







## Environmental and climate change and health services: paths to mitigation

*Mudanças ambientais, climáticas e os serviços de saúde: caminhos para mitigação*

*Cambios ambientales, climáticos y servicios de salud: caminos para la reducción*

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### ABSTRACT

**Objective:** to evaluate the scenarios of environmental change and climate crises and their influence on public health services. **Content:** Environmental changes and planetary climate crises are emerging from the contemporary scenario, producing multiform impacts that transcend geopolitical borders. As a result, there are significant gaps in public health systems, in relation to the health surveillance system, considering the attention of the Health Care Network (HCN) in caring for the affected population. This highlights the need for multidisciplinary and collaborative approaches to develop these participatory strategies. **Final considerations:** climate change, such as the increase in heat waves and the intensification of extreme events, impacts public health by increasing the incidence of respiratory and vector-borne diseases, as well as overloading health services in vulnerable regions. Adaptive measures are essential to mitigate these effects and strengthen the resilience of health infrastructures.

**Descriptors:** Climate Change; Environment and Public Health; Health Governance; Health Services; Health Vulnerability.

### RESUMO

**Objetivo:** avaliar os cenários das alterações ambientais e das crises climáticas e suas influências sobre os serviços de saúde pública. **Conteúdo:** As alterações ambientais e as crises climáticas planetárias emergem do cenário contemporâneo, produzindo impactos multiformes que transcendem fronteiras geopolíticas. Consequentemente, observam-se lacunas significativas nos sistemas de saúde pública, no que se refere ao sistema de vigilância em saúde, considerando a atenção da Rede de Atenção à Saúde (RAS) no atendimento à população afetada. Ressalta-se, aqui, a necessidade de enfoques multidisciplinares e colaborativos, para desenvolver estas estratégias participativas. **Considerações finais:** as mudanças climáticas, como o aumento das ondas de calor e a intensificação de eventos extremos, impactam a saúde pública ao elevar a incidência de doenças respiratórias e transmitidas por vetores, além de sobrecarregar os serviços de saúde em regiões vulneráveis. Medidas adaptativas são essenciais para mitigar esses efeitos e fortalecer a resiliência das infraestruturas de saúde.

**Descritores:** Mudança Climática; Meio Ambiente e Saúde Pública; Governança em Saúde; Serviços de Saúde; Vulnerabilidade em Saúde.

### RESUMEN

**Objetivo:** evaluar los escenarios de cambios ambientales y crisis climáticas y la influencia que tienen en los servicios de salud pública. **Contenido:** los cambios ambientales y las crisis climáticas en el planeta derivan del escenario contemporáneo, y producen impactos multiformes que trascienden las fronteras geopolíticas. Como resultado, se observan lagunas importantes en los sistemas públicos de salud, en lo que respecta al sistema de vigilancia de la salud, considerando la Red de Atención a la Salud (RAS) en la atención a la población afectada. Cabe destacar que es necesario adoptar enfoques multidisciplinarios y colaborativos para desarrollar estrategias participativas. **Consideraciones finales:** el cambio climático, como el aumento de las olas de calor y la intensificación de eventos extremos, afectan la salud pública al aumentar la incidencia de enfermedades respiratorias y transmitidas por vectores, además de sobrecargar los servicios de salud en regiones vulnerables. Las medidas adaptativas son fundamentales para reducir dichos efectos y fortalecer la resiliencia de las infraestructuras sanitarias.

**Descriptores:** Cambio Climático; Medio Ambiente y Salud Pública; Gobernanza; Servicios de Salud; Vulnerabilidad en Salud.

## INTRODUCTION

Environmental changes and planetary climate crises are emerging on the contemporary scene, producing global impacts<sup>1</sup> and multifaceted challenges that transcend geopolitical boundaries<sup>2,3</sup>. Anthropogenic actions, such as deforestation, greenhouse gas emissions and fires, contribute to triggering a series of effects on various aspects of human life and the integrity of ecosystems. These are the main factors linked to extreme climate change<sup>2</sup>.

