



OPEN ACCESS

EDITED BY
Arthit Phosri,
Mahidol University, Thailand

REVIEWED BY
João Carlos Macedo,
University of Minho, Portugal

*CORRESPONDENCE
Toni Buterin
✉ toni.buterin@uniri.hr

RECEIVED 29 April 2025
ACCEPTED 08 July 2025
PUBLISHED 17 July 2025

CITATION
Buterin T, Rinčić I, Muzur A and
Doričić R (2025) Climate change from the
perspective of the New Public Health.
Front. Public Health 13:1620117.
doi: 10.3389/fpubh.2025.1620117

COPYRIGHT
© 2025 Buterin, Rinčić, Muzur and Doričić.
This is an open-access article distributed
under the terms of the [Creative Commons
Attribution License \(CC BY\)](#). The use,
distribution or reproduction in other forums is
permitted, provided the original author(s) and
the copyright owner(s) are credited and that
the original publication in this journal is cited,
in accordance with accepted academic
practice. No use, distribution or reproduction
is permitted which does not comply with
these terms.

Climate change from the perspective of the New Public Health

Toni Buterin^{1,2*}, Iva Rinčić^{1,2}, Amir Muzur^{1,2} and Robert Doričić^{1,2}

¹Faculty of Health Studies, University of Rijeka, Rijeka, Croatia, ²Faculty of Medicine, University of Rijeka, Rijeka, Croatia

The modern-day ecological crisis and gradual degradation of the environment, mostly due to anthropogenic effects, surpass other contemporary societal issues. Despite being largely perceived through a (bio)medical lens, the complexity of climate change as a topic is seen in different trends concerning its impact on the living world. These include historical, economic, cultural and social dimensions. Therefore, there is a need for an integrated and interdisciplinary approach resulting in more comprehensive measures to allow society to recover, but which also exploit the positive potential of climate change, through models and methods that the New Public Health can provide. Starting from the definition of the New Public Health, this paper combines and connects two topics, New Public Health and climate change, that are rarely explored together in the literature. The aim is to fill the gaps in the public health literature, where climate change is frequently viewed solely as a medical or health issue; here, we frame it as a critical challenge encompassing social, humanistic, and environmental dimensions. In addition, we offer a conceptual contribution that emphasizes their interconnection within the context of contemporary challenges.

KEYWORDS

climate change, the New Public Health, ecological crisis, society, adaptation

Introduction

The World Health Organisation emphasises that climate change represents one of the greatest global threats of our time (1, 2). The human impact on the natural environment has resulted in (ir)reversible processes, most often associated with industry (3, 4). Preventive measures and strategic planning therefore have a positive effect on the population's health by reducing the anthropogenic impact of environmental pollution (5). Although the greatest effect of climate change is on human health, it should not be viewed exclusively in medical terms. By broadening perspectives, moving away from an anthropocentric approach and integrating social, human, technical and natural sciences, we obtain a bio-social view of this public health and environmental issue. In this context, results can be more complete, and concrete action can be taken in line with climate policy (6, 7) in an interdisciplinary environment on which the foundations of the New Public Health concept rest (8, 9).

Environmental protection and climate change prevention policies are largely based on strategies, acts and measures to reduce pollution from industry, which has left a significant mark on the environment, population health, and even mortality (10, 11). We cannot deny the thesis that the widespread use of fossil fuels is a major contributor to climate change. Fossil fuels are the primary factor behind climate change that currently harm human health, wellbeing, and ecosystems. This point must be taken into account because without a full understanding of the causes and consequences of climate change, we cannot develop more effective solutions. While there are proponents of fossil fuel use, some sources

emphasize their benefits, particularly in driving economic progress and technological advancement, it is crucial to recognize that these views are widely debated within the scientific community. Many researchers advocate for a transition to renewable energy to mitigate environmental and health risks (12, 13), and this perspective has far more significant implications for the field of the New Public Health.

