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Leveraging AI-Driven One Health Surveillance in Sub-Saharan Africa: A Narrative Review of Planetary Health Intelligence for Climate-Responsive Pandemic Preparedness

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Systematic Review

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Abstract

Background: Climate change intensifies health threats through vector range expansion, extreme weather events, and food insecurity, placing 1.1 billion people in sub-Saharan Africa (SSA) at heightened risk of pandemics. Current surveillance systems are fragmented, with only 48% of SSA countries (20 of 42) partially implementing integrated One Health surveillance and 94% relying on the underfunded Integrated Disease Surveillance and Response (IDSR) framework. Artificial intelligence (AI) offers opportunities for predictive analytics, real-time data integration, and early warning systems; however, its use in SSA remains limited.

Objective: To review the literature on AI-driven One Health and planetary health intelligence systems for climate-responsive pandemic preparedness in SSA, highlighting population-level impacts, barriers, and opportunities.

Methods: A narrative review of English-language publications from January 2015 to June 2025 was conducted across PubMed, AJOL, Web of Science, Google Scholar, WHO IRIS, and gray literature sources (WHO, Africa CDC, UNESCO). The search terms included *"climate change," "pandemic preparedness," "one health," "planetary health intelligence," "AI," and "Sub-Saharan Africa."* Out of the 4675 records identified, duplicates (n = 29) were removed, leaving 4646 for screening. Following the eligibility assessment, 19 publications were included: 8 quantitative studies and 11 qualitative/review/policy reports. Data on the study design, population size, AI methodology, and findings were extracted.

Results: Quantitative studies (n = 8) analysed populations ranging from 1,132 surveillance events (Gashema et al., 2025) to 1.6 million health records (Innes et al., 2022), with regional models covering up to 1.1 billion people. Only 48% of sub-Saharan African (SSA) countries have partially integrated One Health surveillance systems, and rural communities remain severely undercovered (~40% reach). Climate change is projected to contribute to an additional 250,000 deaths annually between 2030 and 2050, driven by malaria, diarrheal diseases, malnutrition, and heat stress. AI applications have demonstrated promise; for example, DigiCare in Cameroon automated data collection across 4,100 households and 52 veterinary posts, detecting 31 abnormal events in nine months. Similarly, Zindi in South Africa mobilized over 50,000 data scientists to develop AI models for climate prediction and public health monitoring. Compared with manual methods, AI-enhanced GIS and remote sensing technologies improved hotspot detection accuracy by up to 32%. However, scale-up efforts face significant barriers, including a shortage of AI-trained professionals (only 8% of SSA universities offer relevant training), inadequate broadband infrastructure, fragmented legal frameworks, and low governmental prioritization.

Conclusion: AI-driven One Health surveillance has the potential to significantly increase pandemic preparedness in SSA by enabling real-time, climate-responsive health intelligence across human, animal, and environmental domains. Existing initiatives demonstrate feasibility and measurable impact at the population level; however, addressing infrastructure deficits, capacity gaps, and policy fragmentation is critical for scale-up. Investing in AI-enabled planetary health intelligence could transform SSA's ability to prevent and respond to pandemics, protecting both ecosystems and vulnerable populations.

Background

Climate change poses a threat not only to the environment but also to health security. With air pollution, extreme heat, and extreme weather conditions currently on the rise—affecting 3.6 billion people globally—it is estimated that the climate crisis will cause 250,000 additional deaths per year from malnutrition, malaria, diarrhea, and heat stress between 2030 and 2050.[1][2] Climate change also influences the distribution and behavior of disease vectors, expanding their geographic range and prolonging transmission seasons as rainfall patterns change and temperatures rise. This has led to the spread of the Zika virus, Lyme disease, chikungunya, and other zoonotic diseases.[3][4]

Sub-Saharan Africa, which has warmed + 0.3°C per decade (1991–2023), is particularly vulnerable. Without urgent action, pandemics driven by climate and ecosystem disruptions could cause catastrophic health and economic losses.

To address these challenges, the One Health approach was endorsed, recognizing that human, animal, plant, and ecosystem health are interlinked.[6] AI technologies can enhance One Health frameworks by providing predictive analytics, data integration, and risk intelligence, forming the foundation for planetary health intelligence systems.[7] This review analyses AI-driven One Health approaches in SSA and their implementation in climate-responsive pandemic preparedness.

Methodology

Study Design

We conducted a narrative review using a PRISMA-aligned framework to systematically identify, screen, and synthesize literature on AI integration in One Health surveillance systems for SSA.

Eligibility criteria

1. Inclusion:
    a. Studies or reports on SSA or transferable insights.
    b. Focus on One Health, planetary health intelligence, pandemic preparedness, or climate-sensitive health threats.
    c. Use or discuss AI/machine learning/digital health tools.
    d. Published in English.
2. Exclusion:
    a. Non-SSA studies are irrelevant.
    b. Editorials or opinion pieces without data.
    c. NonEnglish publications without translations.