In this respect, Brazil plays an important role on a global scale, as the Amazon rainforest, the largest part of which is concentrated within the country's borders, is considered to be a major regulator of the planet's climate<sup>4</sup>. However,

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there are challenges to the sustainable management of its natural resources and the mitigation of environmental risks in its space<sup>5,6</sup>, which involve social vulnerabilities<sup>6</sup> and inequities, particularly relevant in the debate on public health policies<sup>3,5</sup>.

This confluence represents a significant additional burden on public health services, as the increasing frequency and intensity of extreme weather events, together with the geographical dispersion of emerging pathogens<sup>7-9</sup>, challenge the operational capacity and effectiveness of health systems. These challenges manifest themselves in various dimensions, including a shortage of resources, inefficient response times to health incidents, worsening health inequalities, regional complexities and deficits in health infrastructure and structure<sup>9</sup>.

International and national policies discuss and assess the possible repercussions and impacts of the relationship between humans and the environment, using parameters such as those of the Intergovernmental Panel on Climate Change (IPPC), which include contextual dynamics, temperature projections, impact and risk assessments, adaptation strategies and monitoring of concentrations and emissions of atmospheric gases<sup>2,3</sup>. In addition to forecasting scenarios, they show the direction in which this unbalanced relationship is taking as the problems progress, as well as its repercussions on the environment and human health.

Despite this, there are important gaps in public health systems, in terms of disease control, water quality, food production and measuring air pollution, considering the special attention of the Health Care Network (HCN) in caring for the affected population<sup>3,5,6</sup>. Furthermore, it is possible to observe a distancing between health professionals and environmental health actions, especially when pointing out actions and strategies developed in Primary Health Care (PHC), which should lead strategic actions, given its prevention model.

Tactics aimed at eliminating or controlling the consequences of anthropogenic actions, such as the development of protocols and technologies, require integration and harmonization between health policies and climate change mitigation and adaptation strategies, which must necessarily be researched and discussed together with the society directly affected<sup>5,10</sup>. This highlights the need for multidisciplinary and collaborative approaches to develop participatory strategies.

In this sense, the question arises: which climate changes are likely to have an impact on public health services? What are the demands on health services and how can decision-making be directed in the light of territorial peculiarities? Based on these questions, the aim of this study is to evaluate the scenarios of environmental changes and climate crises and their influence on public health services.

## CONTENT

This is a study of current theoretical issues, in order to discuss the relevance of the topic using an analysis of the guiding documents on environmental change and climate change.

To this end, in order to address the impacts of global changes on the Health Care Network and the potential organizational directions that can effectively mitigate such problems, this text presents three topics: global environmental changes and emerging and re-emerging diseases, demands on health services and the peculiarities of territories.

### Global environmental change and emerging and re-emerging diseases

Different regions and human groups have been affected in different ways by climate change, which mainly impacts the capacity of health systems to respond to the challenges imposed on them, based on the infrastructure and resources that are usually available, but the actions taken by the teams are far removed from their routines, incipient and without a clear objective for everyone.

These changes threaten essential elements for maintaining health, such as clean air, drinking water, food supply and safe housing, increasing mortality, attributed to environmental factors, air pollution, inadequate water and sanitation, rising heat waves and exposure to harmful chemicals<sup>11</sup>.

It can be seen that environmental changes and climate crises lead to an increase in morbidity<sup>1,2</sup> and directly affect human health, whether through the contamination of drinking water or the destruction of ecosystems that sustain life and balance environments<sup>5,12</sup>. On the other hand, climate crises, generated predominantly by global warming, which results in heat waves and changes in vector habitats, increase the spread of diseases such as malaria, leishmaniasis, Zika and dengue, among others<sup>8,11,12</sup>, due to the environmental imbalances that result from them.

Rising temperatures, changes in variation and humidity patterns<sup>13</sup> and changes in ecosystems create environments that are conducive to the proliferation of disease vectors and facilitate their transmission, increasing the incidence of

different diseases<sup>8,12,13</sup>. As pathogenic elements find new habitats, they intensify outbreak frequencies in areas that were previously at low risk for some diseases, which demonstrates the clear role of climate influences on public health<sup>11</sup>.

