**PMAC 2023 Session - Background paper**

**PS 3.6 "Multi-sectoral Policies and Practices: Adaptation”**

**Giulia Loffreda**

**Informing adaptation strategy through mapping the dynamics linking climate change, health, and other human systems: Case studies from Georgia, Lebanon, Mozambique and Costa Rica**

Giulia Loffreda1, Ivdity Chikovani2, Ana O Mocumbi3, Michele Kosremelli Asmar4, Laura C Blanco5, Liz Grant6, and Alastair Ager1,7

1 Research Unit on Health in Situations of Fragility, Institute for Global Health and

Development, Queen Margaret University, Edinburgh, UK

2 Curatio International Foundation, Tbilisi, Georgia

3 Instituto Nacional de Saúde, Marracuene, Mozambique; and Universidade Eduardo Mondlane, Maputo, Mozambique

4 Institut Supérieur de Santé Publique, Université Saint Joseph of Beirut, Lebanon

5 School of Economics, Universidad de Costa Rica, San José, Costa Rica

6 Global Health Academy, University of Edinburgh, UK

7 Department of Population and Family Health, Columbia Mailman School of Public Health, New York, USA

**Introduction**

Of all nations, low- and middle-income countries (LMIC) face the severest consequences of the climate crisis, despite having contributed the least to its occurrence. Climate change significantly threatens the major health gains witnessed across these settings over recent decades. Established direct and indirect pathways of influence [1] include: floods, increasing risk of water-borne disease; diminishing freshwater availability, eroding food security and sanitation; changes in temperature and rainfall impacting habitats and thus the spread of zoonotic and vector-borne disease; air pollution impacting pulmonary health and lung functions; land degradation and deforestation driving food insecurity and undernutrition; and environmental change compromising mental health [2]. Critically, highly inequitable, inefficient, and unsustainable patterns of resource consumption and technological development, together with population growth, exacerbate these risks.

Addressing these pathways therefore requires an understanding of their interaction and linkage. Adaptation and resilience measures are actions to accommodate environmental changes anticipated as a result of projected increases in global temperature, complementing mitigation actions seeking to reduce drivers of further temperature increase (centrally through reduction of carbon emissions). Resilience, a crucial theme within environmental research, has also emerged as a central concept in the health systems literature. Research has increasingly focused on identifying system capacities for absorption, adaptation, and transformation developed from system dynamic analyses [4, 5]. Similarly, the planetary health education framework highlights the importance of using system dynamics to understand how different factors interact as part of a complex system. [6]. Adaptation and resilience became focal points for CoP26: the Glasgow Climate Pact agreed by 197 countries at its conclusion set out a way forward from the 2015 Paris Agreement, emphasising the urgency of scaling up action and support to enhance adaptive capacity, strengthen resilience and reduce vulnerability [7]. CoP 27 then saw the launch of the [Sharm-El-Sheikh Adaptation Agenda](https://climatechampions.unfccc.int/wp-content/uploads/2022/11/SeS-Adaptation-Agenda_Complete-Report-COP27_FINAL-1.pdf) which outlines thirty adaptation outcomes which would serve to enhance resilience for up to 4 billion people living in the most climate vulnerable communities by 2030 [8].

This study addressed the linkages between climate change and health, by adopting a case study approach drawing on system science. The aim was to map the complex dynamics between climate change and population health across four settings [9]. By making more explicit the interrelationships between the factors shaping climate and health in each context the aim was to identify key entry-points and pathways for targeted adaptation and resilience measures.

**Methods**

**Theoretical framework**

The study adopted a socio-ecological and political ecology approach. The emerging field of planetary health reinforces the importance of the interconnections between environmental and human health and the relevance of considering these to formulate feasible solutions to the complex challenges of climate change [6]. We also drew on system thinking to better understand the non-linear relationships that exist among the complex systems under study and to address key adaptation and resilience measures.

