The Blue-Green Continuum Framework: An Integrated Environmental Governance Model for One Health and Sustainable Development

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ABSTRACT

Environmental and health governance frequently treats land, water, biodiversity, human health and animal health as separate policy domains. This conceptual study develops the Blue-Green Continuum Framework as an integrated One Health governance model. Through an integrative review and framework synthesis, it identifies four system layers, six operating pillars and a six-stage governance cycle. The model links ecological conditions, institutional decisions and health outcomes, offering a practical architecture for coordinated risk assessment, investment, implementation and accountability across vulnerable landscapes in diverse institutional contexts.

KEYWORDS

Blue-Green Continuum Framework, One Health, environmental governance, water security, biodiversity, sustainable development

I. INTRODUCTION

Human, animal and ecosystem health are produced within the same social-ecological systems, yet public institutions commonly govern them through separate mandates, budgets, evidence systems and performance measures. A contaminated catchment may simultaneously affect drinking water, fisheries, livestock, food safety, household income and disease exposure, but each signal is usually processed through a different agency. Fragmented responses can therefore be technically competent within individual sectors while remaining collectively inadequate at the scale of the problem.

One Health has emerged as an influential approach for recognising the interdependence of people, animals, plants and ecosystems. The One Health High-Level Expert Panel defines it as an integrated and unifying approach that aims to sustainably balance and optimise the health of people, animals and ecosystems. The Quadripartite Joint Plan of Action similarly calls for coordinated action across health systems, food systems, ecosystems and environmental drivers. Despite this progress, implementation often remains centred on inter-agency collaboration, outbreak preparedness and surveillance, without a sufficiently explicit governance architecture for connected land-water systems.

This limitation is especially consequential in regions where livelihoods, infrastructure and exposure pathways are tightly coupled to rivers, wetlands, forests, farms and coastal ecosystems. In the Niger Delta, for example, hydrocarbon pollution, flooding, erosion, waste, declining fisheries, urban expansion and weak service delivery can interact in a single community. Treating these pressures as separate environmental, health, agricultural or infrastructure problems obscures cumulative impacts and weakens accountability. Comparable patterns occur in rapidly urbanising deltas, coastal zones, dry land livestock corridors and food-producing catchments across Africa and other low- and middle-income regions.

The central research problem addressed in this article is therefore not whether health sectors should collaborate, but how institutions can govern ecological and social interdependence in a durable, measurable and operational manner. Existing One Health frameworks acknowledge the environment, but many do not specify how blue systems such as rivers, wetlands, aquifers and coasts should be governed together with green systems such as forests, farms, biodiversity, wildlife habitats and restored landscapes. Nor do they consistently explain how law, finance, data, participation, safeguards and adaptive management should convert ecological evidence into shared decisions.

This paper develops the Blue-Green Continuum Framework as an original environmental governance model for One Health and sustainable development. The framework was first conceived as a means of integrating water-based and land-based development systems. In this study, it is reformulated into four interacting layers: blue systems, green systems, a governance core and One Health outcomes. Six operating pillars and a six-stage governance cycle are then derived to support implementation. The framework does not seek to replace sectorial expertise or established One Health instruments. Its contribution is to provide a practical architecture that links ecological connectivity, institutional responsibility, public investment and measurable outcomes.

The study has four objectives: first, to identify the governance gap created by fragmented treatment of land, water and health systems; second, to synthesise relevant One Health, environmental governance and sustainability concepts; third, to construct and explain the Blue-Green Continuum One Health Governance Model; and fourth, to assess its policy relevance for vulnerable landscapes, with particular attention to Rivers State and the Niger Delta. The paper concludes with implementation principles, indicators and limitations intended to support further empirical testing.