The pre-established conditions, identified in studies on the extent of meteorological variables and on the epidemiology of emerging and re-emerging diseases<sup>8,13</sup>, already represent significant demands and impact the way of life of human populations and the ecosystems around them<sup>14</sup>. And these do not only include zoonoses, as changes in temperature affect terrestrial and aquatic systems, reaching other dimensions such as food chains and waterborne disease cycles, such as cholera<sup>15</sup>, from adjacent linear effects.

Therefore, in addition to producing environmental vulnerabilities, planetary climate change inextricably increases social problems, which, in the long term, are amplified by economic and political crises - exemplified in intergenerational and gender inequalities and in economic discrepancies and access to material bases for survival - constituting potential mechanisms for the promotion of outbreaks and endemics<sup>12,15,16</sup>.

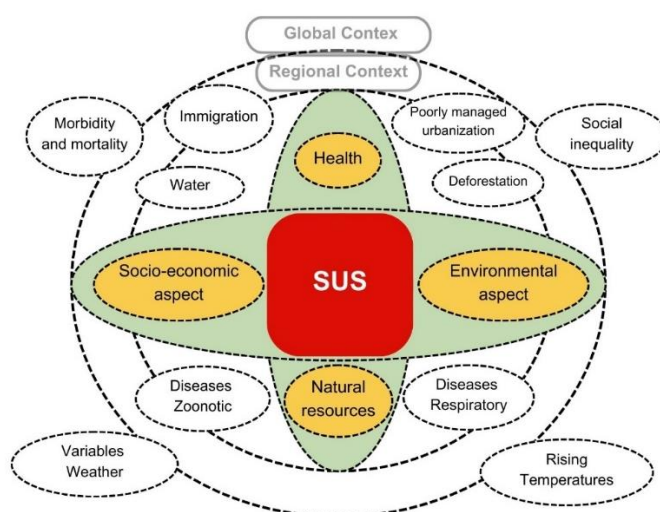
Global changes are increasing morbidity, mortality rates and health care processes in the face of resurgent epidemics, such as zoonotic diseases like Ebola, avian flu, monkeypox and bovine spongiform encephalopathy. These diseases have contributed to defining new paradigms, especially in relation to food safety policies and, more generally, public health protection<sup>17</sup>. This demonstrates the need for greater cooperation between local, regional and global networks in order to monitor these diseases<sup>18</sup>.

In addition, it is clear that recent events are associated with cases of respiratory diseases<sup>3,19</sup>, as different types of land use contribute to emissions and air pollution. This is directly related to human activities such as deforestation and greenhouse gas emissions, which contribute to the emergence of new diseases, the re-emergence of chronic respiratory diseases and increased susceptibility to respiratory tract infections resulting from heat or cold waves, which are related to morbidity data, especially in the elderly and children<sup>20,21</sup>.

While influencing ways of life, environmental changes affect the availability, quality and quantity of water needed for basic human demands, since changes in precipitation and evaporation regimes have significant implications for water supply, with direct repercussions on the health of the most vulnerable<sup>22</sup>, such as Amazonian riverside groups, who have a strong relationship with water, used for food extraction and to support work and daily activities, situations that must be perceived in a multidimensional way<sup>23</sup>.

On this path, an additional important factor is poorly managed urbanization, which can create favorable conditions for the spread of emergencies, especially in the context of globalization, a phenomenon that facilitates the dispersal of diseases across borders<sup>24,25</sup>, especially when this is associated with inadequate land use, deforestation and conflicts that are exponents for thinking about health and the environment<sup>26</sup>.

In general, this movement is identified from vulnerable populations - indigenous people, quilombolas, riverine communities, immigrants, among others - who experience deficits in access and comprehensive care from universal health services, such as the Unified Health System (*Sistema Único de Saúde, SUS*)<sup>27</sup> at macro and micro levels<sup>23</sup> (Figure 1).



**Figure 1:** Conceptual framework for vulnerabilities related to climate change. Adapted from Santos e Augusto, 2011<sup>23</sup>.