Information Sources

1. Databases: PubMed, AJOL, Web of Science, Google Scholar
2. Gray literature: WHO IRIS, Africa CDC, UNESCO, WMO, AI for Good (ITU), Zindi

Search strategy

Keywords:
"climate change" OR "climate-sensitive diseases" AND
"pandemic preparedness" OR "health security" AND
"one health" OR "planetary health intelligence" AND
"artificial intelligence" OR "AI" OR "machine learning" AND
"Sub-Saharan Africa" OR "SSA"

Selection process

1. Identification: 4663 database records + 12 gray literature = 4675 records
2. Screening: 29 duplicates were removed; 4646 titles/abstracts were screened; 4615 were excluded
3. Eligibility: 31 full texts reviewed; 12 excluded (8 unrelated to SSA, four not AI related)
4. Included: 19 publications (8 quantitative, 11 qualitative/policy reports)

Data Extraction and Analysis

Data extracted: author/year, country, design, sample size, AI methodology, findings.

Quantitative studies analysed detection rates, AI model performance, and population-level outcomes. Qualitative/policy studies were synthesized thematically into the following:

1. Surveillance gaps
2. Climate-sensitive health risks
3. Existing AI applications
4. Barriers and constraints
5. Recommendations

Results

Surveillance Gaps

1. Forty-eight percent (20/42) of SSA countries have partially integrated One Health surveillance[9].
2. Surveillance coverage in rural communities remains ~ 40%[2].

Climate-Sensitive Risks

Climate change has expanded vector ranges for mosquitoes and rodents by 20–30%, impacting ~ 110 million additional people[3]. If left unchecked, climate change may cause 250,000 additional annual deaths by 2030–2050[1].

AI Applications

1. DigiCare (Cameroon): 4,100 households covered; 31 abnormal events detected over 9 months[16].
2. Zindi (South Africa): AI competitions engaging 50,000 + data scientists; 12,000 from SSA[18].
3. Resch et al. (2025): AI-enhanced GIS improved hotspot detection by 32% compared with manual methods[15].

Barriers

Only 8% of SSA universities offer AI-related training. Weak legal frameworks, limited broadband, and poor political prioritization are consistent constraints affecting the successful integration of AI[11].

Recommendations

1. AI-driven surveillance should be embedded in national preparedness plans.
2. Regional AI research hubs and data-sharing frameworks should be established.
3. Scale AI education for 10 million students by 2030.

Table 1: Characteristics of the included studies (end of document)

Table 1
Characteristics of the Included Studies

Author & Year	Country/Region	Study Design	Population/Context	AI/One Health Focus	Key Findings
Lugten & Hariharan (2022)[1]	Multicountry (LMICs)	Quantitative	Climate-health projections for 92 LMICs	Health system adaptation & pandemic preparedness	Climate crisis may cause 250,000 annual deaths by 2030–2050
WHO (2023)[2]	SSA region	Policy report	1.1 billion people in SSA	Climate-health vulnerability & surveillance coverage	Surveillance reach in rural communities is < 60%
Srivastava et al. (2024)[3]	SSA and LMICs	Quantitative	47 climate-health datasets	Vector expansion analysis	Vector ranges expanded by 20–30% in SSA (affecting 110 M people)
Kaseya et al. (2023)[4]	SSA	Policy analysis	42 SSA countries	Climate-pandemic action agenda	Weak cross-sector coordination limits preparedness
WMO (2024)[5]	SSA	Policy report	40/48 SSA countries	Climate-disaster data & adaptation	At least one extreme event/year per country (2018–2023)
CDC (2025)[6]	Global	Concept paper	N/A	One Health definition	Clarifies human-animal-environment linkages
Mago et al. (2024)[7]	Global	Review	N/A	Planetary health relevance	Supports an integrated risk intelligence approach
Bergquist et al. (2024)[8]	SSA & global	Review	N/A	AI and zoonoses integration	Emphasizes AI in climate-sensitive disease prediction

Author & Year	Country/Region	Study Design	Population/Context	AI/One Health Focus	Key Findings
Gashema et al. (2025)[9]	SSA	Quantitative	42 SSA countries; 1,132 surveillance events	Integrated One Health surveillance	48% SSA countries have partial integration; detection timeliness improved 25%
Mremi et al. (2021)[10]	SSA	Quantitative	39 SSA countries; 20 years of IDSR data	Disease surveillance evaluation	94% rely on IDSR; integration remains incomplete
Ip (2024)[11]	Global	Perspective	400 M+ mobile health users in SSA	Ethics & data privacy in digital planetary health	Urgent need for ethical frameworks
Walther (2024)[12]	Global	Conceptual framework	N/A	ProSocial AI framework	AI integration across micro, meso, macro, and meta levels
Das & J.C. (2023)[13]	Global	Quantitative	Health facilities' energy data	AI for reducing climate footprint	Identifies efficiency gains via AI-based energy optimization
Resch et al. (2025)[14]	SSA	Quantitative	35 SSA countries; GIS data	AI foundation models in geospatial health	AI hotspot detection is 32% more accurate than manual
Innes et al. (2022)[15]	Thailand (transferable to SSA)	Quantitative	1.6 million animal health records	AI-enhanced avian influenza surveillance	AI improved outbreak detection; lessons transferable
Tanue et al. (2025)[16]	Cameroon	Program report	4,100 households; 52 veterinary posts	DigiCare - AI4PEP network	31 abnormal events were detected in 9 months using automated data

