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The 'One Health' Synthesis: Climate Change and Infectious Disease Preparedness

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Abstract: *The rising climate crisis has been reported to be the key element of the modern outbreak of infectious diseases, and empirical evidence has indicated that a quarter of all the known human pathogens are now complexified by climatic risks (Anderson, 2003). The paper explains that One Health synthesis is an important paradigm in the 21st century of biosecurity, where changes made by man, such as global warming, erratic weather patterns, habitat destruction, and others, play a role in the spread of vectors, water-borne diseases, and zoonotic spillovers. Despite the theoretical benefits of One Health, a deficiency of application exists due to silos that typify the sectors, disproportional investment in animal and environmental health, and the use of stationary disease models that are incapable of elucidating the quick warming of the planet.The following paper reflects an argument to support active change in the concept of medical response in the case of a crisis to that of an integrated digital infrastructure, which can be viewed as multisectoral and real-time surveillance, based on the synthesis of recent data and the lessons of the COVID-19 pandemic. Some of the recommendations are the institutionalisation of One Health into the national climate adaptation plans, land-use changes to undergo Health Impact Assessment, and the establishment of climate-sensitive early warning systems. The hypothesis in the paper is that, to safeguard the well-being of the world's health, human, animal and environmental well-being must be viewed as a single assembly that is of importance in achieving the UN Sustainable Development Goals.*

Keywords: *Climate Change. Environmental Surveillance, Global Health Security, Infectious Disease Preparedness, One Health, Zoonotic Spillover.*

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1.0 Introduction

Global health systems are increasingly challenged by unprecedented instability driven largely by anthropogenic climate change (Briggs, 2023). Rising global temperatures and increasing climatic variability are altering environmental and ecological stability worldwide. . The fact is that climate change is a major driver for new pathogen appearance and recurrence of old diseases because the phenomenon literally changes the map of health risks on the Earth (Hutchins et al., 2019). The environmental changes, which include a decrease in precipitation, wetland destruction, and heating oceans, are also compelling the wildlife to reside close to human settlements (He & Silliman., 2019). Such ecological disruption also allows the so-called spillover effects, in which pathogens are transmitted from animal reservoirs to human populations (Abrahms et al., 2023). Additionally, the expansion of tropical climatic conditions facilitates the geographic spread of disease vectors like mosquitoes and ticks in regions once under temperate climatic conditions and transforms any localized outbreak into a worldwide menace.

To cope with such dynamic landscapes, the One Health approach has emerged as a critical framework has evolved into a critical paradigm. One Health is an integrative, holistic concept that recognizes that human health is intrinsically interconnected with animal and environmental health of the health of animals and of our shared abode. It challenges traditional sectoral approaches to disease management as well as supports a shared venture between the fields of public health, veterinary medicine, and environmental science to monitor and mitigate hazards at their level (Prata et al., 2022). However, despite growing recognition of One Health principles, practical integration of climate data, environmental monitoring, and health surveillance systems remains limited within existing infectious disease preparedness frameworks.

Some disease preparedness strategies are reactive and anthropocentric with the growing knowledge of such interdependencies. This fragmented policy fails to take into account the environmental predispositions of disease, which puts the world's systems at risk of another epidemic (Zabaniotou, 2020). An integration of climate science and clinical practice, a synthesis that is holistic and bridges the gap between the two, is no longer a theoretical possibility, but the logical necessity of the new biosecurity.

This study proposes that a strengthened One Health synthesis can significantly enhance infectious disease preparedness under accelerating climate change. Specifically, the study aims to examine how integrated climate, environmental, animal, and human health surveillance systems can improve early warning, response capacity, and global health resilience. Climate information combined with animal and human health surveillance will make us finally move to an active paradigm of global health. The study contributes to ongoing scientific and policy discussions by providing a conceptual framework linking climate adaptation strategies with infectious disease preparedness and global health security planning. As more and more zoonotic and climate threats continue to rise, this type of integrated strategy is required in order to develop a robust mechanism that will ensure the protection of human, animal, and ecosystem health within an increasingly climate-altered world.

2.0 Conceptual Framework: Climate-Infectious Disease Linkages

2,1 Pathways: Vector expansion, water/foodborne, zoonotic spillovers.

A complex and overlapping system of mechanisms that bypasses the conventional geographic boundaries defines the interconnection of a changing climate and the dynamics of infectious diseases (Semenza et al., 2022). The most obvious are the growth of vectors; the area of habitable mosquitoes, ticks and sandflies is increased by the action of the global isotherms, as they move outwards, upwards. The warmer winters and longer summers elevate the metabolic rates of the vectors, and fewer cycles of extrinsic incubation of such pathogens as Malaria, Dengue, and Lyme disease, which stems from the increased frequency of the cycles of transmission during a season (Matthew et al., 2022).