II. LITERATURE REVIEW / THEORETICAL FRAMEWORK

A. From One Medicine to One Health

The intellectual foundations of One Health extend from the recognition that human and veterinary medicine share biological, epidemiological and social determinants. Contemporary One Health scholarship has broadened this insight to include wildlife, ecosystems, food systems and environmental change. Zinsstag et al. (2011) argued for systemic approaches that move beyond parallel human and animal health interventions, while Destoumieux-Garzón et al. (2018) emphasised the need to understand health within

complex ecological and socio-economic systems.

Recent global guidance has strengthened the environmental dimension. OHHLEP (2022) explicitly includes ecosystems in the definition of One Health, and the Quadripartite Joint Plan of Action identifies environmental degradation, climate change, food systems and antimicrobial resistance as interconnected domains (FAO et al., 2022). UNEP and the International Livestock Research Institute (2020) further link zoonotic emergence to land-use change, biodiversity loss, agricultural intensification and wildlife exploitation. These developments make clear that One Health is not solely an emergency coordination mechanism; it is also a development and environmental governance agenda.

B. Environmental Governance and Social-Ecological Systems

Environmental governance concerns the institutions, laws, norms, knowledge systems and power relations through which societies manage environmental resources and risks. It is inherently multi-level because watersheds, habitats, markets and pollution pathways rarely align with administrative boundaries. Social-ecological systems scholarship similarly treats ecological and human systems as coupled, adaptive and characterised by feedback, uncertainty and threshold effects. Governance arrangements must therefore be capable of learning, coordinating across scales and adjusting when ecological or social conditions change.

Adaptive governance is particularly relevant because the effects of climate change, pollution, and biodiversity decline and land conversion are dynamic and unevenly distributed. Fixed sector plans may become obsolete when hazards interact. Flooding, for example, can mobilise contaminants, disrupt clinics, destroy livestock feed, alter vector ecology and intensify food insecurity. The Intergovernmental Panel on Climate Change (2022) identifies such compound and cascading risks as central to contemporary vulnerability. Integrated governance must therefore combine anticipatory capacity, cross-sector analysis, coordinated delivery and continuous learning.

C. Blue and Green Systems as Health Infrastructure

Blue systems include rivers, lakes, wetlands, groundwater, fisheries, estuaries, coasts and marine ecosystems. They provide water, food, transport, livelihoods, climate regulation and cultural value, but can also transmit pathogens, nutrients, chemicals and antimicrobial residues when degraded. Green systems include forests, farms, rangelands, wildlife habitats, soils, biodiversity, urban vegetation and restored landscapes. These systems regulate water flows, heat, erosion, pollination, animal movement, food production and carbon storage.

The distinction between blue and green is analytically useful but ecologically porous. Agricultural inputs enter waterways; forest removal alters runoff and flood peaks; urban drainage affects wetlands; coastal development changes fisheries and storm exposure; energy infrastructure influences habitats and livelihoods. The United Nations 2030 Agenda recognises these interdependencies across the Sustainable Development Goals, but implementation is often divided across sector institutions (United Nations, 2015). The

Kunming-Montreal Global Biodiversity Framework likewise calls for integrated spatial planning and restoration, while wetland guidance has long stressed the links among ecosystem condition, water security and human well-being.

D. Research Gap and Novelty

Three gaps emerge from the literature. First, the environmental component of One Health is frequently represented as an additional stakeholder or theme rather than as the physical operating system through which risks are generated, transported, buffered or amplified. Second, many frameworks emphasise coordination but give limited attention to legal authority, finance, procurement, safeguards and accountability. Third, practical implementation tools are often organised by sector rather than by landscape, catchment, food corridor or shared outcome.

The Blue-Green Continuum Framework addresses these gaps by combining ecological architecture with an institutional operating model. Its novelty lies in four features: it joins land and water systems within one governance space; it places a governance core between ecological conditions and health outcomes; it defines six substantive pillars for integrated action; and it specifies a repeatable governance cycle that connects monitoring, risk assessment, policy, implementation, accountability and adaptation. This makes the framework adaptable to development planning, environmental management, public health, veterinary systems, climate resilience and natural-resource governance.