Author & Year	Country/Region	Study Design	Population/Context	AI/One Health Focus	Key Findings
UNESCO (2022)[17]	SSA	Policy report	413 universities in SSA	AI education gaps	Only 8% universities offer AI/data science in health
Zindi (2023)[18]	South Africa & SSA	Program report	50,000 + data scientists (12,000 SSA)	AI modelling challenges for climate & health	Successful innovation challenges with practical outputs
ITU AI for Good (2024)[19]	SSA	Program report	Multicountry	AI-driven solutions for climate disasters	Strengthened early warning & resilience models

Discussion

This review highlights the significant potential of AI-driven One Health surveillance systems to transform pandemic preparedness in sub-Saharan Africa (SSA). These findings confirm that AI-enhanced planetary health intelligence can address existing surveillance gaps, enable earlier detection of climate-sensitive disease outbreaks, and provide actionable insights across human, animal, and environmental health domains.

Surveillance Gaps and Public Health Risks

The review revealed that less than half (48%) of SSA countries have partially integrated One Health surveillance into their public health systems[9]. The reliance on the Integrated Disease Surveillance and Response (IDSR) framework by 94% of SSA countries underscores the region's dependence on a system that, while foundational, lacks interoperability and real-time data capabilities[10]. Limited rural coverage (~ 40%) further weakens the ability to detect outbreaks at the community level[2]. These gaps are compounded by climate-sensitive risks: vector expansion and ecosystem disruption are projected to lead to 250,000 additional annual deaths by 2030–2050, primarily from malaria, diarrheal diseases, and malnutrition (Lugten & Hariharan, 2022)[1].

Role of AI in Bridging Surveillance Gaps

AI technologies offer scalable solutions to overcome these weaknesses. Compared with manual methods, GIS-enhanced AI models achieve a 32% improvement in hotspot detection[15]. Case studies such as DigiCare (Cameroon) illustrate how AI-powered platforms can integrate data from multiple sources to detect 31 abnormal events within nine months, even in rural contexts[16]. Similarly, Zindi's South Africa-based data science competitions, which involved 50,000 + data scientists (12,000 from SSA), highlight the potential of AI-driven innovation networks to rapidly produce climate–health models at scale[18].

Barriers to Implementation

Despite their promise, implementation remains constrained by limited AI-related human capital: only 8% of SSA universities offer AI or data science programs relevant to health systems[17]. Broadband infrastructure deficits hinder real-time data transmission, whereas weak legal frameworks exacerbate challenges related to data privacy, algorithmic bias, and ethical governance[11]. The political prioritization of AI-enhanced surveillance remains inconsistent, leading to fragmented initiatives and underfunded pilots.

Policy and Systemic Implications

To achieve climate-responsive pandemic preparedness, SSA governments must embed AI-driven One Health surveillance into national health security strategies. Investment in regional AI research hubs is essential for building models tailored to SSA's epidemiological, ecological, and linguistic diversity. Early warning systems, interoperable data-sharing frameworks, and cross-sector partnerships with global actors (e.g., the WHO, Africa CDC, and ITU AI for Good) will be critical for scaling successful programs such as DigiCare. Expanding AI education at all levels is urgent: training 10 million students by 2030 would begin to address the current human resource deficit.

Global Relevance

While this review focused on SSA, the lessons have extended globally. Climate change is an accelerator of health security threats worldwide, and AI-enhanced planetary health intelligence offers a blueprint for other low- and middle-income regions with fragmented surveillance systems. Integrating One Health and AI in preparedness frameworks can facilitate rapid outbreak response, avert cross-border epidemics, and protect vulnerable ecosystems.

Conclusion

AI-driven One Health surveillance represents a transformative opportunity for strengthening pandemic preparedness in Sub-Saharan Africa. The evidence from this review demonstrates that AI can enhance early warning systems, improve outbreak detection rates, and integrate disparate data sources into cohesive planetary health intelligence platforms. Successful initiatives such as DigiCare (Cameroon) and Zindi (South Africa) prove that AI-enabled surveillance is feasible and impactful even in resource-limited settings.

However, realizing this potential will require urgent action:

1. Political commitment: Governments must prioritize AI-driven surveillance in national health security strategies.
2. Infrastructure investment: Expand broadband networks, laboratory diagnostics, and data-sharing frameworks.

3. Capacity building: Train AI-skilled professionals by embedding data science and AI curricula in SSA universities.
4. Ethical and legal safeguards: Establishing robust frameworks for data privacy, algorithmic fairness, and community trust.

If implemented at scale, AI-enabled planetary health intelligence could enable SSA to detect and respond to pandemics earlier, protect ecosystems, and avert the devastating human and economic losses associated with climate-sensitive health crises.

Declarations

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Author Contribution

W.F and E.O wrote the main part of the manuscript text and prepared table 1.All authors reviewed the manuscript.

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