Besides the threat posed by the vectors, the fundamental nature of climate change is the disruption of biological security through the waterborne and foodborne routes, and zoonotic spillover. Drastic floods and rising sea level also tend to ruin the sanitation systems, and also cause the proliferation of enteric diseases, including Vibrio cholera (Basin et al., 2022). Concurrently, climate change results in forced migration of ecological species of wildlife to places where human beings thrive. It upgrades the contact on the human-animal interface, which offers additional opportunities of new pathogens to traverse the species barrier, transferring local ecological pressure into the potential pandemic diseases at the global scale (Magouras et al., 2020).

2.2 Evidence Synthesis: Impact Measurement

The recent empirical surveys have pointed out the spectacular scale of health risks associated with climate. A historic analysis of the existing body of empirical evidence, with the latest 2022-2024 figures, has shown that in one way or another, approximately 50 percent of all human infectious diseases (218 of 375 known pathogens) have been exacerbated by climatic risks (Saraswati et al., 2024). These risks are not isolated but rather an amalgamation of these risks to create a multi-hazard environment in which the human populations and health care systems are constantly exhausted by the impacts of these risks.

This is alluded by the fact that the most pervasive cause is the warming of both atmosphere and the oceans and this allows an expansion of the diseases originally believed to have been a tropical disease in a poleward direction. In addition, the study shows that the cumulative impact of these risks is non-linear (Craig, 2020); specifically, drought and resulting massive flooding can result in waterborne disease epidemics. This combination of information validates the fact that it is no longer expected but a fact that the climate-infectious disease relationship has become a reality and that there is a need to strategically change interventive efforts in the area of this field to proactive and climate-awareness.

3.0 Evidence of Climate-Driven Disease Dynamics (up to 2024)

To understand the current trajectory of global biosecurity, it is essential to quantify the tangible shift in disease patterns attributed to environmental stressors. The following section synthesizes recent empirical data and conceptual models to illustrate the scale of climate-induced health risks. This evidence base transitions the discussion from theoretical risk to observed impact, highlighting the urgent need for a multisectoral response.

3.1 Observed Impacts and Transmission Trends

The following table provides a concise summary of how specific climatic hazards have altered the transmission dynamics of prominent infectious diseases. By mapping primary transmission routes against specific climate links, such as warming isotherms and extreme precipitation, we can observe the direct correlation between environmental change and rising disease incidence.

The relationships between major climate hazards and infectious disease transmission pathways are summarized in **Table 1**, highlighting observed epidemiological impacts across vector-borne, waterborne, and zoonotic diseases between 2015 and 2024.

3.2 Visualizing Pathogen Aggravation and the Integrated Solution

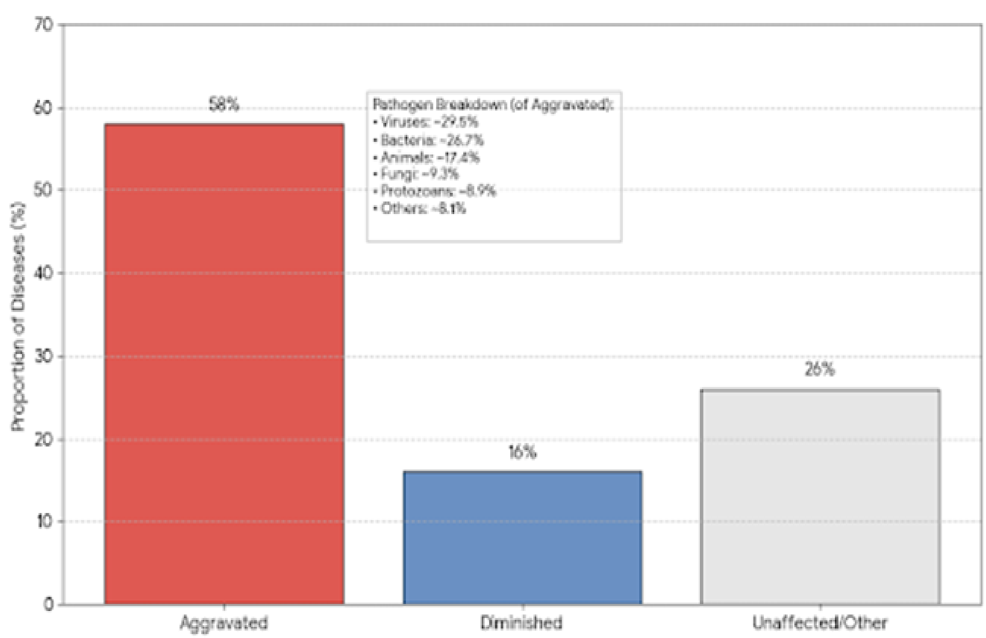
As illustrated in Fig. 2, climatic hazards currently aggravate a substantial proportion of infectious diseases globally, emphasizing the expanding scale of climate-sensitive health risks. The scale of this challenge is further emphasized in Figure 1, which reveals that a staggering 58% of known infectious diseases are currently aggravated by climatic hazards. The breakdown of these pathogens—ranging from viruses to protozoans—suggests that no category of infectious threat is immune to the effects of a warming planet.