III. STUDIES AND METHODS

A. Research Design

This study adopts a conceptual, integrative review and framework-synthesis design. It is not a systematic review or meta-analysis and does not claim exhaustive coverage of the One Health literature. The purpose is theory building: to bring together established concepts from One Health, environmental governance, social-ecological systems, climate resilience, biodiversity policy and sustainable development, and to organise them into an operational governance architecture.

The source base comprised major international policy instruments and selected peer-reviewed literature addressing One Health definitions and implementation, zoonotic and environmental drivers, coupled systems, climate risk, biodiversity, wetlands and sustainable development. The analysis also drew on the author’s original Blue-Green Continuum concept and practical knowledge of environmental safeguards, natural-resource administration and riverine development contexts.

B. Analytical Procedure

The framework was developed through four analytical stages. First, recurring governance failures were identified, including sectorial diagnosis, delayed prevention, fragmented data, unclear authority, unaligned budgets and activity-based accountability. Second, the

literature was coded conceptually around ecological domains, institutional functions, risk pathways and outcome categories. Third, these elements were synthesised into a layered model and tested for internal coherence using source-pathway-receptor logic. Fourth, the model was translated into operating pillars, a governance cycle and implementation indicators.

Conceptual validity was assessed through five criteria: comprehensiveness, meaning that the model includes the principal ecological and institutional dimensions; parsimony, meaning that it remains understandable to decision-makers; causal plausibility, meaning that the proposed links between ecological conditions, governance and outcomes are defensible; operational relevance, meaning that the model can guide decisions and investment; and adaptability, meaning that it can be applied at local, state, national or regional scales.

C. Scope and Ethical Considerations

The study focuses on governance design rather than clinical, epidemiological or ecological measurement. It uses no human participants, personal data or animal experimentation and therefore required no research ethics approval. Illustrative scenarios are generic and are included to clarify institutional mechanisms. Application to a particular jurisdiction should be supported by local data, legal review, stakeholder participation and environmental and social safeguards.

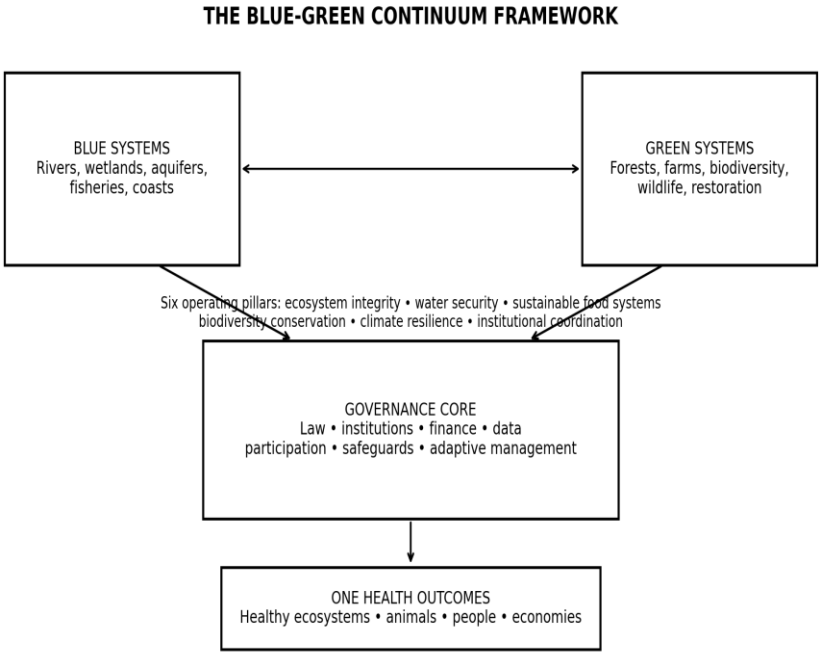

Figure 1. The Blue-Green Continuum One Health Governance Model

IV. FINDINGS AND RESULTS

A. Fragmentation Produces Predictable Governance Failures

The synthesis indicates that fragmentation generates three recurrent failures. Diagnostic failure occurs when institutions hold separate pieces of evidence and no mechanism combines them into a shared risk picture. Timing failure occurs when action begins only after impacts appear in hospitals, farms, fisheries or markets, even though environmental signals were available earlier. Accountability failure occurs when agencies report activities within their mandates but no institution owns the shared outcome.

