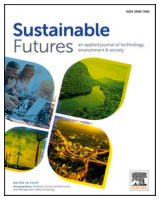
Sustainable Futures 9 (2025) 100627

Contents lists available at ScienceDirect

Sustainable Futures

journal homepage: www.sciencedirect.com/journal/sustainable-futures



Climate change and public health: Governance approaches and challenges in Lithuania

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ARTICLE INFO

Keywords:
Climate change
Public health
Risk governance framework
DPSIR framework
Health in all policies
Northern Europe
Multilevel governance
Health inequity

ABSTRACT

Human-induced climate change is widely acknowledged to be one of the greatest threats to public health globally. The intersection of climate change impacts on public health and the governance of these risks remains a critical area of research. While there is a large body of work analysing both the public health risks and climate change governance, there is a lack of research on the governance of such risks in the specific region of northern Europe, which is characterized by relatively lower yet growing climate change susceptibility. This article presents a case study exploring the approaches to governance of climate change-induced risks to public health in Lithuania. In the studied case, climate change-induced risks to public health range from extreme heat events to infectious diseases. The analysis follows an integrated conceptual model based on the risk governance framework, the drivers-pressures-state-impact-response framework and health-in-all-policies approach. The analysis is based on literature review and document analysis. The results have revealed fragmented governance of climate change-induced public health risks in Lithuania, highlighting the need for integrated health and climate policies, stronger international engagement, enhanced intra- and cross- sectoral cooperation and improved monitoring. To ensure better preparedness and resilience to climate change-induced public health risks, more research is needed, especially exploring intra- and cross- sectorial collaboration, responses from diverseision-makers and reduction of health inequities. The analysis identified inadequate integration of health considerations into climate change governance strategies and insufficient stakeholder engagement across sectors. It also shows that Lithuania's current governance framework lacks robust mechanisms for addressing health inequities exacerbated by climate change, and highlights a need for targeted interventions to enhance resilience and equity.

1. Introduction

Human induced climate change and the wide array of problems directly caused by it is the greatest threat to human health globally [1]. Governments worldwide are working to reduce the effects of climate change and manage its resulting impacts, but most implemented plans and strategies are designed with long timelines. However, the effects of climate change are already visible, therefore there is a need to assess and improve the implementation of climate change policies [2]. In Northern Europe, the climate change-induced risks are compounded by the region's specific climatic and socio-economic conditions. Lithuania specifically faces a number of climate change-induced risks, including increased heat stress, which put additional strain on an already heavily laden health system. According to the Organization for Economic Co-operation and Development (OECD), Lithuania is increasingly at risk of negative implications of climate change on public health [3].

Climate change implications on public health and the efforts to govern these risks is currently an under-researched area [4]. Though there is a large body of research on the effects of human induced climate change, a relatively small amount of this research to date has investigated the direct and indirect links between climate change and public health. There is no simple clearly visible reason for this but a supposition might be that research into the more immediately direct climate change effects has been better funded. The amount of research in the topic has increased over time with 373 studies on the topic published in 2019 compared with just 58 in 2008 [5]. Another area that seems to be under-explored is the ways that risk governance frameworks are employed to effectively govern the climate change related public health risks. This is true both on a global level and even more so on a regional Northern European level.

Understanding how climate change-induced risks to public health are governed in northern Europe, where advanced policy environments

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https://doi.org/10.1016/j.sftr.2025.100627
Received 30 December 2024; Received in revised form 10 April 2025; Accepted 13 April 2025
Available online 14 April 2025

intersect with region-specific vulnerabilities, remains a critical yet underexplored area. This article seeks to address this gap. The aim of the article is to examine the governance of climate change-induced risks to public health in a northern European case of Lithuania. In order to implement the aim of the research, this article will first develop a theoretical framework, then will outline an analytical model, and will finally present results of the analysis of governance of climate change-induced risks to public health in Lithuania.

The research presented in this article follows a pragmatic perspective and solution-oriented research approach [6]. The analysis employs a combination of literature review and document analysis to answer a list of research questions. The 2nd section of the article develops a conceptual framework that integrates insights from risk governance studies, the drivers-pressures-state-impact-response framework (DPSIR) framework, and the health-in-all-policies approach to guide analysis. The research questions are developed and presented in the 3rd section of this article. Data sources, methods and analytical processes are also explained in the 3rd section of this article. The 4th part presents results of a comprehensive analysis of legal documents in Lithuania to address governance of climate change-induced risks to public health.

2. Theoretical framework

To explain the governance of climate change-induced risks to public health, it is essential to conceptualize the issue by integrating insights from risk governance studies. International Risk Governance Council's (IRGC) risk governance framework has been designed to guide the identification, assessment, and management of risks, particularly those that are systemic, complex and come with huge uncertainty [7]. The IRGC risk governance framework focuses on pre-assessment, risk appraisal, characterization (evaluation), and management of risks, while also considering three cross-cutting aspects, including risk communication, stakeholder engagement and understanding the broader contexts [7].

Pre-assessment phase looks at local, regional, national, supra-national and global contexts of the risk, defines the scope and boundaries of the risk, and the stakeholder networks. Historical, political, spatial, institutional and other contexts are important in understanding how actors mediate multi-level regulatory constraints and solve problems through routines, trust, and mutual understanding [8]. The Quadruple Helix approach [9] to stakeholder analysis focuses on the interactions among stakeholders from governmental, academic, civil and private sectors. Local authorities, national governments, international organizations, the private sector, non-governmental organizations, public sector and academia are all important in multilevel climate governance [10]. The smart public governance concept draws attention to the need of active stakeholder engagement and networking driven by timely, integrated information, using appropriate structures, processes, techniques, and tools [11]. Complex risks, like those posed by climate change on human health, showcase the importance of collaboration and interorganizational networks instead of more traditional hierarchies. Non-hierarchical networks include stakeholders that are managed and financed independently, but share common goals [12]. Empowerment lies at the core of participatory governance, emphasizing the involvement of a broader and more diverse group of stakeholders in discussions, deliberations, andision-making processes, ultimately aiming to achieve more informed and equitable outcomes [13].