These conditions put pressure on health infrastructures, which is exacerbated in the socio-economic vulnerability scenarios mentioned here. All that remains is for HCNs to adapt to the diverse complexity and scope of zoonoses, resulting from the peculiarities of the groups and the shortcomings of the health system, in an attempt to respond effectively to the contextual demands. This is a potential challenge for health surveillance, as well as for the diligent prevention and control of zoonoses and other diseases, considering the magnitude of the global problems described here<sup>17,24</sup>.

Therefore, the pressure on health infrastructures involves issues that are not only related to increases in zoonoses<sup>3,6,8</sup> and other diseases, but also to health inefficiencies and social vulnerabilities<sup>13</sup>, aspects that have an influence on both the Brazilian and global contexts, since they impact on the health indicators of all population<sup>28,29</sup>.

Likewise, the functioning of protected areas must be addressed, in relation to the construction of multifunctional and healthy strategies<sup>30</sup>, a topic that must also cover the most affected human groups, especially the marginalized, due to their limited access to essential services, discrimination and social exclusion, to which they are disproportionately subjected in the current climate crisis, given that these contingents must be perceived, made visible and included in the development of efficient mitigation and adaptation strategies<sup>31</sup>.

### **Demands on Health Services and Territorial Peculiarities**

The health of human groups is impacted by climate change, exposing various groups, especially the most vulnerable, to increased exposure to diseases and their consequences<sup>32</sup>. Currently, this discussion is being reinforced by the loss of biodiversity and the expansion of social inequalities, urbanization and the dispersion of CO<sub>2</sub> in the atmosphere, among others. Recent reports, such as The Closing Window, point out that the way forward in the current scenario is through the transformation of society.

Science has been warning about these facts since the Stockholm meeting in 1972, RIO 92, Rio+20 and, more recently, the Amazon Dialogues and Summit, which took place in Belém do Pará, Brazil, in 2023. This discussion involves Brazil, the fourth country in the world in per capita emissions, the seventh in greenhouse gas emissions, and the sixth in historical emissions, which gives it importance on the world stage, mainly due to the Amazon and the concentrations of carbon dioxide, nitrous oxide and methane (CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>) in the country's environment, which have led to the warming of the earth's atmosphere, according to the IPCC<sup>2,3</sup> report.

In the Arctic, Siberia and Canada, it can be seen that warming has advanced exponentially, whereas in Brazil, certain regions, such as the São Francisco River Valley, the Northeast and the eastern part of the Amazon, already have different climate configurations. This data is significant for understanding the direct impacts of human actions on health demands and food production, among other issues, which raises the alarm about possible malnutrition in the Brazilian population<sup>33,34</sup>.

It is known that countries with low Human Development Indexes (HDI) are increasingly exposed to climatic events<sup>35</sup>, the effects of which fall mainly on urban regions and vulnerable groups such as children and the older adults, and in conditions of social and health inequalities, creating a way of stratifying society and the associated risks.

It ratifies the need to monitor the exposure and vulnerability of these groups to climate change<sup>35</sup>, taking into account age groups, environments, work and leisure activities. Similarly, indicators of forest fires, droughts, fatalities, infectious diseases, vulnerability to vector diseases, food security, among others, should be assessed together, considering the different cultures and the associated political conditions<sup>36</sup>.

Another important condition is extreme events, which greatly affect environments as they progress, worsening access to drinking water<sup>32</sup>, impacting basic sanitation and food diversity, aggravating food and nutrition issues and threatening poverty reduction and inequality targets.

It is known that the availability, quality and quantity of water required for basic human needs represent complex and multifaceted conditions, since extreme climatic events are making water scarcer<sup>22,32</sup>, more unpredictable and more polluted, bringing direct effects on the water cycle and threats to biodiversity and people's access to water and sanitation, a problem that demands attention<sup>22</sup>, especially with regard to waterborne diseases, by the HCN.

The consequences of humanitarian crises also have an impact on health, through heat stress, reduced air quality, changes in water quality and quantity, food insecurity and unavailability, and changes in the distribution and ecology of disease vectors, which threaten everyone<sup>36</sup>.