**Research design**

We conducted case studies with partners in four LMICs: Mozambique, Lebanon, Georgia, and Costa Rica. These four settings exhibit diverse geographical, social, and political characteristics and forms of climate vulnerability. We adopted a mixed method approach incorporating a preliminary scoping literature review followed by group-based system dynamic modelling.

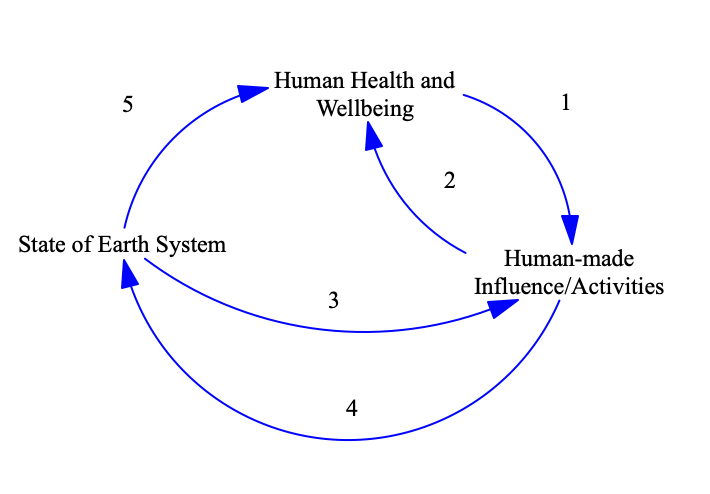
**Literature review**

The search strategy for the preliminary scoping literature review included key terms such as climate change, country name, and adaptation or resilience. No timeframe restrictions were applied. We searched peer-reviewed articles and grey literature both in English and Spanish (for Costa Rica) in the following databases: PubMed/Medline, Google Scholar, WHO IRIS, World Bank. Based on our pre-defined inclusion criteria, we identified 36 papers. An additional six papers were shared by country partners and included for data extraction.

The country specific literature was complemented and triangulated with key references from the global literature to assess accuracy of information on the more general issues. We piloted, revised, and finalised an extraction matrix covering the following information: bibliographic information; socio-ecological factors (such as climate, political, social stressors, human health, animal health) [10]; adaptation and resilience measures proposed; political ecology factors [11]; and other themes such as gender [12].

**Participatory workshops and system dynamic modelling**

We collated information from this preliminary scoping literature review – separately for each country - using a causal loop seed model (see Fig 2) suggested by the work of Proust and colleagues [13]. This spatially located variables identified in the reviewed literature with respect to three core domains: the state of the earth system; human made influence/activities, and human health/wellbeing. An initial causal loop diagram (CLD) was then elaborated for each country linking variables on the basis of the evidence presented by the reviewed literature.

**Fig 2. Seed model adopted for the development of causal loop diagrams.** Adapted from Proust et al. (2012) showing five key causal linkages between the state of the earth system, human influence and activities and human health and well-being.

These CLDs were then refined during online consultations with collaborators in each setting. The consultations involved participatory workshops with health, climate and environment specialists convened in each setting. Each workshop lasted approximately 2.5 hours and was conducted online between July and August 2021. A total of 18 participants took part across the four workshops. Participants were predominantly academics in different fields (climate science, health, forestry, economics etc.) and all based in the countries under study.

Workshops involved confirmation of the key variables of relevance and negotiation – on the basis of the local multidisciplinary expertise and evidence available – of the core dynamics linking them. The consultations concluded with a review of implications for national and local adaptation strategies.

CLD models underwent iterative critical analyses. This entailed comparing variables and their definitions, comparing pathways to ensure both consistent and divergent information was captured, and highlighting pathways and variables specific to each country. Further, researchers discussed indicated leverage points and indicated adaptation strategies suggested by the analysis. Finally, we conducted integrative analysis, comparing the four models to identify common features and potential synergies regarding adaptation strategy.

**Ethics**

Ethical approval for the research was granted through the Research Ethics Panel at Queen Margaret University (QMU).