The second element or risk governance framework, the risk appraisal, looks at hazards as well as vulnerabilities and assets [7]. Appraisal of risks is prone to amplification [14,15]. Social amplification occurs when the characteristics of climate change related events interact with social, psychological, cultural, and institutional processes and structures, magnifying and multiplying the associated risks.

The evaluation of risks, the third element of the IRGC risk governance framework, assesses climate change-induced public health risks by considering their likelihood of occurrence and scope of impact [16]. According to the Greek mythology model, defined by Klinke and Renn [16], the climate change-induced risks to public health pertain to "Pythia" risk class (probability of occurrence and the scope of damage remain unclear), but if the risks would remain unattended, they would transition to the "Casandra" risk class (high probability of occurrence and broad scope of damage) [16].

The fourth element of the IRGC risk governance framework speaks of risk management. Multidimensional issues, like climate change implications, span multiple areas of public management. Addressing these challenges necessitates comprehensive and integrated government responses, often requiring solutions at the global level. The European Union (EU) exemplifies multi-level governance, whereision-making and governance occur across regional, national, and supranational levels [17]. Understanding the dynamics of collaboration and coordination across these diverse levels is essential, particularly in addressing health risks driven by climate change.

The drivers-pressures-state-impact-response (DPSIR) framework adds another analytical layer to the theoretical framework of this article. DPSIR is a conceptual model developed as a tool for the analysis of environmental issues, ranging in scale from global systems to localized ecosystems [18]. This framework adds the causes and effects relationship to the conceptual analytical model. The progression of effects in the DPSIR framework begins with driving forces (D) that serve as underlying causes and are related to human activities [19]. As indicated by the scoping document of the United Nations Environment Programme Seventh Edition of Global Environmental Outlook [20], major drivers of global environmental crises include demographic change, urbanization, increasing production and consumption, scientific and technological innovation, etc. The driving forces create pressures (P) on human and natural systems, i.e., emissions, land use change and others, that coupled with natural processes, like solar radiation, result in deteriorating state (S) of environment, like climate change, biodiversity loss and pollution and land degradation.

This paper is positioned between the DPSIR element of impact (I) and response (R). The I element encompasses direct and indirect impacts of climate change on public health, including heat related disorders [21], undernutrition [22], vector-borne diseases [23] and others. And the R element is about dealing with and governing the impacts. In this paper, the analysis of the R element includes governance processes, actions, policies, and stakeholders.

The exploration of governance as a response (the R element) to the climate change-induced risks on public health, is guided by the health-in-all-policies approach [24]. This approach acknowledges the influence of non-health policies on the health sector and emphasizes integrating health policies across diverse sectors beyond conventional public health system boundaries. In our context, the critical role of climate change mitigation and adaptation policies in addressing public health risks is well recognized.

The above explored concepts and frameworks amount to a conceptual model that guides the analysis of the governance of climate change-induced risks to public health in Lithuania (see Fig. 1).

3. Research questions, information sources and methods

The analysis follows a pragmatic approach and is based on literature review and analysis of national, European Union and global policy relevant documents, focusing exclusively on documents valid as of the end of 2023, with publication dates ranging from 2012 to 2022. The research questions addressed in this article relate to the key elements of governance of public health risks caused by climate change in Lithuania, as presented in Fig. 1: context of the risks, content of national policies and structure of stakeholder network, that all combined help understanding the response to the climate change impacts.

Following the conceptual model (Fig. 1), the analysis will start with short description of the international context, and will then proceed characterizing the climate change-induced risks to public health in

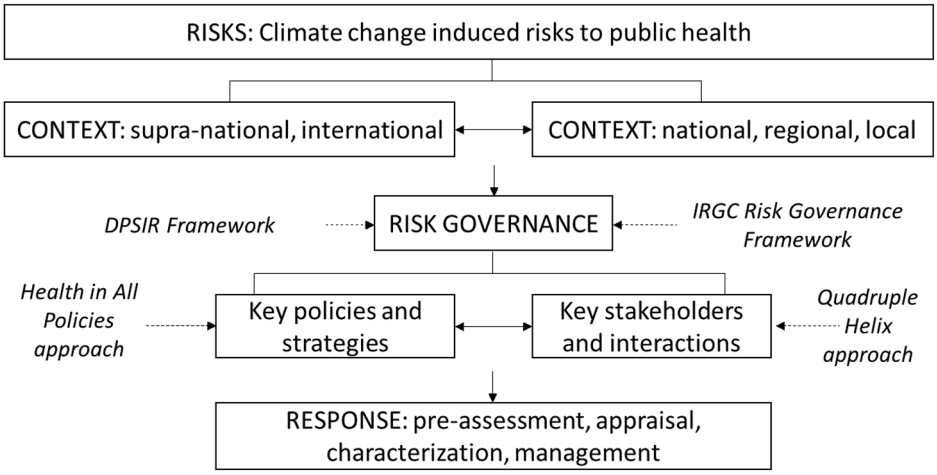

Fig. 1. The conceptual model for exploring the governance of climate change-induced risks to public health in Lithuania.

Lithuania (setting the scope and boundaries of risks). The analysis will finally be structured along these research questions:

RQ1: How is pre-assessment of public health risks associated with climate change carried out in Lithuania?

RQ2: What indicators are employed and how concern assessment is implemented for the appraisal of the risks in Lithuania?

RQ3: What is the stakeholders' network in the governance of climate change-induced risks to public health in Lithuania?

RQ4: What is the policy coverage of the diverse public health risks induced by climate change in Lithuania?

Various sources of information were used to answer the research questions, and the analysis is supported by an unpublished study conducted by the first author of this article Rima Prosceviciute [25]. Publicly available documents, including legal documents, key policies, strategies, studies, action plans, recommendations, etc. were selected following purposive criterion sampling. The document search and sampling were based on a set of inclusion criteria, that are outlined in Table 1.