The integrated response strategy proposed in this study is conceptualized in Fig. 2,, which presents a One Health preparedness framework linking environmental monitoring, animal health surveillance, and human public health systems.In response to these compounding risks, a paradigm shift is required. Figure 2 outlines the One Health Preparedness Framework, a synthesis hub designed to bridge the gap between environmental science, veterinary monitoring, and human public health. This circular, reinforcing model demonstrates how "Early Warning Detection" and "Risk Assessment" can transform reactive systems into a proactive, resilient global health infrastructure.

Table 1: Impact of Climate Hazards on Disease Transmission (2015 to 2024)

Disease	Primary Transmission	Climate Hazard Link	Observed/Estimated Impact
Dengue	Vector (*Aedes* mosquito)	Warming and expanded environmental suitability	10–15% transmission increase since 1950s baseline; millions more cases projected.
Malaria	Vector	Highland expansion and temperature rise	R_0 increase of 0.1–0.3 per 1°C in some regions.
Lyme Disease	Vector (ticks)	Habitat shift and northern spread	Rising incidence in new areas (e.g., Canada).
Cholera / Leptospirosis	Waterborne / Floods	Extreme precipitation and flooding	5–10x spikes post-flood events (e.g., 2024 cases).
Zoonoses (general)	Animal-to-human	Habitat disruption and spillover	>75% of emerging infections are zoonoti

Selected climate-sensitive diseases and linkages, based on syntheses up to 2024. **(Romanello et al., 2024)**



Fih. 1: Bar Chart shown scheme fot yhe– Proportion of Infectious Diseases Aggravated by Climatic Hazards (Mora et al., 2022)

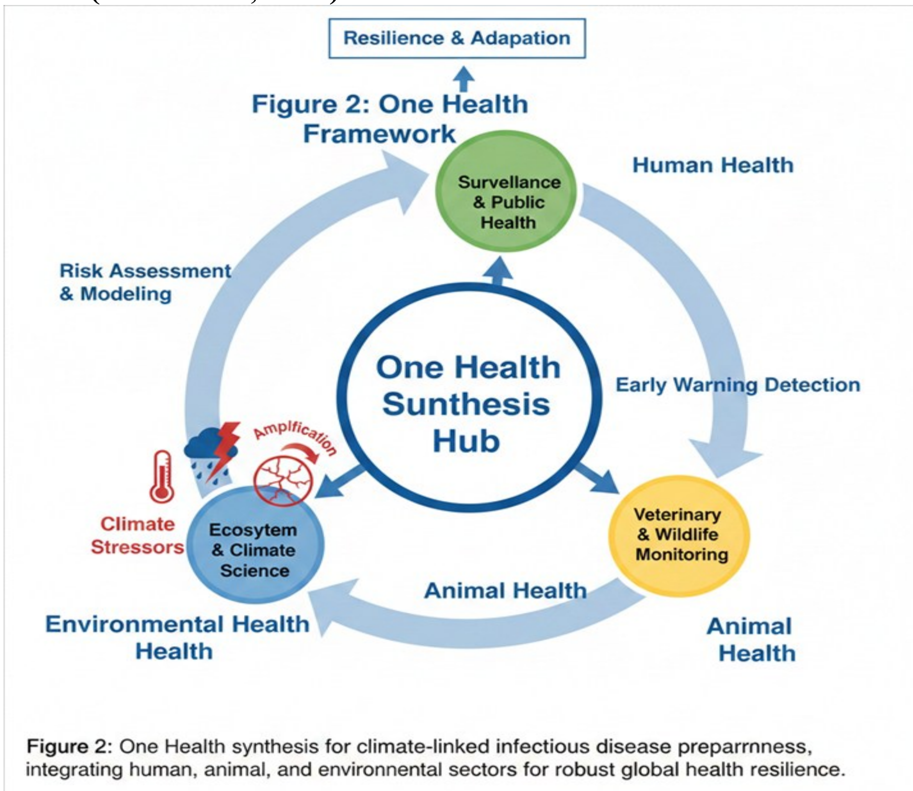


Fig. 2: Conceptual Diagram or Flowchart – One Health Preparedness Framework (World Health Organization, 2024)