In this regard, an important contribution to the adaptation of society and the environment to climate change is provided by the synergy and integration of different disciplines. As industrial pollution and anthropogenic impacts are the main causes of global warming and climate change, the consequences for humans are mainly related to the biomedical aspects of their impact on health, which are mostly on the respiratory and cardiovascular systems. These impacts are also associated with the development of neoplasms, skin diseases, and neurodegenerative and endocrine disorders (14–16). The main subject of research in this area is air pollution, because it affects the largest number of systems in the human body (17). However, the impact on water and soil is neglected, though numerous ecological studies on water and soil pollution show significant consequences for public health (18). As a result, solutions are offered in terms of technical forms of reducing pollution (19, 20). Studies to date indicate that most research linking climate change and public health is focused on the deterioration of human health (21). Epidemiological data arising from human activities that cause climate change provide strong evidence of their impact on populations. The fact remains that Epidemiology needs to keep evolving by creating innovative methods and incorporating insights from other fields like geography and climatology (22). Numerous studies report increases in mortality and morbidity associated with air pollution (23), and such data combine descriptive and analytical approaches what play a crucial role in identifying causal links between environmental changes and health outcomes. Emphasizing these epidemiological insights is essential for guiding public health policies and interventions that address the real health threats posed by climate change, further reinforcing the need for an integrated and prevention oriented approach as advocated by the New Public Health.

Some research, however, suggests that more decisive responses are needed to address the challenges of climate change, which is adding further strain to the existing weaknesses in health systems. This not only affects health but is prompting a reassessment of priorities. The most effective responses appear to be strengthening key factors such as environmental management, and systems for monitoring and controlling the consequences of natural disasters and changes in infectious disease patterns. A more proactive approach to decision-making is called for. These interventions are often not new but rather build on existing tools that are underutilized due to key barriers such as a lack of political will or financial resources. Climate change therefore requires an intensification of preventive measures in public health, and this task should take a central place in sustainable development strategies (24).

The philosophy of the New Public Health seeks to balance the excessive emphasis on health preservation priorities exclusively through the biomedical aspect (8). Such an approach integrates various disciplines that are interrelated at the human-society level. Based on the application of a wide range of scientific and technological methods and evidence-based management models of various professional, political and ethical dimensions, it is possible to improve

attitudes toward prevention and protection of individual and societal health in a broader form (8).

Methods

Using a combined approach of a literature review and the description method, the key characteristics of the publications published so far on the topic of the New Public Health and climate change have been structured, synthesized and described in detail. Given that only a small amount of literature that directly connects these two topics has been found, the research question arises of whether there is a need for newer public health approaches and paradigms, and what are the key elements, challenges and interventions needed which are directly or indirectly related to climate change. With this critical review, we aim to identify the vulnerable dimensions of society, and trends and limitations in the integration of problems caused by climate change in the philosophy of the New Public Health by using more explicit present-day examples.

Results

The trend in the contemporary development of the New Public Health concept is interesting to follow. In the late 20th century, public health faced numerous challenges but also made significant progress. Each crisis in public health and weakening of it demonstrated the need for new approaches to dealing with a particular problem. The increase in chronic diseases and the increased manifestation of neoplasms required new preventive strategies, while infectious diseases remained the primary global threat. Therefore, scientists called for the reintegration of public health into clinical practice and advocated the need to consider medical history and better education (25, 26).

At the turn of the 20th and 21st centuries, globalization, urbanization and environmental issues further highlighted the need for integrated approaches to public health focused on prevention, education and strengthening health systems worldwide. Effective public health required building on the changes in society over the previous decade in moving toward a new approach to public health. It was necessary to move away from the dominance of the medical model and turn toward a socio-environmental model that would be more comprehensive in terms of sustainable health improvement (27).

In the 21st century, public health has faced numerous challenges that continue to threaten population health and that have been marginalized until now. The need has arisen to create priorities, especially improving basic healthcare for vulnerable groups, expanding cooperation among health partners, establishing broader disease surveillance, instituting early warning and rapid response systems, reducing morbidity and mortality (for mothers, newborns and children under five years of age), but also providing psychosocial support to victims (28). Environmental degradation, wars and terrorism, growing economic inequality, and weakening social ties have been the main threats. Although public health was once primarily focused on medical approaches, there is a growing need for multidisciplinary approaches, with an emphasis on the social, economic and environmental factors that shape people's health (29). It is necessary to go beyond the traditional approach to health by

including social factors that can affect the public health picture of the population (30). At the time, milestones in the development of public health have been presented through historical legacy, current status and innovative approaches to health promotion, but with an emphasis on striving to create newer approaches to solving problems at some future time that will again create new challenges (31).