Three main public document repositories were used for document search: repository of the Office of the Seimas of the Republic of Lithuania (access through https://e-seimas.lrs.lt/), documents register of the European Commission (access through https://ec.europa.eu/transparency/documents-register/), and the repository of the United Nations (access through https://documents.un.org/prod/ods.nsf/home.xsp). Documents were also sourced from official websites of these organizations or institutions: Climate-Adapt for European Union adaptation policies (access through https://climate-adapt.eea.europa.eu/?set_language=en), Organisation for Economic Co-operation and Development (access through https://www.oecd.org/environment/reform-options-for-lithuanian-climate-neutrality-by-2050-0d570e99-en.htm), Ministry of Health of the Republic of Lithuania (access through https://sam.lrv.en), Ministry of Environment of the Republic of Lithuania (access through https://am.lrv.lt/en/), My Government (access through https://epilietis.lrv.lt/en).

To ensure a comprehensive document selection process, we also employed expert elicitation method, i. e. conducted several discussions with peers and experts in climate change policy and health policy from the Faculty of Social Sciences, Arts, and Humanities at Kaunas University of Technology during the spring months of 2024. Their insights helped to confirm that the most relevant policy documents were included in the analysis.

In total, 30 different documents were sampled. The list is provided in the supplementary materials to this article. The study further employed a qualitative interpretative approach to document analysis. The documents were read and manually coded deductively. Excel spreadsheets were used to organise the document excerpts according to the following codes: reference to international documents, reference to stakeholders (noting the type of stakeholder by sector and level - categories can be seen in Table 2), reference to assessment or indicators or monitoring, reference to climate change effects and impacts, reference to health risks (noting whether risks are mentioned in general or specifically, and these references are categorised by groupings as seen in Table 3). The quality of coding was ensured through inter-coder agreement, achieved via informal discussions, allowing for a nuanced and context-sensitive interpretation of the data. A document comparison analysis was then conducted to verify the presence of the identified themes (codes) in the documents and analyse the content of the relevant excerpts in context. The results of the analysis are summarised below in the results chapters, in the form of tables and descriptive and interpretative text.

Table 1
Inclusion criteria for document selection and analysis.

Criterion type	Inclusion criteria
Geographical	The document must be relevant and valid in Lithuania.
Recency	The document must be valid as of the end of 2023.
Keywords	1. The document must include both keywords of "climate change" and "public health" (or variations such as "health", "impact on health"). 2. May include one or several additional risk-specific keywords: "heatwave" (or "heat event"), "tropical nights", "forest fires", "air pollution", "extreme weather events" (general) or specific events such as "floods", "storms", and "droughts", "allergens", "airborne pathogens", "infectious diseases", "waterborne pathogens", "vector-borne pathogens", "food insecurity", and "mental health".
Reliability	The document must be findable from the trusted document repositories (see below)

4. Empirical analysis of governance of climate change-induced risks to public health in Lithuania

The analysis section opens by a brief presentation of the international context for the Lithuanian case. This is followed by an overview of the risks to public health from climate change, highlighting the specific impacts in Lithuania and indicating the magnitude and increase in impacts. Then the text continues on to the sub-sections, each of which is devoted to answering the research questions formulated in section 3.

4.1. Characterization of the international context

Climate change is a global issue with geographically unrestricted effects, requiring governance structures and processes that span local to global levels, where local, regional, and national governance cooperate

Table 2
Horizontal and vertical stakeholder network structure for governance of climate change-induced risks to public health in Lithuania.

Levels/ Sectors	Governments/agencies	Industries, private sector	Experts and academia	Civil society and NGOs
Local	Local government authority – municipality; Health and Social Security Committee; Municipal Community Health Council; Municipality Public Health Bureau; Department of Land and Environmental Protection	Local businesses; local farmers	Public health workers; health specialists and researchers	Civil society; Communities; Community-based organizations (CBOs)
Regional	Regional administration; regional hospitals; Primary health care centres; Regional Development Agencies	Medium to big scale businesses and farmers	Research and Innovation Parks; regional universities	Media, Conferences, and events for general public
National	Ministry of Health of the Republic of Lithuania; National Public Health Centre; State Health Care Accreditation Agency; Institute of Hygiene; Health Emergency Situations Centre under the Ministry of Health; Environmental Protection Department under the Ministry of Environment; Radiation Protection Centre under Ministry of Health; Ministry of Finance; Committee of Health Affairs of Seimas; the Ministry of Education, Science and Sports.	Pharmaceutical companies; agriculture sector; energy, manufacturing, transportation, and waste management companies like Grigeo Group, Klaipėda State Seaport Authority, Ignitis Group, Lithuanian Railways, Ecoservice, etc.	Vilnius University; Lithuanian University of Health Sciences; Kaunas University of Technology; National Public Health Surveillance Laboratory	Lithuanian Red Cross; Lithuanian environmental NGOs; Lithuanian Green Building Council; Lithuanian Sustainable Business Association, etc.
Supra-national	The European Union (EU); The Organization for Economic Co-operation and Development (OECD); European Centre for Disease Prevention and Control (ECDC); European Environment Agency (EEA)	Orlen Lithuania; DHL; Lidl and others	European Public Health Association (EUPHA); universities and research institutions across Europe	European Environment Bureau; Baltic Environmental Forum; The Foundation for Environmental Education, etc.
Global	World Health Organization (WHO), World Bank, The Food and Agriculture Organization of the UN (FAO); The United Nations Environment Program (UNEP)	Philips Morris International; Johnson & Johnson; Nestle; Coca-Cola; LTP Texdan and others	Research institutes of global reach	Health and Environment Alliance (HEAL); The Nature Conservancy and other NGOs

Based on unpublished study [25].

Table 3
Policy documents covering climate change-induced risks to public health in Lithuania.

