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Editorial

Panama as a Natural Laboratory of Climate Resilience, Environmental Health, and Territorial Sustainability: Reflections from the 2025 Special Cluster

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ABSTRACT

Panama is at a critical moment. Increasing pressure on its water sources, declining food quality, accelerated soil degradation, and the vulnerability of its coastlines intersect with the growing effects of climate change and long-standing territorial inequalities that persist today. This Special Cluster of the BioNatura Journal brings together studies conducted across different regions of the country, which have been expanded and strengthened through external peer review under the supervision of the BioNatura Institutional Publishing Consortium (BIPC). The investigations explore microbiological risks in water and food, agricultural microbiota in tropical soils, marine conservation, climate-driven displacement of Indigenous communities, educational ergonomics, urban mobility, and flooding. This editorial situates these contributions within global frameworks such as One Health, climate resilience, emerging contaminants, and water–food security, highlighting the University of Panama's role as a driver of applied science and a bridge between knowledge, society, and public policy.

Keywords: Panama; One Health; climate resilience; environmental health; emerging contaminants; drinking water; food safety; soil microbiota; coastal vulnerability; sustainable urbanism; Panama Canal; BioNatura Journal.

EDITORIAL

Panama occupies a unique position in the region. It is a natural bridge between oceans and cultures, a global transit hub, and at the same time, a country deeply shaped by the diversity of its landscapes: vulnerable coastlines, watersheds that sustain entire cities, rural regions with unevenly distributed resources, and Indigenous communities preserving ancestral identities. This richness also makes it a territory where the effects of climate change, demographic pressure, and infrastructure gaps are felt with particular intensity.

Science has increasingly documented this reality. The IPCC[1] and recent regional studies[2] show that Central America is experiencing sea-level rise, more frequent flooding, and hazardous compound climate events—the concurrence of extreme rainfall, high tides, or heatwaves—widely described in global assessments[3]. For those living in coastal neighborhoods, low-lying zones, or riverbanks, these events are not abstract projections: they are real disruptions, economic losses, health risks, and in some cases, unavoidable displacement.

Added to this scenario are silent threats such as microplastics[4], PFAS[5], and pharmaceutical residues[6]—emerging contaminants whose accumulation in water, soil, and organisms is now evident in many tropical countries. Although this issue focuses on microbiological risks, the expanding global evidence of their impacts on human and environmental Health cannot be ignored.

Within this complex context, the studies included in this Special Cluster become particularly relevant. Each contributes a piece to a broader puzzle: how to secure safe water, how to produce food without degrading ecosystems, how to protect coasts and communities, how to design more livable cities, and how to sustain public Health in an era of climatic uncertainty.

The science presented here aligns with global frameworks such as One Health, water and food security, and climate resilience[7],[8],[9]. These approaches emphasize that human Health, animal health, and ecosystems cannot be addressed separately. In Panama—where the well-being of rural communities depends on water, soil, and climate as much as on healthcare services—this perspective is particularly pertinent.

Figure 1. Conceptual representation of the One Health framework illustrating the interconnectedness of human, animal, and environmental Health. Key determinants—such as food security, disease vectors, intensive livestock farming, biodiversity loss, air and water pollution, climate change, and population dynamics—highlight the systemic nature of health risks relevant to Panama's climate resilience and environmental sustainability.

Editorial Rigor and a Sense of Purpose

The manuscripts in this collection are not conference proceedings. Each study was independently expanded, verified, and peer-reviewed. The process, led by the BIPC and Clinical Biotec S.L., ensures institutional diversity and the total absence of endogamy (or self-referentiality). This allows knowledge generated in rural regions, urban areas, or Indigenous territories to engage with global scientific debates without losing authenticity.

Water, Food, and Environmental Health

Studies on Cryptosporidium spp., helminths, coliforms, and nematodes in drinking water systems confirm patterns observed in tropical countries[10],[11],[12],[13]. When water is viewed through daily experience—the faucet

of a rural household, a community storage tank, or a treatment plant—its quality ceases to be a technical abstraction and becomes a condition for life.

The microbial contamination detected in foods from fairs and community events mirrors findings in informal markets throughout Latin America[14], underscoring that public health and food culture must move forward together, not in tension.

Soils, Agriculture, and Microbiota

Contributions on soil microbiota and PGPMs provide a hopeful trajectory for maintaining agricultural productivity in an era of global fertilizer crisis[15] and the imperative to shift toward more regenerative systems[16],[17],[18].

Panama's agriculture—like that of many tropical countries—is characterized by degraded soils, excessive climatic variability, and reliance on imported inputs. National scientific research on microbiota-related solutions is a step toward technological freedom and sustained competitive advantage.

Marine Biodiversity, Climate Refugees, and Environmental Justice

The Olive Ridley Sea Turtle (*Lepidochelys olivacea*)[19] conservation is an example of how marine biodiversity is not just an ecological value but also a cultural one.

The case of Gardi Sugdub[20] reveals a painful phenomenon: climate displacement. For Indigenous families leaving their islands, sea-level rise is not a statistical datum but the loss of home and identity. Such studies call for adaptation policies that are sensitive, just, and evidence-based.

Urbanism, Flooding, and Well-being

Research on mobility, rest, and academic performance[21] shows that Health is not confined to hospitals: it is shaped by daily commutes, learning environments, and life rhythms.

Analyses of critical infrastructure and flooding[23],[24] demonstrate that Panamanian cities must anticipate rising risks and design solutions integrating engineering, architecture, nature, and community.

In a country that hosts the Panama Canal, any water or climate crisis has global repercussions. Territorial resilience is therefore a strategic and geopolitical issue.

The University of Panama and Science for the Country

This Special Cluster shows the University of Panama as an articulating actor—a space where microbiology, architecture, public Health, biotechnology, geosciences, and community knowledge converge.

It also underscores the need to strengthen scientific governance, open data, integrated surveillance, and long-term funding, in line with UN–FAO–UNEP frameworks.

Science, when connected to real population needs, becomes a tool for transformation.

CONCLUSIONS

Panama faces challenges that intertwine climate, Health, territorial development, and sustainability. The studies gathered in this Special Cluster show that applied science—when carried out with rigor, local commitment, and global vision—can provide concrete answers and open pathways toward a more resilient future.

The issue reaffirms the importance of the One Health approach and highlights emerging topics such as persistent contaminants and compound climate events. It also reminds us that territorial inequality, coastal vulnerability, and urban pressure are shared challenges across Latin America that demand sustained scientific cooperation.

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