These failures are reinforced by separate budgets, incompatible data systems, short project cycles and legal mandates that treat cross-sector effects as externalities. The result is a response-heavy system that pays for treatment, compensation and emergency repair while underinvesting in source control, ecosystem protection and prevention.

Table 1. Fragmented governance problems and corresponding Blue-Green responses

Fragmented practice	**System consequence**	**Blue-Green response**	**Expected benefit**
Separate sector surveillance	Signals recognised late	Interoperable environmental, human and animal-health intelligence	Earlier detection and joint risk assessment
Project-by-project appraisal	Cumulative impacts overlooked	Landscape and catchment appraisal	Better management of source-pathway-receptor relationships
Sector-only budgeting	Prevention benefits remain unfunded	Aligned budgets and multi-benefit appraisal	Greater fiscal efficiency and prevention
Joint committees without authority	Meetings do not change delivery	Mandated governance core with decision rights	Clear accountability and coordinated implementation
Activity reporting	Outputs substitute for outcomes	Shared outcome indicators and public reporting	Learning, transparency and adaptive management

B. The Framework Requires Four Interacting Layers

The first layer comprises blue systems: rivers, lakes, wetlands, aquifers, fisheries, estuaries, coasts and marine ecosystems. The second comprises green systems: forests, farms, soils, rangelands, wildlife habitats, biodiversity, settlements, renewable-energy landscapes and ecological restoration. These layers represent the connected natural and productive systems within which exposure, livelihoods and ecosystem services are generated.

The third layer is the governance core. It includes law, institutional mandates, finance, data, participation, environmental and social safeguards, enforcement, dispute resolution and adaptive management. Its functions are to assemble evidence, manage trade-offs, coordinate authority, mobilise resources and enforce accountability. The fourth layer is the outcome set: healthy ecosystems, healthy animals, healthy people and healthy economies.

The layers operate as a feedback system rather than a hierarchy. Governance changes pressures on land and water systems; ecological conditions alter exposure and production; health and livelihood outcomes influence public priorities; and monitoring feeds new evidence back into decisions. The model therefore treats ecological integrity and economic development as mutually conditioning rather than automatically opposing objectives.

C. Six Operating Pillars Translate the Model into Action

1. Ecosystem integrity

Critical ecosystems should be managed as preventive health infrastructure. Wetlands, mangroves, forests, soils and riparian zones regulate floods, water quality, heat, fisheries and food production. Governance instruments include critical natural-asset registers, cumulative-impact assessment, ecological thresholds, restoration obligations and performance guarantees.

2. Water security

Water governance should connect source protection, abstraction, distribution, sanitation, wastewater, storm water, agricultural runoff, industrial discharge, groundwater recharge and environmental flows. A One Health approach monitors microbial, chemical and ecological indicators alongside human and animal-health signals.

3. Sustainable food systems

Food governance should extend from ecosystems and inputs to production, animal health, processing, markets, consumption and waste. Priority controls include biosecurity, antimicrobial stewardship, safe water, veterinary oversight, cold chains, risk-based inspection and safe nutrient recovery.

4. Biodiversity conservation

Biodiversity governance should address risky disruption at wildlife-livestock-human interfaces while protecting legitimate livelihoods. Habitat connectivity, wildlife-health surveillance, community stewardship, tenure recognition and benefit sharing are central to durable prevention.

5. Climate resilience

Adaptation should assess compound impacts across water, ecosystems, health services, livestock, food, settlements and infrastructure. Effective portfolios combine nature-based measures with engineered protection, early warning, resilient facilities and inclusive disaster planning.