4.0 One Health Implementation and Preparedness Gaps

Despite the theoretical strength of the One Health framework, significant implementation gaps persist, largely due to weak institutional integration and fragmented surveillance systems. Most international health monitoring systems remain sectorally siloed, whereby human health data, veterinary records, and environmental indicators are collected by separate agencies with minimal interoperability. (Biek and Micucci, 2024). Such fragmentation creates critical blind spots at the human–animal–environment interface, a case in point would be for example, an increase in wildlife mortality during extreme heat events may remain undetected by public health systems until zoonotic spillover into human populations occurs. Effective preparedness therefore requires a unified digital infrastructure capable of enabling real-time data sharing across ministries of health, agriculture, and environment. (Lamb and Vale, 2024).

Furthermore, substantial inequalities exist in the technical and financial capacities required to sustain integrated One Health systems, particularly in low-resource settings. Even though the beneficiary of most international funding is human health surveillance, environmental and animal health sectors remain chronically underfunded (Zinsstag et al., 2022). This imbalance limits the development of comprehensive early warning systems. Limited local laboratory capacity for simultaneous genomic sequencing of animal and human samples, together with inadequate environmental sensor networks for pathogen monitoring, prevents proactive detection of emerging threats. Zoonotic disease surveillance and antimicrobial resistance (AMR) monitoring provide practical illustrations of these preparedness gaps. In most of these places,surveillance programs frequently focus primarily on livestock populations and do not monitor wildlife reservoirs that are displaced due to deforestation and climate change (Sharan et al., 2023). Consequently, displaced wildlife increasingly interacts with human populations, yet standardized monitoring policies for spillover-prone species remain largely absent, allowing emerging pathogens ("Disease X") to circulate undetected for extended periods. Relatedly, AMR preparedness is often considered a clinical issue, whereas flooding caused by climate change and rising temperatures are also cited to enhance the horizontal gene transfer of resistance in environmental reservoirs, such as wastewater and soil, which receive significantly less surveillance attention compared with clinical healthcare settings.(Purwaningrum and Pratama, 2023).

Another emerging weakness is the limited incorporation of climate adaptation into One Health preparedness strategies. Most of the current models of infectious diseases are built on the stationary environmental assumptions that fail to account for rapidly shifting climatic baselines (Srensen et al., 2024). An example here is a West Nile Virus surveillance program, which may rely on fixed seasonal transmission windows , and which would not be able to adapt to the reality of the shorter, warmer winters, when vectors remain active throughout the year. In order to ensure that the preparedness measures are not only climate-resistant, but also capable of predicting the ecological transformations of the next decades, it must be possible to implement the predictive climate modeling into the One Health efforts (Tepa-Yotto et al., 2024).

Integrating predictive climate modelling, ecological forecasting, and multisectoral surveillance is therefore essential for transforming One Health from a conceptual framework into an operational preparedness strategy.

5.0 Recommendations for Enhanced Preparedness

To address the systemic vulnerabilities identified in current biosecurity frameworks, the institutionalization of multisectoral policies is paramount. A critical objective is the integration of One Health principles into national climate adaptation strategies and international biosecurity treaties. This necessitates a shift in governance from informal coordination to a Whole-of-Government mandate, where ministries of environment, agriculture, and health are legally and financially incentivized to collectively mitigate emerging disease risks (WHO, 2024).

A practical application of this governance model involves the implementation of mandatory Health Impact Assessments (HIAs) for major land-use changes, such as large-scale deforestation or dam construction. These assessments serve as predictive tools to evaluate the potential for zoonotic spillover or the creation of vector-breeding habitats. By harmonizing these regulatory standards internationally, global stakeholders can ensure that climate mitigation efforts and pandemic preparedness are viewed as a unified pillar of national resiliency rather than competing priorities.

Furthermore, technical preparedness must be augmented through the deployment of Climate-Sensitive Early Warning Systems (EWS). These systems require sophisticated digital infrastructures capable of centralizing and harmonizing synoptic meteorological data—including rainfall, humidity, and temperature fluctuations—with real-time genomic surveillance across livestock, wildlife, and clinical settings (Wang et al., 2023).