When disasters - or environmental crimes - occur, the risk of diseases such as cholera and typhoid fever from drinking contaminated water increases, due to inadequate post-event sanitation, which poses a further threat to the lives of children and leads to conflicts over water<sup>44</sup>. Therefore, water indicators make it possible to understand how scarce access to water resources and their quality affect these groups, providing insights for strategic actions to reduce the effects of these problems in the medium and long term.

In turn, the effects of climate variability on food production are related to access to nutritious food, the HDI and food security<sup>37,38</sup>, and some regions are already showing progressive, negative and heterogeneous impacts<sup>39</sup>, a situation that serves as a warning for the SUS HCN.

In relation to air pollution, there has been an increase in allergies and asthma, especially in urban areas, as the significant presence of pollutants in urban areas and around previously forested territories, such as indigenous lands, indicates the effects of development on the environment. It comes from the circulation of public and passenger transport vehicles, from industries, which pollute the air and raise temperatures. This phenomenon is also related to deforestation and fires.

In the Amazon's case, when looking at possible demands, the issue is permeated by the way of life of its human inhabitants, such as riverside dwellers, indigenous people and quilombolas, mainly, but not only, because water plays a significant role in their territories, including aspects such as mobility, culture and the preservation of ecosystems that support their food chains<sup>5,27,30</sup>.

In this scenario, the cultural factor is a condition indirectly associated with the impacts identified in climate crises, a fact highlighted in laws and health policies and should be made visible in health actions in order to overcome social and health inequities, not to mention environmental racism, which involves groups and regions<sup>27</sup>. Furthermore, the Brazilian health system has policies aimed at these groups, which can support specific strategic actions.

In fact, the scenario indicates that health services should stem from a multi-faceted approach that considers direct and indirect impacts, with attention to economic, social and ecological aspects, which includes implementing laws to limit emissions of polluting gases, encouraging renewable energies, urban planning aimed at promoting green spaces and building protection strategies for vulnerable groups, with special attention to serving the population directly affected, such as indigenous peoples and traditional communities. Therefore, the development of adaptation strategies is necessary and should involve targeting multidisciplinary and interdisciplinary attention points (Figure 2).

There is also a need to move forward in terms of technological innovations, such as clean energy technologies, promoting the use of vehicles that reduce toxic gas emissions, especially in public transport systems, monitoring air quality, especially in areas at risk, promoting behavioral changes through awareness campaigns about the effects of air pollution and climate change on health and the environment, and encouraging sustainable behavior and conscious consumption by populations through an integrated system, as shown in Figure 3.

ATTENTION POINTS	ELEMENTS	DESCRIPTION	INDICATORS	EXPECTED RESULTS
EXTERNAL INFLUENCES	Climate Change	Increased incidence and distribution of diseases and illnesses.	Morbidity and mortality rates and extreme weather events.	Reduction in the incidence of associated diseases and mortality.
	Social Inequalities	Unequal access to health resources and services.	Indices of access to basic services, Gini Index.	Improving access to basic services and reducing social inequality.
	Environmental Racism	Disproportionate impacts on black, indigenous and rural populations.	Disparities in health and environmental indicators by race/ethnicity.	Reducing health and environmental disparities between different racial/ethnic groups.
POWER STRUCTURE	Health Policies	Policies that determine the allocation of resources and public health priorities.	Numbers of policies implemented, health coverage.	Increased effectiveness and coverage of public health policies.
	Public Health Infrastructure	Capacity of health services to respond to emergencies and ongoing challenges.	VigiDesastres	Strengthening the public health infrastructure to better respond to disasters and emergencies.
	International Organizations	Global guidelines and assessments that inform national health policies.	IPPC and WMO	Influence of international organizations on national health policies.
GOVERNANCE	Public Health Management	Governance strategies to integrate public health, sustainability and equity.	SUS-IDSUS Performance Index, SIHSUS Hospital Information System and SUS-SIASUS Ambulatory Information System	Improved integration of public health with sustainability and equity in governance strategies.
	Public Health Environmental Policy and Legislation	Laws and regulations that promote environmental protection and public health.	Number of environmental laws passed and regulatory compliance.	Strengthening environmental laws and regulations to protect public health and the environment.
INTERNATIONAL ALLIANCE	Global Cooperation	International partnerships to share information and resources.	Number of international agreements, collaborative projects.	Expansion of international cooperation and collaborative projects to address global health and climate change issues.
	Advocacy Networks	Networks that promote awareness and action on climate change and health.	Campaigns carried out and reach of advocacy.	Greater public awareness and engagement in health and environmental issues.
COLLABORATIVE PROCESSES	Co-creation with Communities	Inclusion of indigenous and traditional communities in the strategy development.	Number of co-creation projects implemented and with community involvement.	Number of projects implemented and with community involvement.
	Health Professionals	Integration of technical knowledge and multidisciplinary practices.	Number of joint training programs and publications.	Training health professionals to face emerging challenges.
	Academics	Research and analysis to inform and improve health practices.	CVs and published studies.	Advances in research and analysis in the face of climate change.
STRATEGIC ACTIONS	Protocol Review	Continuous updating of health practices to meet new challenges.	Number of revised protocols and adherence to new protocols.	Health protocols aligned with current and future challenges.
	Human Resources Training	Education and training for health professionals to respond effectively.	Number of professionals trained and skills assessments.	Developing a trained and adaptable workforce capable of responding efficiently to emergencies.
	Socio-environmental Advocacy	Promoting policies and practices that protect health and the environment.	Number of advocacy initiatives.	Greater awareness and engagement in health and environmental issues.