**Results**

**Georgia case study - Emerging themes and strategies**

Workshop participants highlighted several dynamics characterising climate impact in the country (see Fig 3).

***Fig 3. Georgia causal loop analysis.*** Key pathways exacerbating threat considered in the workshop flagged in light blue; potential foci of adaptation and resilience shown in red.Fig 3_Informing Adaptation Strategy.tif

Among those, extreme weather events (such as floods) are causing coastal erosion, which impacts the livelihoods and mental health of people living in coastal areas; coastal erosion has also led to the displacement of communities. Despite most of the Georgian population having access to improved water supplies, participants noted that availability of water resources and sanitation was potentially at risk with projected increases in extreme weather events. For many of these pathways of impact it was observed that risks fell disproportionally on lower-income households, and act to increase socio-economic and health inequalities in the country.

In terms of adaptation, capacity building was considered to be a key requirement. In the health sector, one participant highlighted the importance of planetary health advocacy targeted to medical students and health professionals. Setting up multi-sectoral collaborations and a ‘whole-of-society-approach’ was viewed as essential for political progress on, and effective implementation of, adaptation strategies. To achieve this necessary coordination across actors and stakeholders in tackling climate change networks or institutions needed to be established connecting civil society, non-governmental organisations and academics. In terms of practical measures to strengthen resilience, discussion focused on the establishment of alerts and early warning systems to protect populations from the risks of floods and poor air quality.

**Mozambique case study - Emerging themes and strategies**

Workshop participants addressed several dynamics linking climate change and health (see Fig 4). Key threats were identified in relation to the increased intensity and frequency of extreme weather events. Participants highlighted that water resources were a particular focus of concern with regard to both floods (influenced by La Niña, in the north) and droughts (by El Niño, in the south). During floods, large amounts of water (including from neighbour countries) strained the ability of the country to effectively manage water resources, impacting water quality and sanitation and thus population health risk from water-borne disease. Population health was also impacted by the influence of restricted access to health services due to flooding.

Current governance of the health system, constraints on the health workforce due to migration and damage to infrastructure due to extreme events were all contributing to greater fragility of the health system, with implications for addressing the increasing burden of both non-communicable (including mental health) and communicable disease (including emerging infections and chronic infectious disease such as HIV and TB).

***Fig. 4. Mozambique causal loop analysis.*** Key pathways exacerbating threat considered in the workshop flagged in light blue; potential foci of adaptation and resilience shown in red.Fig 4_Informing Adaptation Strategy.tif

Discussion on adaptation strategies focused particularly on issues of water management. Monitoring and surveillance systems needed to be strengthened, particularly in the coastal areas and to anticipate flooding. Given hydrological linkages with neighbouring countries, the political security of water needed be addressed when designing water management strategies. In this regard, stronger data collection and information systems would enable and support political decision-making as well as inform locally driven strategies. Strengthening the health system – in terms of preparedness, capacity and resilience of infrastructure – was also identified as a key focus for action if the impacts of climate change were to be moderated.

**Lebanon Case Study - Emerging themes and strategies**

Human displacement and population pressure were other factors considered to be shaping the dynamics of climate and health. War and conflict in the region have driven a cycle of environmental degradation and population movement. The influx of refugees has exacerbated pressure on land, urban settlements, food and water, adding to the direct impacts of climate change. The political and economic crisis facing the country drives further dynamics eroding population health and the capacity to moderate climate impacts. There are implications for food security and the sustainability of agricultural production. Economic conditions are also restricting access to vital commodities to support the operation of the health system. Together with population displacement involving outward migration of health workers, these trends are contributing to greater fragility of the health system, with major implications for population health.