The direct impact of climate change on population health, but also on society, is visible in meteorotropic diseases, while the indirect effect of weather variations can be seen in their impact on food production, the availability of drinking water, infrastructure, mental health and the transmission of infectious diseases. Many of the consequences of a polluted environment which can have an impact on health are visible only after some time or appear as longer-term consequences of chronic exposure. Other health risks include increasingly frequent climate variations that cause high-frequency and intense heatwaves, temperature oscillations, extreme precipitation changes and even fires (32). Just as climatic conditions can affect the causative agents of infectious diseases, they can also affect their carriers and vectors. The occurrence of vectors and the spread of infection are interrelated with climate change, which leads to the expansion of their habitats, but also the transmission routes of vector-borne diseases (33, 34). We are increasingly witnessing exceptional cases of flooding of coastlines, including island and coastal towns, while flora and fauna are changing their habitats depending on the need to adapt to new climate conditions. The complexity of the topic of climate change requires an interdisciplinary approach. Identifying vulnerable dimensions of society besides health, such as the economy or culture, can show different trends in the impact of climate change on society. Starting from the local community, it is possible to act at a global level – with models and methods for mitigating climate change and adapting and coexisting with it when it is already present – by expanding and integrating different scientific disciplines for more comprehensive action (35).

For these reasons, there is an increasing call for a redefinition of global public health. The challenges of the 21st century have resulted in threats that may be caused by climate change. These require, among other things, political action and systemic changes (36). We are witnessing how global climate summits and conferences are increasingly taking the form of public spectacles characterized by elitist approaches to organization, often lacking in concrete outcomes or meaningful agreements. Of course, exceptions exist, and certain individuals and initiatives do stand out even within such constrained settings. It is important not to overlook the pioneering efforts of the 1972 United Nations Conference on the Human Environment in Stockholm, which addressed environmental protection, including early concerns about climate change (37). Equally significant are the ongoing efforts of the *Intergovernmental Panel on Climate Change* (IPCC), which plays a central and irreplaceable role in understanding and managing climate-related challenges through a multidisciplinary approach at the global level (38).

We can certainly resort to such multidisciplinary solutions through the lens of the New Public Health, which has in recent times been keeping pace with global challenges. The basic prerequisites have already been created and are being developed from year to year, having significant importance in dealing with climate change (9).

Therefore, it seems crucial to: (I) increase the availability of information on climate change from different scientific and professional perspectives; (II) identify vulnerable bio-social elements

of society in relation to climate change; (III) increase the awareness and ability of the population to recover from the negative effects of climate change by popularising science; (IV) strengthen the social system by adapting to climate change and exploiting its possible positive potentials.

A comprehensive definition of health that refers to a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity (39), underlines the need to consider the broader picture of the consequences of climate change rather than just focusing on its medical ones. Climate change is a complex issue that shows different trends of influence across the historical, economic, cultural, economic, legal, social and political dimensions of society. Depending on the values of an individual or group, the focus of combating climate change, adapting to it or promoting climate action will depend on perceptions and needs (6). When seen from a cultural approach, where culture and tradition intertwine through a dynamic process of adaptation and transformation, climate change affects the culture, identity and material heritage of communities, while cultural patterns shape the perception of the population and thus (their) responses to environmental challenges (40). Climate change can also be viewed from the sociological perspective – for example, through rapidly increasing climate-driven migrations that (un)consciously change demographic structures, causing social tensions and impacting the identity of communities (and which may be interrelated with the previously mentioned cultural perspective). At the same time, social responses to migration result in new needs for adaptation and solidarity toward vulnerable populations (41, 42). Economic activity is not devoid of consequences in terms of the impact of climate change either. This is particularly true for the tourism sector, where both positive and negative consequences can be seen. On the one hand, a warmer climate can prolong the tourist season in certain regions and attract tourists, which can boost economic growth. On the other hand, extreme weather conditions, rising sea levels and the destruction of natural resources can lead to the migration of local populations (which can again be linked to the previously mentioned sociological perspective) and the loss of the attractiveness of tourist destinations, but also cause a loss of tourist revenues (43–45). Agronomy and agriculture should not be ignored either. In this area, there is a possibility of improving the conditions for growing certain crops in new regions where this has not previously been possible. However, on the other hand, there is a danger of droughts, floods and fires that can reduce yields, increase production costs and threaten food security (46, 47). The health component largely encompasses the impact on human organ systems and the spread of diseases. However, it is equally important to pay attention to the social dimension of health – especially regarding working environment and conditions (48, 49). There are other fields and disciplines such as bioethics, ecoethics and environmental ethics that contribute to understanding the problem and that attempt to participate in the study of climate change through an interdisciplinary approach that comprises ethics, values and responsibility both in real time and for the future (50–52).