6. Institutional coordination

Coordination must be designed through legal or executive mandates, a convening authority, and permanent technical capacity, shared data rules, aligned financing and clear accountability. Joint responsibility should always include a named accountable owner and co-owners.

Table 2. Operating pillars, instruments and illustrative indicators

Pillar	Priority governance question	Illustrative instruments	Illustrative indicators
Ecosystem integrity	Which ecological functions protect health and livelihoods?	Asset registers; thresholds; restoration bonds	Habitat condition; ecological flow; restoration survival
Water security	How are uses and risks connected across the full water cycle?	Catchment boards; water safety plans; discharge controls	Microbial/chemical quality; service reliability; flood exposure
Food systems	Where do environmental and animal risks enter the food chain?	Biosecurity; stewardship; market standards	Disease reporting; residue compliance; food-safety failures
Biodiversity	Where are risky wildlife-livestock-human interfaces?	Interface mapping; community surveillance; connectivity plans	Unusual mortality; habitat fragmentation; response time
Climate resilience	Which compound hazards can disrupt the whole system?	Vulnerability assessment; early warning; resilient facilities	Service disruption; loss and damage; preparedness coverage
Institutional coordination	Who has authority, resources and accountability?	Mandate; secretariat; joint budget; public dashboard	Joint budget execution; grievance resolution; data timeliness

D. A Six-Stage Governance Cycle Connects Evidence to Results

1. Integrated monitoring

Environmental condition, climate information, human-health trends, animal-health signals, production data and community observations are assembled around priority landscapes and decision-relevant indicators.

2. Integrated risk assessment

Hazards, exposure, vulnerability, uncertainty and distributional effects are analysed across people, animals and ecosystems using source-pathway-receptor and cumulative-impact approaches.

3. Policy integration and prioritisation

Evidence is translated into standards, spatial priorities, investment choices and explicit trade-offs. Responsibilities and safeguards are assigned before implementation.

4. Coordinated implementation

Agencies deliver complementary interventions through aligned work plans, enforcement, procurement, community partnership and financing organised around outcomes rather than isolated projects.

5. Outcome monitoring and accountability

Performance is assessed through reductions in exposure, ecological degradation, animal loss, disease and inequity, supported by financial reporting, public dashboards and grievance feedback.

6. Adaptive governance

Policies and programmes are revised through after-action review, periodic reassessment and open learning as evidence, climate, technology, behaviour and institutional capacity change.

The cycle closes the gap between collecting information and changing decisions. It also prevents integrated governance from becoming a one-time plan: each implementation phase generates evidence that should reshape subsequent priorities.

E. The Framework Is Applicable to Vulnerable Resource Landscapes

In Rivers State and the Niger Delta, the framework can organise response to interacting pressures in riverine and oil-producing communities. An integrated pollution response would combine source control, independent environmental assessment, safe water, exposure monitoring, health services, fisheries and animal assessment, livelihood restoration, grievance procedures and long-term ecological surveillance. Success would be measured by reduced exposure and recovered ecosystem function rather than by the completion of remediation contracts alone.

For flood-prone settlements, the model would connect land-use planning, wetland protection, drainage, waste management, water-point protection, clinic continuity, livestock evacuation, post-flood sampling and community communication. For food corridors, it would join farm biosecurity, veterinary services, market sanitation, drainage, cold storage, waste management and receiving-water protection. These applications illustrate why landscapes and catchments are often more appropriate delivery units than ministries.

Implementation should begin with a limited number of priority landscapes and measurable outcomes. During an initial 100-day phase, government can map risks, mandates, data and finance; designate an accountable leader; establish a technical secretariat; select common indicators; and deliver visible preventive actions. Subsequent phases can align budgets, strengthen law, improve surveillance interoperability and scale integrated programmes.

