilient infrastructure, inclusive governance, and empowered communities into a cohesive ecosystem capable of addressing emerging global health challenges proactively and effectively.

In this envisioned future, integrated surveillance and predictive analytics systems will operate at unprecedented levels of precision, providing real-time, predictive insights that anticipate and preempt disease outbreaks long before they manifest. Leveraging advancements in genomic sequencing, artificial intelligence, and environmental monitoring, these interconnected systems will continuously scan ecological and societal dynamics, enabling early interventions and significantly reducing the risks of zoonotic spillover, antimicrobial resistance, and climate-related health crises.

Health systems across Europe and Africa will be deeply interconnected through interoperable digital platforms and cross-sectoral data-sharing agreements, underpinned by transparent, secure, and ethically sound data governance frameworks. Artificial intelligence and machine learning will be routinely deployed to enhance health surveillance, optimize resource allocation, and facilitate rapid, targeted responses during emergencies. Advanced robotics, telemedicine, and drone technologies will have dramatically expanded healthcare access, particularly in remote or underserved regions, promoting equitable health outcomes and resilience across both continents.

Education and workforce development will have fully institutionalized One Health principles, resulting in a multidisciplinary workforce capable of agile and coordinated responses to complex health challenges. Robust academic and research partnerships between European and African institutions will have become commonplace, producing continuous innovation, evidence-based policy recommendations, and context-specific solutions. African-led centers of excellence, working collaboratively with European partners, will spearhead global research and innovation in health security, biodiversity conservation, climate resilience, and sustainable agriculture.

Community empowerment and participatory governance structures will underpin local and regional resilience, fostering deep-rooted social trust, transparency, and collective responsibility in health management. Community-driven monitoring, governance, and advocacy will ensure sustained engagement and ownership, embedding health security as a shared societal value across diverse populations.

Policy coherence and regulatory alignment will have reached full maturity, guided by harmonized legislative frameworks, unified standards, and robust transboundary cooperation mechanisms. EU-Africa collaborative governance structures will consistently prioritize equity, transparency, and accountability, maintaining adaptive flexibility to navigate evolving health landscapes.

By 2030 and beyond, the EU-Africa One Health partnership will exemplify a global standard in health security, demonstrating the transformative potential of collaboration, scientific innovation, and shared commitment. This visionary yet achievable future ensures that both continents not only respond effectively to immediate health crises but proactively shape a healthier, more resilient, and sustainable world for generations to come.

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10 Annex – Contributors

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