In the case of climate change, it is clear that resources, which have already come under significant strain, are being additionally burdened. This further highlights the importance of integrated surveillance systems for future adaptations (21). Therefore, the intertwining and interdependence of the previously identified vulnerable dimensions of society affected by climate change require the constant updating and modernisation of a discipline like public health – regardless of

whether we call it *Public Health*, *New Public Health* or *Newer Public Health*. Interventions and strategies for adaptation to and/or mitigation of the impact of climate change will need to adjust to new challenges that are already present, but also to those that are coming. It is of great importance to adopt innovative forms, increase awareness and the ability of society to recover, and to exploit any positive potentials through appropriate communication and more effective actions that keep pace with the times (53, 54). These can be found in the guiding principles of the New Public Health philosophy (9).

Conclusion

The challenges posed by climate change are most often associated with health issues and are rarely considered in the specific context of the New Public Health. Although there are clear and scientifically based links between climate change and the philosophy of the New Public Health, we believe that scientific discourse needs to emphasize them more explicitly and more frequently. This Mini Review explores the relationship between climate change and the New Public Health, two distinct yet interconnected phenomena that are still rarely and insufficiently addressed together in current literature. In light of the escalating global health threat posed by climate change, the review underscores the relevance of the New Public Health paradigm, with particular emphasis on interdisciplinarity, community engagement, and proactive protection strategies. This approach offers a valuable framework for both adaptation and mitigation efforts. Key priorities include: improving the accessibility of climate change-related information across scientific and professional domains; identifying vulnerable bio-social segments of society to better inform protective interventions; promoting scientific literacy and public engagement to enhance societal resilience; and strengthening the social system through adaptive strategies that also acknowledge and harness the potential positive aspects of climate change.

Climate change brings risks that go beyond the medical aspect and encompass other ecological, economic, business and social issues. The future development of public health should include more systematic research and integration of the impacts of climate change into the broader spheres of protection and adaptation policies and strategies. We need to encourage an inter/multi-disciplinary approach that will connect experts from different fields in order to provide comprehensive solutions to the challenges posed by the climate crisis. This paper encourages further academic discussion about the need for frequent transformation and modernization of public health in the era of climate change, and provides a basis for the development of policies

aimed at longer-term sustainability. Its importance lies in its contribution to the understanding of the interdependence of the environment and people and the need to integrate all the factors that create their interrelationship within the discipline of the New Public Health.

Author contributions

TB: Writing – original draft, Investigation, Resources, Writing – review & editing, Methodology, Project administration, Conceptualization. IR: Writing – review & editing, Validation, Supervision. AM: Formal analysis, Supervision, Methodology, Validation, Writing – review & editing. RD: Supervision, Writing – review & editing, Visualization, Validation.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This work has been fully supported by the University of Rijeka project uniri-mladi-biomed-23-16.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Briggs D, Corvalan CF, Nurminen M. Linkage methods for environment and health analysis: General guidelines. Geneva: World Health Organization (1996).
2. World Health Organization. Health, environment and climate change: report by the director-general report no.: 71 (2018). A71/10:1. Available online at: <https://apps.who.int/iris/handle/10665/276332> (Accessed November 15, 2024).
3. Simmons IG. Global environmental history. 10,000 BC to AD 2000. Edinburgh: Edinburgh University Press (2008).
4. Huges JD. What is environmental history? Cambridge: Polity Press (2006).
5. O'Neill MS, Carter R, Kish JK, Gronlund CJ, White-Newsome JL, Manarolla X, et al. Preventing heat-related morbidity and mortality: new approaches in a changing climate. *Maturitas*. (2009) 64:98–103. doi: 10.1016/j.maturitas.2009.08.005
6. Bouman T, Steg L, Perlaviciute G. From values to climate action. *Curr Opin Psychol*. (2021) 42:102–7. doi: 10.1016/j.copsyc.2021.04.010
7. Steg L. Psychology of climate change. *Annu Rev Psychol*. (2023) 74:391–421. doi: 10.1146/annurev-psych-032720-042905
8. Tulchinsky TH, Varavikova EA. What is the “new public health”? *Public Health Rev*. (2010) 32:25–53. doi: 10.1007/bf03391592
9. Tulchinsky TH, Varavikova EA, Cohen MJ. The new public health. 4th ed Academic Press (2023).
10. Bressler RD. The mortality cost of carbon. *Nat Commun*. (2021) 12:4467. doi: 10.1038/s41467-021-24487-w