Risk	Documents
Extreme heat events	National Strategy for Climate Change Management Policy (2012); National Climate Change Management Agenda (2021); Lithuanian Health Strategy (2014–2025); National Adaptation Strategy (NAS, 2012); National Energy and Climate Action Plan (NAP) 2021–2030; National Public Health and Heat Prevention Action Plan for 2016–2020 (2015); Assessment of the Health Impacts of Climate Change in Lithuania (2019); Eighth National Communication and Fifth Biennial Report on Climate Change (2022); Climate change projections to 2100
Wildfires	National Adaptation Strategy (NAS, 2012); Eighth National Communication and Fifth Biennial Report on Climate Change (2022); Assessment of Climate Change Impacts on Forests and Adaptation to Climate Change in the Forestry Sector of Lithuania (2015); National Forest Fire Prevention and Control Plan (2016–2020); Climate change projections to 2100
Flooding	Lithuanian Health Strategy (2014–2025); National Adaptation Strategy (NAS, 2012); Eighth National Communication and Fifth Biennial Report on Climate Change (2022); National Flood Risk Management Plan (FRMP) (2018); Climate change projections to 2100; National Energy and Climate Action Plan (NAP) 2021–2030
Air pollution	National Strategy for Climate Change Management Policy (2012); National Climate Change Management Agenda (2021); Lithuanian Health Strategy (2014–2025); National Adaptation Strategy (NAS, 2012); Assessment of the Health Impacts of Climate Change in Lithuania (2019); Eighth National Communication and Fifth Biennial Report on Climate Change (2022); Climate change projections to 2100
Allergens and pollen	National Strategy for Climate Change Management Policy (2012)
Airborne pathogens	National Climate Change Management Agenda (2021) Assessment of the Health Impacts of Climate Change in Lithuania (2019); National Climate Change Management Agenda (2021); Lithuanian Health Strategy (2014–2025)
Infectious diseases	National Strategy For Climate Change Management Policy (2012); National Climate Change Management Agenda (2021); Lithuanian Health Strategy (2014–2025)
Vector-borne pathogens	National Strategy For Climate Change Management Policy (2012); Lithuanian Health Strategy (2014–2025); Assessment of the Health Impacts of Climate Change in Lithuania (2019); Eighth National Communication and Fifth Biennial Report on Climate Change (2022)
Waterborne pathogens	Lithuanian Health Strategy (2014–2025)
Food insecurity	National Climate Change Management Agenda (2021); Lithuanian Health Strategy (2014–2025); National Adaptation Strategy (NAS, 2012); Assessment of the Health Impacts of Climate Change in Lithuania (2019); Eighth National Communication and Fifth Biennial Report on Climate Change (2022); National Energy and Climate Action Plan (NAP) 2021–2030; Voluntary National Review on the Implementation of the 2030 Agenda for Sustainable Development
Mental health issues	National Strategy for Climate Change Management Policy (2012); National Climate Change Management Agenda (2021); Lithuanian Health Strategy (2014–2025); Assessment of the Health Impacts of Climate Change in Lithuania (2019); Eighth National Communication and Fifth Biennial Report on Climate Change (2022)
Health infrastructure stress	Lithuanian Health Strategy (2014–2025); Vilnius City Council Climate Change Adaptation Plan; National Energy and Climate Action Plan (NAP) 2021–2030; Eighth National Communication and Fifth Biennial Report on Climate Change (2022); National Action Plan for Public Health and Heat Prevention 2016–2020; National Public Healthcare Development Programme for 2016–2023

Based on unpublished study [25].

and complement international responses to address the transnational nature of the risks. Lithuania's approach to addressing public health risks from climate change is shaped by global agreements and EU policies, with only the main agreements outlined in this section.

The Paris Agreement adopted in 2015 as a part of the United Nations Framework Convention on Climate Change, sets out a framework for countries to create country specific plans and pledges on how to reduce greenhouse gas emissions and adapt to climate change [26]. The Paris Agreement explicitly references health only in the context of human rights, emphasizing that governments should uphold the right to health while taking action to address climate change. In 2018, a WHO representative described the Paris Agreement as a public health agreement [27]. A 2021 modelling study found that countries meeting their Nationally Determined Contributions (NDCs) would result in significant annual reductions of deaths attributed to air pollution and diet among others [28]. The 26th UN Climate Change Conference (COP26) in 2021 brought a highly significant milestone in pushing public health to the front of the climate change agenda [29]. Commitments made by a number of countries at COP26, led to the creation of the WHO-led mechanism the Alliance for Transformative Action on Climate and Health (ATACH) [30]. The ATACH framework supports climate-resilient health systems by guiding vulnerability and adaptation assessments, developing national health adaptation plans, and facilitating access to climate funding while promoting net-zero emission health systems. By October 2023, over 70 countries, including 10 in Europe, had committed to targets for health in climate resilience, low-carbon sustainability, or both. However, Lithuania has not signed onto this initiative. Despite its significance in addressing public health and climate change, ATACH remains a voluntary framework without legal enforcement mechanisms.

The Sustainable Development Goals (SDG) are part of the United Nations 2030 Agenda for Sustainable Development. SDG3 'Good Health and Well-Being' relates to health topics; and while it does not connect climate change and health, being more focused on things like maternal mortality, it does set targets for ending preventable infant deaths and fighting infectious diseases which are both affected by climate change. It is important to note that Lithuania is making progress on SDG 3, but the status is worse than the EU average [31].