V. DISCUSSION

A. Contribution to One Health Governance

The Blue-Green Continuum Framework contributes to One Health by making the environmental domain structurally explicit. Rather than placing environment alongside human and animal health as a fourth sector, it identifies connected land and water systems as the operating context within which health risks and protective functions arise. This distinction matters because environmental agencies alone cannot govern all of the decisions that affect ecosystems. Agriculture, energy, urban planning, infrastructure, finance and local government all shape blue and green conditions.

The framework also moves beyond coordination as an end in itself. Multispectral meetings may improve relationships, but durable governance requires authority, decision rules, finance, procurement, safeguards and performance systems. The governance core specifies these institutional functions and thereby helps explain why technically sound One Health initiatives may fail when they are not embedded in routine public administration.

B. Policy and Economic Significance

An important implication is that ecosystem protection should be treated as preventive health and economic infrastructure. Wetlands can reduce flood peaks, forests can stabilise catchments, safe food markets can reduce disease transmission, and pollution prevention can protect fisheries and household income. Investments should therefore be appraised through multiple benefits, including avoided treatment costs, avoided animal losses, resilience, ecosystem services and distributional effects.

This approach may improve fiscal efficiency because it reveals where several ministries are financing different consequences of the same underlying risk. Budget tagging and joint appraisal can identify duplication, gaps and opportunities for co-financing. However, integrated finance must not weaken accountability. Each shared outcome should have a clearly accountable owner, transparent expenditure tracking and public reporting.

C. Equity, Participation and Safeguards

Integrated governance can generate new risks if it centralises authority, hides trade-offs or privileges powerful actors. Environmental and social safeguards, gender analysis, livelihood restoration, indigenous and local knowledge, accessible grievance mechanisms and distributional monitoring are therefore integral rather than optional. Communities should participate in defining problems, validating evidence, designing interventions and evaluating results.

Participation also strengthens early warning. Fishers, farmers, pastoralists, market workers and community health volunteers often observe ecological or animal-health changes before formal systems. Their knowledge should be linked to clear reporting and feedback pathways while protecting privacy, preventing stigmatisation and recognising ownership.

D. Limitations and Research Agenda

This article is conceptual and does not provide empirical validation of the framework. The proposed causal relationships, pillars and indicators require testing through case studies, comparative institutional analysis and implementation research. The framework is also deliberately broad; adaptation will be necessary to reflect legal systems, ecological conditions, cultural institutions and administrative capacity.

Future research should assess whether Blue-Green governance improves response time, reduces duplication, shifts expenditure toward prevention and produces measurable ecological and health benefits. Pilot applications could compare baseline and follow-up indicators in selected catchments or food corridors. Further work should also examine power, political economy, financing incentives and the conditions under which integrated institutions remain effective during political transitions.

VI. CONCLUSION

Sustainable development and One Health cannot be fully achieved when environmental governance treats land, water, biodiversity, human health and animal health as separate policy worlds. The systems are already connected in reality; the institutional challenge is to govern them at the scale at which risks, resources and livelihoods interact.

The Blue-Green Continuum Framework provides an original and practical architecture for that task. It links blue and green systems through a governance core and directs public action toward healthy ecosystems, healthy animals, healthy people and healthy economies. Six operating pillars define the substantive areas of action, while a six-stage governance cycle connects evidence, risk assessment, policy, implementation, accountability and learning.

The framework does not propose the dissolution of specialised institutions. It proposes that specialisation should operate through shared outcomes, connected data, aligned finance, safeguards and clear decision rights. Its immediate value lies in helping governments and partners move from fragmented activities to integrated prevention and landscape-based delivery. Its longer-term value will depend on empirical testing, transparent adaptation and measurable reductions in ecological degradation, harmful exposure, animal loss, human illness and inequality.

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2. Declarations

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Ethical approval: Not applicable. The study used no human participants, personal data or animal experimentation.

Data availability: No new empirical dataset was generated. The conceptual synthesis is based on the sources cited in the manuscript.

Author contribution: The author conceptualised the framework, conducted the synthesis, developed the model and wrote the manuscript.

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