11. Buterin T, Doričić R, Broznić D, Ćorić T, Muzur A. The Labin region, an ecologically vulnerable geographical area in Croatia: mortality characteristics in an area polluted by industrial over a 40-year period. *Geospat Health*. (2022) 17. doi: 10.4081/gh.2022.1082
12. Lelieveld J, Klingmüller K, Pozzer A, Burnett RT, Haines A, Ramanathan V. Effects of fossil fuel and total anthropogenic emission removal on public health and climate. *Proc Natl Acad Sci USA*. (2019) 116:7192–7. doi: 10.1073/pnas.1819989116
13. Lehtomäki H, Rao S, Hänninen O. Phasing out fossil fuels would save millions of lives worldwide. *BMJ*. (2023) 383:p2774. doi: 10.1136/bmj.p2774
14. Prüss-Üstün A, Wolf J, Corvalán C, Bos R, Neira M. Preventing disease through healthy environments. A global assessment of the burden of disease from environmental risks. Second Edition. Geneva, Switzerland: World Health Organization (2016).
15. Bongioanni P, Del Carratore R, Corbianco S, Diana A, Cavallini G, Masciandaro SM, et al. Climate change and neurodegenerative diseases. *Environ Res*. (2021) 201:111511. doi: 10.1016/j.envres.2021.111511
16. Science for Environment Policy. What are the health costs of environmental pollution? 21. Bristol: UWE (2018).
17. Juginović A, Vuković M, Aranza I, Biloš V. Health impacts of air pollution exposure from 1990 to 2019 in 43 European countries. *Sci Rep*. (2021) 11:22516. doi: 10.1038/s41598-021-01802-5
18. Lillini R, Tittarelli A, Bertoldi M, Ritchie D, Katalinic A, Pritzkeleit R, et al. Water and soil pollution: ecological environmental study methodologies useful for public health projects. A literature review. *Rev Environ Contam Toxicol*. (2021) 256:179–214. doi: 10.1007/398_2020_58
19. Remoundou K, Koundouri P. Environmental effects on public health: an economic perspective. *Int J Environ Res Public Health*. (2009) 6:2160–78. doi: 10.3390/ijerph6082160
20. Campbell-Lendrum D, Neville T, Schweizer C, Neira M. Climate change and health: three grand challenges. *Nat Med*. (2023) 29:1631–8. doi: 10.1038/s41591-023-02438-w
21. Rocque RJ, Beaudoin C, Ndjaboue R, Cameron L, Poirier-Bergeron L, Poulin-Rheault RA, et al. Health effects of climate change: an overview of systematic reviews. *BMJ Open*. (2021) 11:e046333. doi: 10.1136/bmjopen-2020-046333
22. Xun WW, Khan AE, Michael E, Vineis P. Climate change epidemiology: methodological challenges. *Int J Public Health*. (2010) 55:85–96. doi: 10.1007/s00038-009-0091-1
23. Liu C, Chen R, Sera F, Vicedo-Cabrera AM, Guo Y, Tong S, et al. Ambient particulate air pollution and daily mortality in 652 cities. *N Engl J Med*. (2019) 381:705–15. doi: 10.1056/NEJMoa1817364
24. Campbell-Lendrum D, Corvalán C, Neira M. Global climate change: implications for international public health policy. *Bull World Health Organ*. (2007) 85:235–7. doi: 10.2471/BLT.06.039503
25. Horton R. The new new public health. *Lancet*. (1998) 352:904.
26. Frenk J. The new public health. *Annu Rev Public Health*. (1993) 14:469–90. doi: 10.1146/annurev.pu.14.050193.002345
27. Baum F. The new public health: An Australian perspective. Melbourne: Oxford University Press (1998).
28. Puntarić D, Ropac D, Jurčev Savičević A. Javno zdravstvo [Public Health]. Zagreb: Medicinska naklada (2015).
29. Baum F. The new public health. South Melbourne, VIC: Oxford University Press (2002).
30. Rosenbrock R. Was ist New Public Health? [What is the New Public Health?]. Bundesgesundheitsblatt – Gesundheitsforschung – Gesundheitsschutz umfasst (2001) 44:753–62. doi: 10.1007/s001030100231
31. Awofeso N. What's new about the "new public health"? *Am J Public Health*. (2004) 94:705–9. doi: 10.2105/ajph.94.5.705
32. Patz JA, Hatch MJ. Public health and global climate disruption. *Public Health Rev*. (2013) 35:1–23.