While it not be as widely noticed or cited as the Paris Agreement and the SDGs, the European Green Deal is far reaching and extremely ambitious. The European Parliamentlared a climate emergency in 2019 and asked the European Commission to adapt plans and proposals on climate change to a target limit of 1.5 °C above pre-industrial levels and a significant reduction in greenhouse gas emissions. The response from the European Commission was the European Green Deal, a set of targets and a roadmap for Europe to be the first climate-neutral continent by 2050 [32]. The Green Deal promotes the development and use of renewable energy, promotes a transition to a circular economy, outlines plan to both protect and restore natural areas and biodiversity, create cleaner transportation and other infrastructure, and build more sustainable agriculture systems. Additionally, it contains initiatives to improve both air and water quality, both of which have a significant impact on public health. As with most other documents discussed here, public health is not explicitly talked about and there are no specific commitments to meet health targets, but the other components of the Green Deal all contribute to significantly improved public health outcomes. The European Union Adaptation Strategy is a plan for countries within Europe to adapt to and mitigate the effects of climate change. Announced in 2019 and adopted inruary 2021, the strategy is a part of the European Green Deal. What sets it apart from the rest of the Green Deal or the Paris Agreement is that its focus is not on reducing, slowing, or stopping climate change, but solely on adapting to it and increasing climate resilience. The public health is not mentioned explicitly anywhere in the document, although there is an acknowledgement that the impacts of climate change can have significant health-related outcomes.

To sum up, Lithuania's response to climate change-induced risks to public health is influenced by global agreements like the Paris Agreement, the Sustainable Development Goals (SDGs), and the European Green Deal, though public health is often only indirectly addressed. While the Paris Agreement highlights the right to health and the SDGs set related targets, Lithuania struggles with pollution-related health goals and lags behind the EU average in SDG 3 progress. Initiatives like ATACH and the European Adaptation Strategy provide frameworks for resilience, but Lithuania has not joined ATACH, and public health remains underrepresented in these strategies.

4.2. *Climate change induced risks to public health in Lithuania*

Climate change impacts public health in various ways, ranging from direct and visible effects, such as higher summer temperatures exacerbating cardiovascular health issues [21], to less apparent consequences like mental health stress [33]. Scientific literature and international assessments identify a list of public health risks that are either directly caused by, or have highly increased risks due to, climate change across Europe, and in Lithuania specifically: extreme heat events, wildfires, flooding, air pollution, allergens and pollen, airborne pathogens, infectious diseases, waterborne pathogens, vector-borne pathogens, food insecurity, mental health and other indirect risks (for references see further section 4.2.).

The European Climate Adaptation Platform (Climate-ADAPT), a partnership between the European Commission and the European Environment Agency [34], utilizes the high-emission climate scenario RCP8.5 to project changes in heatwave days and tropical nights from 1971 to 2000 to 2031–2060. According to these projections, the central-western region of Lithuania is expected to experience a 3.8-fold increase in heatwave days and at least a sevenfold increase in tropical nights [35].

Higher temperatures and drier conditions are a contributing factor to a rapid increase in the number of forest fires. Almost every country in the European Union has experienced increased rates of forest fire in the last fewades. Between 2006 and 2022, the average of hectares destroyed by forest fires in Lithuania each year was 16.41 while the European Forest Fire Information System estimate for forest fires in Lithuania in 2023 is 305 hectares [36]. Not only are the number and intensity of these fires increasing, but increasing urbanization is raising the public health risks as cities expand into fire prone areas [37].

Climate change is also increasing the likelihood of and the public health risks from flooding. In Lithuania specifically the majority of flooding is from rivers and urban flooding when wastewater systems become overloaded, with relatively low levels of coastal flooding [38–40]. The next important risk is related to air pollution. According to United Nations Environmental Program estimates, air pollution is a contributory factor in around 9 million premature deaths each year globally [41] and approximately 99 % of the world population, including the population in Northern Europe and Lithuania, regularly breathes air that does not meet WHO air quality guidelines [42].

Rising air temperatures caused by climate change are leading to earlier and longer pollen seasons while enabling plant species to expand into regions where they previously could not thrive [43]. This influences the level of pollen and fungal spores that are produced and emitted into the atmosphere. The increase in extreme weather events, such as storms and flooding, also increases the risks of allergies by allowing for greater amounts of mold and fungus growth [44].

Climate change is an important contributing factor in the increase of cases of infectious diseases [45]. In northern European region and Lithuania, a number of factors attenuate this risk, i. e. good sanitation, access to clean water and nutritious food, and access to and quality of public health services. A lack of physical borders and freedom of movement contributes to (amplifies) the risk of increased levels of infectious diseases [46]. We can broadly divide infectious diseases by transmission methods: vector-borne, waterborne, foodborne, zoonotic, and airborne. Each of these transmission methods are growing global problems, but waterborne and vector-borne pathogens and a rise in

zoonotic diseases and parasites in the region currently pose the greatest risks specifically in Lithuania and the northern Europe [47]. Changing temperatures and other climatic conditions have been predicted to have a significant impact globally on the infection rates from many water-borne pathogens including Cholera, Typhoid, Leptospirosis, Toxocariasis, Cryptosporidiosis, and Giardiasis [47]. Though many of these diseases are not common in northern Europe, they are also not unheard of, and the most common diarrheal infections are estimated to increase yearly deaths by 250,000 by 2050 [47].

Insect vector risks not be very high in northern Europe and Lithuania specifically, but there has been a clear rise in the number of cases of tick-borne diseases in the Baltic States over the pastades with strong evidence to suggest that this is linked to climate change [48]. Lyme borreliosis is already the most widespread vector-borne disease in the European Union [49]. Multiple studies have all concluded that the prevalence of Tick-Borne Encephalitis and Lyme Disease are both expected to increase by another 10 % before the end of this century [48,50]. Baltic States including Lithuania have some of the highest levels in Europe. The estimated prevalence rate of Lyme borreliosis in Western Europe in 2016 was 22.05 cases per 100,000 people [51], while the prevalence rate in Lithuania, which does keep a mandatory register, was 101.6 cases per 100,000 people [52].

Climate change affects multiple dimensions of food security [53,54] through the influence of rising ambient temperatures andlining soil fertility on crop yields, increased illnesses from foodborne pathogens, heightened malnutrition rates, and the exacerbation of poverty and nutritional inequalities as reduced agricultural production drives up consumer food prices. Most studies related to the effects of climate change on food security are concerned with the Global South and nations with existing higher levels of poverty, but it is also an important issue for Europe, including the most developed nations. As food supplies are very globalized, it means that even in a country like Lithuania where yields increase the overall availability and affordability of food willrease [2]. In the last few years food security in Europe has faced a number of other challenges including the Russian invasion of Ukraine. Water security is also a growing concern, particularly due to the potential increase in the cost of domestic clean water supplies and sanitation. An estimated 10 % of the poorest households in Lithuania are expected to face affordability challenges, double the EU average of 5 % [55].