Strategic investment should be prioritized for rural and high-risk "hotspots" situated at the human-animal interface. Predictive modeling allows governments to anticipate potential outbreaks weeks in advance, facilitating targeted interventions such as localized vector control or livestock vaccination. Such proactive measures are essential to preventing localized, climate-driven ecological shifts from escalating into international public health emergencies. The core structural elements required to achieve this synthesis are detailed in Table 2.

Table 2: Core Elements of One Health Synthesis for Disease Preparedness

Element	Description	Benefits for Disease Preparedness
Integrated Surveillance	Joint human-animal-environment monitoring	Early detection of spillovers
Cross-Sector Governance	National/regional coordination	Reduced silos (e.g., post-COVID frameworks)
Capacity Building	Training, labs, data sharing	Addresses resource-limited settings
Climate Integration	Hazard modeling in One Health plans	Proactive against vector/zoonotic shifts

***One Health Preparedness Elements (Romanello et al. 2024)**

6.0 Discussion

The integration of One Health into the global development agenda offers profound synergies with the United Nations Sustainable Development Goals (SDGs). Specifically, One Health serves as a direct catalyst for SDG 3 (Good Health and Well-being), SDG 13 (Climate Action), and SDG 15 (Life on Land) by ensuring that health policy intersects with species conservation and ecosystem stability (WHO, 2022). The restoration of degraded habitats transcends mere nature conservation; it represents the fortification of an "ecological safety net" designed to prevent the spillover of pathogens from animal reservoirs into human populations (Khoday, 2021). By prioritizing ecological integrity, the spectrum of climate-sensitive diseases—as detailed in Table **1** is naturally constrained, illustrating that human prosperity is not a competitor to the environment but a direct extension of it.

The COVID-19 pandemic provided a costly yet enlightening lesson regarding the limitations of isolated health management (Lee et al., 2022). The crisis demonstrated that effective pandemic prevention begins not at the hospital entrance, but in the forests, livestock markets, and climate-monitoring stations. While the pandemic accelerated global genomic monitoring and real-time data transmission, it also exposed a critical environmental lapse in our early warning systems (Series et al., 2023). It is now recognized that a "green recovery"—wherein low-carbon development is inextricably linked to pandemic prevention—is the only viable mechanism to break the cycle of zoonotic emergence.

Ultimately, the One Health synthesis represents a fundamental shift from reactive crisis management to proactive risk mitigation. The drivers of climate change—deforestation, intensive agriculture, and rising temperatures—are identical to the drivers of infectious disease outbreaks. Consequently, infectious disease preparedness has evolved from a purely medical endeavor into a complex, multisectoral mission (Kogan, 2023). The global community now possesses a unique window of opportunity to implement a system that safeguards the health of all living creatures on a rapidly changing planet.

7.0 Conclusion

The evidence synthesized in this paper confirms that the escalating climate crisis is the primary driver of modern infectious disease outbreaks. Traditional reactive medical systems are fundamentally ill-equipped for the non-linear challenges of the 21st century, particularly as 58% of known human pathogens are now exacerbated by climatic hazards. The only viable path toward robust preparedness is a transition to a **One Health synthesis** that integrates human, animal, and environmental surveillance into a unified framework, as visualized in the **One Health Preparedness Framework (Fig. 2)**.

This transition requires more than technical innovation; it demands sustained political and financial commitment to multisectoral governance. As the post-2020 landscape has shown, the cost of proactive prevention—exemplified by the elements in **Table 2**—is negligible compared to the astronomical economic and human costs of a global pandemic. By embedding One Health strategies within the SDG framework, we establish a roadmap for a more stable world. Protecting the ecosystems that regulate our climate and the biodiversity that shields us from disease is the ultimate guarantee of security for all species in an increasingly volatile environment.

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Declaration

Consent for publication

Not Applicable

Availability of data

The publisher has the right to make the data public

Ethical Considerations

Not applicable

Competing interest

The authors report no conflict or competing interest

Authors' Contributions

The authors jointly conceptualized the study and developed the One Health framework linking climate change with infectious disease preparedness. Literature synthesis and policy analysis were collaboratively conducted. Dymphna Ghasarah led public health interpretation, Adebusola Akomolafe contributed systems and policy perspectives, Jacinta Ogbemudia supported analytical development, while Christianah Ayodele provided clinical and nursing insights. All authors reviewed and approved the final manuscript.