33. Buterin T, Doričić R, Eterović I, Muzur A, Šantić M. Javnozdravstvena perspektiva utjecaja industrijskog onečišćenja na globalno zatopljenje i pojavnost zoonoza [public health perspective of the impact of industrial pollution on global warming and the incidence of zoonoses]. *Šumar List*. (2021) 145:63–9. doi: 10.31298/sl.145.1-2.6
34. Ogden NH. Climate change and vector-borne diseases of public health significance. *FEMS Microbiol Lett*. (2017) 364. doi: 10.1093/femsle/fnx186
35. Tulchinsky TH, Varavikova EA. Expanding the concept of public health. *New Public Health*. (2014):43–90. doi: 10.1016/B978-0-12-415766-8.00002-1
36. Goniewicz K, Burkle FM, Khorram-Manesh A. Transforming global public health: climate collaboration, political challenges, and systemic change. *J Infect Public Health*. (2025) 18:102615. doi: 10.1016/j.jiph.2024.102615
37. United Nations. Report of the United Nations conference on the human Stockholm, 5–16 June 1972. United Nations. (1973). Available online at: <https://undocs.org/en/A/CONF.48/14/Rev.1>
38. Paglia E, Parker C. The intergovernmental panel on climate change: Guardian of climate science In: A Boin, LA Fahy and P t Hart, editors. Guardians of public value. Cham: Palgrave Macmillan (2021)
39. World Health Organization. Basic documents: forty-ninth edition (including amendments adopted up to 31 may 2019) (49th Edn.). Geneva, Switzerland: World Health Organization (2020) p. 1.
40. Clark Barrett H, Armstrong J. Climate change adaptation and the back of the invisible hand. *Philos Trans R Soc Lond Ser B Biol Sci*. (2023) 378:0220406. doi: 10.1098/rstb.2022.0406
41. Ladas I. Global health, climate change, and migration: ethical issues. *Jahr- Europ. J. Bioethics*. (2024) 15:87–106.
42. Balsari S, Dresser C, Leaning J. Climate change, migration, and civil strife. *Curr Environ Health Rep*. (2020) 7:404–14. doi: 10.1007/s40572-020-00291-4
43. Remoaldo P, Lopes H, Ribeiro V, Alves J eds. Tourism and climate change in the 21st century: Challenges and solutions. Cham: Springer Nature Switzerland (2024).
44. Semenza JC, Ebi KL. Climate change impact on migration, travel, travel destinations and the tourism industry. *J Travel Med* (2019) 11:26:taz026.
45. Gössling S, Scott D. Climate change and tourism geographies. *Tourism Geogr*. (2024) 27:1. doi: 10.1080/14616688.2024.2332359
46. O'Brien P, Kral-O'Brien K, Hatfield JL. Agronomic approach to understanding climate change and food security. *Agron J*. (2021) 113:4616–26. doi: 10.1002/agj2.20693
47. Grados D, Kraus D, Haas E, Butterbach-Bahl K, Eivind Olesen J, Abalos D. Common agronomic adaptation strategies to climate change may increase soil greenhouse gas emission in northern Europe. *Agric For Meteorol*. (2024) 349:109966
48. Ferrari GN, Leal GCL, Thom de Souza RC, Galdamez EVC. Impact of climate change on occupational health and safety: a review of methodological approaches. *Work*. (2023) 74:485–99. doi: 10.3233/WOR-211303
49. Levi M, Kjellstrom T, Baldasseroni A. Impact of climate change on occupational health and productivity: a systematic literature review focusing on workplace heat. *Med Lav*. (2018) 109:163–79. doi: 10.23749/ml.v109i3.6851
50. Macpherson CC. Climate change is a bioethics problem. *Bioethics*. (2013) 27:305–8. doi: 10.1111/bioe.12029
51. Macedo JC. Climate change: a bioethical emergency and health priority. *Ethics Med Public Health*. (2023) 27:100872. doi: 10.1016/j.jemep.2023.100872
52. Butler CD. Bioethics, climate change, and civilization. *J Climate Change Health*. (2024) 18:100329. doi: 10.1016/j.jocl.2024.100329
53. Cheng JJ, Berry P. Health co-benefits and risks of public health adaptation strategies to climate change: a review of current literature. *Int J Public Health*. (2013) 58:305–11. doi: 10.1007/s00038-012-0422-5
54. Ansah EW, Amoade M, Obeng P, Sarfo JO. Health systems response to climate change adaptation: a scoping review of global evidence. *BMC Public Health*. (2024) 24:2015. doi: 10.1186/s12889-024-19459-w