In addition to direct health risks, climate change poses indirect threats such as mental health issues, that are very hard to quantify, due to a lack of accurate reporting. This is partially due to causative links not being identified during treatment, but a far larger factor is that many people who are affected by mental illness do not seek help for their condition. A study composed of interviews with healthcare providers in Lithuania found that the stigma of mental illness remains high in the country, and links this to high levels of anxiety that is common to post-socialist societies [56]. This means that we can only work with estimates of the actual number of people who will suffer mental health effects as a result of climate change related events, but a conservative estimate would be that 20 % of the affected population will experience some form of mental health problem [57].

In the forthcoming 30 years, Lithuania will become one of the fastest aging societies in the European Union [58], which further serves as amplifier to the public health risks induced by climate change. The exposure to extreme heat has been linked with hospitalization and mortality rate as well as air pollution has been linked to a range of detrimental health effects in the elderly, including respiratory and cardiovascular diseases [59]. Another important risk multiplier is the amount of people who suffer from chronic diseases or other long term health conditions. A study based on the National Health Insurance Fund (NHIF) database from 2012 to 2014 found that 17.2 % of the adult Lithuanian population had chronic diseases and prevalence of chronic conditions increases with age [60].

Lithuania is comparable to other Nordic and Baltic countries, making it a strong representative case for the broader Nordic-Baltic region. Although its GDP per capita is lower than that of the Nordic countries, it is similar to that of the other Baltic states. Moreover, its socioeconomic indicators – such as aging demographics and urbanization rates – are converging with those of its Northern European neighbours. This convergence directly influences how climate change impacts public health systems. Reports such as the European Environment Agency's Climate Risk Assessment rank Lithuania alongside Nordic countries in terms of moderate but growing vulnerability to climate-induced health risks [61]. Additionally, Lithuania operates under the same EU climate adaptation and public health policies as other Northern European countries, for example the EU Climate Adaptation Strategy and a broader Health-in-All-Policies approach, which create some commonality in governance frameworks. Other Northern European countries including Norway and Sweden are actively developing and implementing adaptation strategies to reduce these risks and protect public health, emphasizing the importance of green infrastructure and community resilience, however recent geopolitical changes in Europe have caused climate actions to be scaled back in favour of a focus on defence [62].

Other nations in the region face similar increased public health risks from climate change to Lithuania, including the northward spread of tick-borne diseases, predominantly encephalitis and Lyme disease [63], increases in respiratory issues due to air quality changes, mental health impacts, and increased danger from extreme weather events. Sweden, Finland, and Lithuania are experiencing similar increases in heat-related mortality due to aging populations and urbanization [64]. These shared vulnerabilities again justify the comparison of public health impacts in Lithuania with richer Northern European countries.

4.3. Pre-assessment of public health risks associated with climate change in Lithuania

In the 2012 Resolution approving the National Strategy for Climate Change Management Policy [65], point 96 noted that Lithuania lacks a dedicated program for public health management and financing to coordinate activities related to climate change. It also highlighted a shortage of studies assessing the impacts of climate change on public health. This document was replaced by the National Climate Change Management Agenda [66], which came into effect on July 3, 2021, and includes an assessment of the strengths, weaknesses, and necessary actions for addressing public health risks induced by climate change. Studies identifying threats to human health induced by climate change were conducted and recommendations prepared in 2014 [67]. Guidelines for climate change mitigation and adaptation were developed for municipalities, highlighting the public health sector as one of the areas affected by climate change. In 2018, a study was conducted to assess sectoral vulnerabilities to climate change, evaluate risks, and identify adaptation opportunities, contributing to the development of the adaptation preparedness scoreboard under the EU's Strategy on Adaptation to Climate Change [68]. In 2021, the Ministry of Environment of the Republic of Lithuania commissioned a report analysing economic sectors, which included an assessment of key climate change hazards and vulnerabilities affecting public health [69]. In 2022, the Ministry of Environment of the Republic of Lithuania's Climate Policy Group published Lithuania's 8th National Communication and the 5th Biennial Report under the UN Framework Convention on Climate Change, which included a vulnerability assessment but did not identify the public health sector as vulnerable [70]. It is important to note that the following reports by the Ministry of Environment already acknowledge climate change impacts on public health. The acknowledgment was further strengthened, when in November 2022 the Ministry of Environment released climate change studies identifying sensitive municipalities, proposing adaptation plans, and forecasting scenarios up to 2100, emphasizing the links between climate indicators and various sectors, including public health [71]. It further highlighted that governance and adaptation of the public health sector in relation to climate

change needs collaboration between public sector institutions and the scientific community. The report had primary focus on heatwaves and highlighted vulnerable groups, including the elderly, infants, people with chronic illnesses (particularly cardiovascular and respiratory), individuals in care facilities with limited physical activity, and urban residents.

4.4. Appraisal of climate change-induced risks to public health in Lithuania

Risk appraisal usually includes a data-based evaluation of the hazard and concern assessment, which includes analysis of public perceptions and concerns. Analysis reported in this article included looking at how indicators are developed for collecting data and what are the public concerns regarding climate change-induced risks.

Concern assessment is an important part of risk appraisal in the risk governance analysis [7]. As shown by data from representative surveys, Lithuanian population puts health as primary concern and ranks climate change as the most important environmental issue for their country [72, 73], thus giving an indication that the risks arising in the nexus of these two concerns have ultimate public priority. Such surveys are carried out by scientists driven by academic interests [74], and although the Ministry of the Environment has commissioned and published a methodology for monitoring the climate change attitudes and behaviour of the Lithuanian population [75], such regular national surveys have not been initiated. Monitoring of public concerns will be enabled by the new research infrastructure "Lithuanian Long-Term Social Survey", which is currently under development [76].