**Fig 5. *Lebanon causal loop analysis.*** Key pathways exacerbating threat considered in the workshop flagged in light blue; potential foci of adaptation and resilience shown in red.Fig 4_Informing Adaptation Strategy.tif

Potentialadaptation strategies addressed include strengthening sustainable agricultural solutions (such as climate smart agriculture, agroforestry and greater use of small ruminants such as local goats and sheep) and developing sustainable water services. Although government policy can facilitate development, given the economic and governance challenges in the country, local community-based initiatives were considered crucial. Conflict- and climate- sensitive approaches were viewed as vital to sustain access to health services enabling universal health coverage (UHC). Greater cross-sectoral collaboration is required to ensure public health safety and disaster risk reduction are integrated into national health plans.

**Costa Rica case study - Emerging themes and strategies**

With important changes in patterns of rainfall, a major focus of discussion amongst participants were the dynamics influencing water resources, whether directly through droughts, floods and salinization of aquifers or indirectly through the impact of forestry and agricultural practices (see Fig 6). A lack of safe water was seen as impacting economic growth (due to water cuts and rationing) and as a major contribution to compromised hygiene and increased risk of diarrhoeal disease. Floods contaminate freshwater supplies, heighten the risk of water-borne diseases, and create breeding grounds for disease vectors, for many of which climate change was lengthening the transmission season and geographic range.

***Fig 6. Costa Rica causal loop anal*ysis**. Key pathways exacerbating threat considered in the workshop flagged in light blue; potential foci of adaptation and resilience shown in red.Fig 6_Informing Adaptation Strategy.tif

Potential adaptation strategies discussed included the need to tackle the direct impacts of climate change via surveillance, monitoring and early warning systems. Strengthened social security strategies were considered of significance in reducing the multiple risks linked to poverty. Health systems need to expand traditional systems of healthcare delivery by integrating climate change considerations (e.g. control of climate-sensitive diseases), improving management of environmental determinants of health (such as water and sanitation, nutrition, and air quality), and establish emergency preparedness plans for extreme events. Urban and housing planning in marginal lands, coastal or flood-risk areas was also considered a key area of intervention.

**Integrative analysis**

**Fig 7. Causal loop diagram showing common dynamics across the four settings**. Key foci of adaptation strategy indicated in red.Fig 7_Informing adaptation strategy.tif

The causal loop diagram (Fig 7) seeks to represent some of the recurrent features from the country system dynamics. The five suggested strategies are focused on i) early warning/preparedness regarding extreme events (thus mitigating exposure to risk); ii) adapted agricultural practices (to sustain food security and community livelihoods in changing environmental conditions); iii) urban planning (to strengthen the quality of housing and infrastructure and thus reduce population exposure to risks); iv) health systems resilience (to maintain access to quality healthcare both for the treatment of disease associated with increased risk exposure and for other conditions for which access may be disrupted by extreme events); and v) social security (supporting the livelihoods of communities vulnerable through the impact of climate change or otherwise) enabling their access to public services, including healthcare.

**Conclusions**

Our research highlights five important lessons. First, system dynamics modelling methods, such as participatory group model building, provide a useful mechanism for convening actors across multiple sectors to consider the development of adaptation strategies [14, 15]. Consultations at national and local levels using approaches informed by systems dynamics should be used to identify linkages that can promote – or, unattended, would undermine - coherent, cross-sectoral action in support of adaptation.

Second, in line with the OECD multi-dimensional analysis of fragility [16], climate-related environmental risks need to be increasingly factored into appraisal of state and regional fragility, alongside issues of security and social, economic and political risks.

Third, our modelling has highlighted how pathways of impact of climate change can disproportionally affect those with lower household incomes, exacerbating inequalities. Adaptation strategies need to consider *a priori* investments which prioritise social security of vulnerable communities and populations.

Fourth, strategies focused on strengthening health systems resilience need to consider the relevant influences not only of national preparedness and early warning systems, but also of evolving agricultural (and wider livelihood) practices and patterns of settlement.

Finally, fifth, effective data monitoring systems need to be prioritised at national level to integrate information from all relevant sectors, with datasets and analyses shared across all ministries.

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