Figure 2: Attention points in the face of the climate crisis for organizing demands on health services. Belém PA, Brazil, 2023



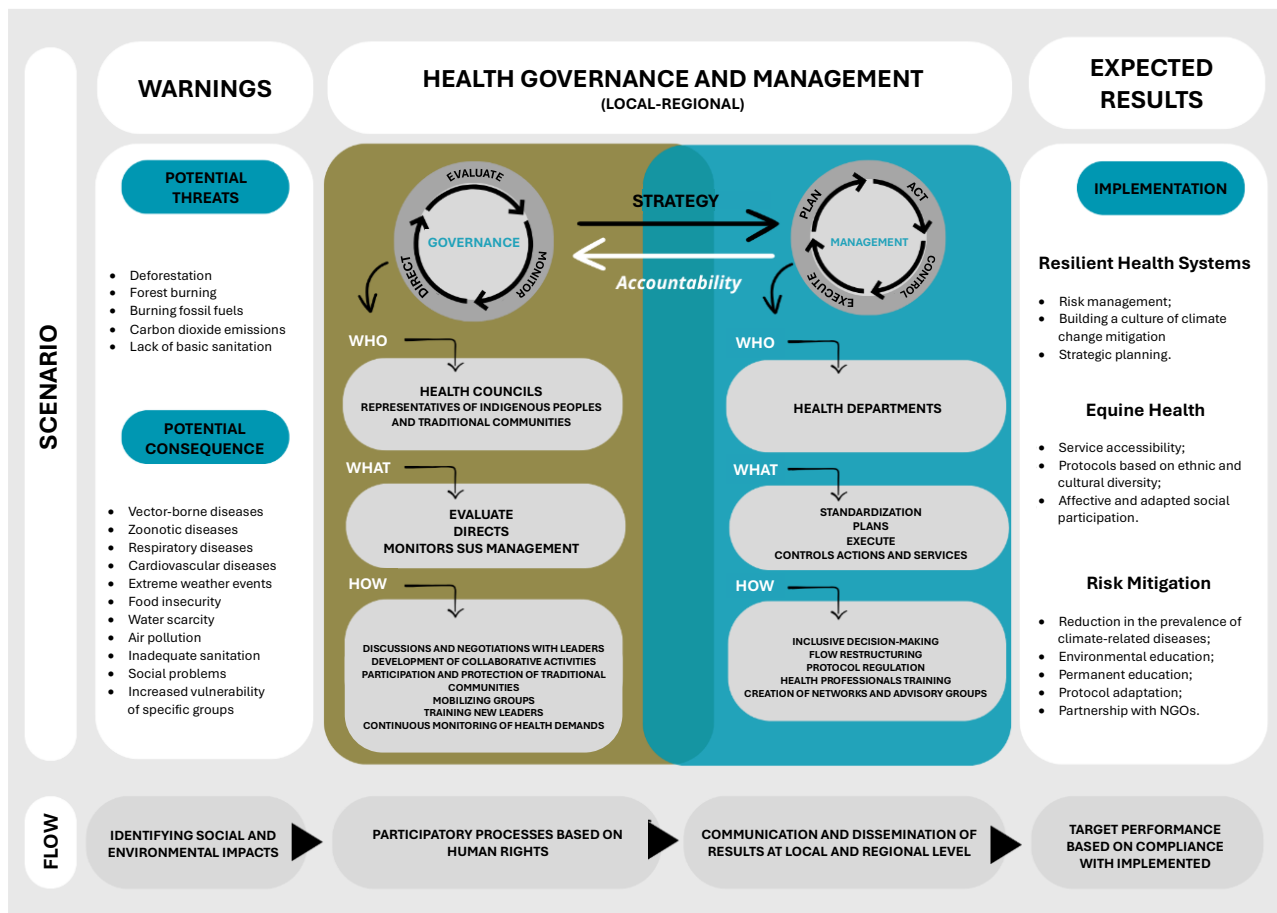


Figure 03: Organizational integration system based on the peculiarities of territories and governance. Belém, PA, Brazil, 2023.

In practice, it is necessary to identify the consequences of such impacts, including civil society in this process, with the aim of applying intersectoral actions and taking into account population growth in certain regions. This is an important relationship that must be monitored by health managers in order to reduce the impact on child malnutrition indicators, for example.

### Study limitations

The study is limited to pointing out potential demands on public health services through contemporary literature, as well as directing decision-making in the face of territorial peculiarities, and further studies are needed to bring the experiences of territories from a local perspective to implement global regulations.

### Final Considerations

This study highlights the importance of understanding situations in a comprehensive and multidimensional way, considering that the direct impact on health promotion actions within the scope of the SUS not only triggers challenges related to environmental aspects, but also accentuates social issues and encompasses disparities between different generations.

Specifically, the impacts of extreme climatic events, such as heat waves, floods and prolonged droughts, which have become increasingly frequent and intense, result in increased morbidity and mortality from heat-related illnesses, worsening respiratory diseases due to air pollution, and a higher incidence of vector-borne diseases such as dengue and malaria. These climate changes affect public health services by increasing the demand for medical and hospital care, especially in vulnerable regions such as densely populated urban areas and rural and riverside communities in the Amazon.