As outlined in subsection 4.1., climate change-induced risks to public health are complex, raising critical questions about how these challenges can be effectively assessed using scientific and analytical tools. A national study by the Ministry of Environment of Lithuania on municipal sensitivity and vulnerability to climate change suggests indicators that include yearly number of tropical nights, duration of sudden cold snaps, cold days, perpendicular surface solar radiation, duration of sunshine, amount of precipitation, extreme rainfall, number of days without precipitation, number of days with snow cover, maximum snow cover thickness and biometeorological parameters [77].

The Institute of Hygiene under the Ministry of Health of Lithuania is responsible for statistical indicators on occupational diseases and causes of death, including morbidity linked to climate change events such as heatwaves. However, the list of cause-of-death codes (ICD-10) used by the National Health Insurance Fund under the Ministry of Health does not include categories directly related to climate change, such as deaths from heatwaves or other climate change-related causes [78].

The presented indicators focus solely on environmental appraisal, with no specific indicators included for monitoring and assessing climate change-induced risks to public health. Lithuania could consider adopting an approach similar to that of the United States, where the Environmental Protection Agency utilizes ICD-9 code E900: “excessive heat—hyperthermia,” particularly subpart E900.0: “due to weather conditions” [79].

4.5. Analysis of stakeholders’ network

Stakeholder networks have both horizontal and vertical interactions [80]. Climate change-induced risk governance is implemented at all levels including regional and global. Even though the focus of this work is at the national level, the levels are interconnected, so are presented in the same table. Table 2 presents the key stakeholders of governing the climate change-induced to public health in Lithuania. It is important to note that there is a wide network of actors, and that this list is not finite and can be expanded.

Several key areas of governance for climate change-induced risks to public health in Lithuania include policies on public health, climate change mitigation and adaptation strategies, and awareness and education initiatives. The main national body responsible for the public health policies in Lithuania is Ministry of Health. It is a central government institution to oversee all health-related affairs. The Ministry of Health of the Republic of Lithuania follows international policies, recommendations, and data from World Health Organization, the United Nations, European Centre for Disease Prevention and Control, Organization for Economic Cooperation and Development, and relies on national level agencies. Lithuania is the member of Joint Action Health Equity Europe from 2018, which promotes health integration in all policies. In addition, the principle of Health in All Policies (HiAP) is explicitly promoted by Lithuania in its Lithuanian Health Strategy 2014–2025 (paragraph 42). The National Public Health Centre plays an important role by providing data, conducting public health surveillance, monitoring and analysis, based on data collected by public agencies like the Institute of Hygiene. The Ministry of Education, Science and Sports is responsible for environmental education and health literacy as fostered through various educational and research programs. Ministry of Environment is the key national body responsible for climate change policies. In relation to climate change mitigation and adaptation strategies, the Ministry of Health of the Republic of Lithuania places a strong emphasis on strengthening the resilience of public health infrastructure. There are specialized agencies under the Ministry of Health and Ministry of Environment responsible for managing specific health and environmental situations, including the Health Emergency Situations Centre under the Ministry of Health, the Environmental Protection Department under the Ministry of Environment, and the Radiation Protection Centre under the Ministry of Health.

Governmental institutions are following the policies and strategies, however, there is a lack of collaboration. For example, Institute of Hygiene started biannual national reporting on climate change and threats to human health [81], and there are also multiple policies and initiatives fostered by the Ministry of Environment that aim to reduce the health impacts of climate change including research and monitoring programs on respiratory diseases, heat stress, and allergies, public awareness campaigns that encourage behavioural change to reduce personal and collective risks, and support for investments in healthcare services to increase preparedness for climate change related health emergencies [70]. However, the Ministry of Health and the Ministry of Environment do not appear to collaborate on the implementation of these reporting activities, and the document analysis did not provide proof of these entities working together, thus highlighting the lack of horizontal cross-department cooperation.

There are systems in place for dialogue between stakeholders on climate and energy issues – Multilevel Climate and Energy Dialogues, which were set out in governance regulations by the European Parliament with countries required to report for the first time in 2023, yet again these do not explicitly include public health. In an EU wide study Lithuania self-reported that it was one of only two countries in the EU to have both existing and new dialogue structures in place between stakeholders regarding MCLEDs and that they are multi-stakeholder [82].

The Ministry of Finance reports that it has created an Inter-Institutional Group on Sustainable Finance, which involves many agencies including the Ministry of Energy, Ministry of Transport, Ministry of Agriculture, and the Bank of Lithuania [83], but again this group does not include the Ministry of Health.

In Lithuania, horizontal governance stakeholders engage in some level of communication regarding reporting and adaptation strategies for climate change-induced public health risks. However, the absence of a formal system for information sharing and collaboration on climate change and health issues results in duplicated efforts and slower progress.

The OECD’s Infrastructure Governance Index, that provides a comprehensive assessment of countries’ progress in developing national policies for involving stakeholders, shows that Lithuania stands out with a score of 0.60 on a scale of 0–1, which is higher than the OECD average

of 0.52 [64]. This gives insights on the horizontal interactions of the stakeholder network. Though having good underlying drive, the horizontal interactions and cooperation among sectors follows a rather passive communication model, primarily directed at fulfilling transparency requirements. Document analysis shows that governmental institutions and public agencies implement a transparency model where performance and financial reporting are the standard practices, alongside press releases and information dissemination. The traditional practices are complemented by public outreach and dissemination activities like publishing informative reports, organizing community events, seminars and visits e.g., to schools, communication via traditional and new social media. These activities bridge the interactions among the sectors.

At local level, municipalities have established Health and Social Security Committees and Municipal Community Health Councils to work with topics of public health, which work according to recommendations based on the Lithuanian Health Programme 2014–2025 [84]. The Health and Social Security Committees are formed by Council members while Municipal Community Health Councils involve representatives from different sectors, including representatives of NGOs, local communities, municipality administration, educational institutions, and Council members. Civil society engagement is further encouraged by providing small grants for community health projects by the district municipality's public health support special program.

4.6. Policy coverage of the diverse public health risks induced by climate change in Lithuania

The synthesis of the results of analysis on the policy coverage of the diverse public health risks induced by climate change in Lithuania is presented in Table 3.

Climate change-induced risks related to extreme heat events, wildfires, flooding, air pollution, food insecurity, mental health issues and health infrastructure stress are widely covered in a number of documents. Health infrastructure stress refers to the strain on health systems associated with increased demand, limited resources, and external pressures caused by a variety of factors, including disease outbreaks, aging populations, climate change, economic constraints in health care. The increase in summer temperatures generally, and an increased number of extreme heat events is the single most documented effect of climate change in the policy documents, being directly pointed out in the Eighth National Communication on Climate Change, the National Energy and Climate Action Plan, the National Climate Change Management Agenda, among others. Despite the wide coverage of the dangers from extreme heat, there are not many specific measures set out to tackle the problem. Article 35.1.5. of the National Climate Change Management Agenda identifies the increased need for green infrastructure, and better access to cooling areas. The need for access to available health care is also highlighted [70]. Lithuania, being a highly urbanized country, faces a growing need for climate-resilient urban planning as the number of high-temperature days continues to rise. Such planning is essential to mitigate the formation of urban heat islands and to promote the integration of cooling and heat recovery systems in both public and private buildings.

Compared to other climate change-induced risks, such as flooding, the risks of forest fires are widely acknowledged, with robust prevention and adaptation strategies in place. Current forestry design and management systems are tailored to reduce fire outbreaks and contain those that occur, accounting for hotter and drier summer conditions. However, there is no specific strategy addressing the heightened risks to public health. This showcases low integration of environmental and risk prevention policies from health policies, violating the health-in-all-policies principle.

Both the National Strategy for Climate Change Management Policy and the more recent National Climate Change Management Agenda acknowledge that Lithuania lacks a dedicated program for public health management and financing to address the prevention of climate change-induced diseases and health issues. These documents, along with the Eighth National Communication on Climate Change [70], also highlight a shortage of studies and training on the scope of these risks and the actions required to mitigate them. While it is recognized that climate change will place additional stress on the healthcare system in both the short and long term, efforts to improve and expand healthcare infrastructure remain largely general, lack specificity, with the exception of certain measures aimed at increasing capacity during extreme heat events.

5. Conclusions

Climate change-induced public health risks in Lithuania and the broader northern European region are related to extreme heat events, wildfires, flooding, air pollution, allergens and pollen, infectious diseases, airborne, waterborne and vector-borne pathogens, food insecurity, and mental health. These risks are amplified in Lithuania by risk multipliers such as ageing population, widespread chronic disorders, poverty, increasing urbanization, lack of physical borders and intense geographical mobility in the region. Effective governance of the public health risks includes pre-assessment, appraisal, characterization and management of risks, with attention to health-in-all-policies approach and stakeholder engagement.

Lithuania's response to climate change-induced public health risks is shaped by global and EU frameworks but lacks direct focus on public health, with key initiatives like ATACH remaining unadopted. Document analysis highlights gaps in monitoring and assessment, with existing indicators focusing primarily on environmental rather than public health dimensions. Adopting specialized indicators like those used internationally, and prioritizing regular national surveys could enhance the country's preparedness and response to these risks.

The network of stakeholders in the governance of public health risks caused by climate change in Lithuania is wide, spreading across different levels and sectors. The main drivers of interactions in this network are governmental institutions, which follow policies at a higher supranational or international level, and initiate cooperation with representatives of other sectors at the national level. Horizontal interdepartmental (intra-sectoral) linkages are weaker than those between national ministries and other sectoral actors at national level (cross-sectoral). Further research is needed to analyse vertical linkages, especially given the difficulty in identifying and accessing sources of information to assess civil-private sector collaborations within and between sectors and levels.

Policies in Lithuania encompass a broad range of climate change-induced public health concerns, demonstrating extensive policy coverage. Yet the policies are fragmented and compartmentalized, e. g. on wildfires, with low degree of alignment and support for related policies, e. g. links to implications of wildfires on public health, lacking a cohesive approach.

Limitations of the analysis include the need to access a wider range of sources, such as NGOs or private sector organizations, to fully explore the stakeholder network, and the analysis relied only on official policy documents, so the apparent focus on the active role of the government sector have been influenced by the preference for information sources. Another important limitation is that only formal documents and actors' interactions were analysed. Further research could rely more on the analysis of informal interactions and documents and include more inclusive methods such as stakeholder interviews. Participatory research could further add scientific value, as it would allow for a better assessment of the concerns and responses of affected social groups and would add equity and justice framework. The response element of the DPSIR framework should extend beyond analysing policy responses by policymakers to also include an examination of responses from the private sector, civic organizations, and communities, collectively addressing how variousision-makers respond to public health risks posed by climate

change.

Overall, it can be concluded that current governance structures for dealing with climate change-induced risks to public health in Lithuania are fragmented. The needed policy response is balancing on the nexus of health and climate change policies, yet these are often developed in siloed approach and evolve in isolation. Bridging this gap requires reflective governance, bolder uptake of available international mechanisms (like ATACH), better horizontal intra-sectoral and cross-sectoral cooperation, improved monitoring, and the health-in-all-policies approach.

CRediT authorship contribution statement

Rima Prosceviciute: Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Audrone Telesiene:** Writing – original draft, Visualization, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used SCOPUS AI tool integrated into Elsevier's Scopus database in order to enhance literature review. OpenAI's ChatGPT (GPT-4 version) was used for grammar and phrasing refinement. After using these tools, the authors reviewed and edited the content as needed and takes full responsibility for the content of the published article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sftr.2025.100627.

Data availability

Data will be made available on request.

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