It is essential to implement governance and management measures that encompass economic, social and environmental dimensions, confirming the need for social participation. They should prioritize the promotion of strategies

in the health care network, taking into account the territorial peculiarities of these regions, such as difficult geographical access and fragile health infrastructures.

There is a need to pursue governance through the participation, in particular, of indigenous people and quilombolas, who have experience in environmental management in their territories. The dynamics should include a flow of identification, processes, communication and performance evaluation, in order to monitor whether the mitigation actions are effective.

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Conceptualization, N.J.C.C.; methodology, N.J.C.C. and L.B.S.; software, N.J.C.C. and L.B.S.; validation, N.J.C.C. and L.B.S.; formal analysis, N.J.C.C., D.N.S., L.B.S. and A.T.P.; investigation, N.J.C.C., D.N.S., L.B.S. and A.T.P.; resources, N.J.C.C. and A.T.P.; data curation, N.J.C.C., D.N.S. and L.B.S.; manuscript writing, N.J.C.C., D.N.S., L.B.S. and A.T.P.; writing – review and editing, N.J.C.C., D.N.S., L.B.S., M.A.T., R.M.A. and A.T.P.; visualization, N.J.C.C., D.N.S., L.B.S., M.A.T., R.M.A. and A.T.P.; supervision, N.J.C.C., D.N.S., L.B.S., M.A.T., R.M.A. and A.T.P.; project administration, N.J.C.C.; acquisition of financing, N.J.C.C. and A.T.P. All authors read and agreed with the published version of the manuscript.