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Review

Climate change and health of the urban poor: The role of environmental justice

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ABSTRACT

Direct effects of climate change on health, such as a rise in the incidence of heat strokes due to summer heatwaves, and indirect health effects such as under-nutrition due to a rise in food prices because of climate change, are mediated through the social and environmental determinants of health (SEDH), which include but are not limited to potable water, clean air, adequate sanitation, safe shelter, and adequate food. Based on a narrative review, this paper identifies possible mechanisms through which human health is impacted by climate change. Evidence has shown that climate change-induced effects such as high temperatures and heat waves, Water, Sanitation and Hygiene (WASH), vector-borne diseases and undernutrition lead to undesirable health outcomes for the urban poor through unfavorable SEDH. Given that health of the urban poor is anticipated to be disproportionately affected by the risks of changing climate, this paper emphasizes the need for focusing on the environmental justice approach to safeguard the health of the urban poor in developing countries. It also argues for strengthening participatory and transparent urban governance to upgrade informal settlements and address factors that enhance health vulnerabilities of the urban poor. It contributes to the limited literature on environmental justice in the context of developing countries and provides a rationale behind mainstreaming the environmental justice approach for reducing the climate change-induced health risks for the urban poor.

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Introduction

Climate change is expected to augment health risks, particularly for inhabitants of the poorest sections in cities of the developing world and it is widely argued that the urban poor face the brunt of climate change-induced health risks [1]. Both the direct effects of climate change on health, such as a rise in the incidence of heat strokes due to heatwaves, and the indirect health effects such as under-nutrition due to rises in food prices as a result of climate change, are mediated through the social and environmental determinants of health (SEDH). Typically, the conceptual approaches to social determinants of health (SDH) have drawn attention to social and political contexts (such as labor markets, political systems) that create differential socioeconomic positions. These hierarchies influence health status via behavioral factors (such as physical activity and nutrition), material (such as housing and working conditions) and psychosocial circumstances (such as stress and social support systems). Environmental determinants are linked to the SDH conceptualization because differences in social hierarchies create differential exposure to biophysical environments [2]. However, since the standard SDH

conceptualization does not explicitly recognize the role of biophysical environments on health, we consider social and environmental determinants as distinct in our analysis and use the term SEDH throughout.

The urban poor are disproportionately vulnerable to both the direct and indirect health effects of climate change via a number of factors such as the precarious nature of their livelihoods, poor housing conditions, inadequate means to mitigate the impact of climate change and limited access to health care sector resources. Given that the global urban population is projected to witness an unprecedented rise from 4.4 billion in 2020 to 6.3 billion in 2050, with the less developed regions accounting for almost 82 percent of the aggregate population in urbanized regions of the world, health risks associated with climate change are anticipated to be severe for the urban poor. Importantly, Asia and Sub-Saharan Africa are expected to contribute as much as 70 percent to the total urban population worldwide in 2050 [3,4]. By compounding existing health risks and urban social inequities, climate change will further cause health inequities to become more entrenched in urban areas of developing countries [5].

The concept of rural-urban migration is integral to the process of urbanization. Rural migrants constitute a substantial percentage of the urban poor in several cities of the world, which makes them particularly vulnerable to the adverse consequences posed by climate

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change [6]. In developing countries, internal migration is often regarded as a response to climate change. Since agricultural activities are under constant jeopardy in rural areas due to land degradation and persistent changes in temperature and rainfall patterns, pressure to seek alternative avenues of employment spurs rural-urban migration [7,8].

Since those who are compelled to undertake distressed rural-urban migration are typically marginal cultivators and agricultural laborers who have limited access to social networks in cities where they arrive, they have no option but to settle for low-paying and risky jobs. They live in densely populated informal settlements, with inadequate or absent access to sanitation, drinking water, sufficient food and nutrition, and waste management services [6]. Therefore, due to their socioeconomic status (SES), rural-urban migrants are doubly exposed to the detrimental impacts of climate change – first, by losing their former source of agricultural livelihood that becomes unviable due to altered climate in rural areas, and second, by working and living conditions in cities which further expose them to the adverse impacts of climate change. Furthermore, the urban poor face denial of basic citizenship rights even in their own countries and can seldom access appropriate health care in cities, thereby becoming victims of exclusionary policies [6]. Studies have indicated that even when the urban poor have lived in cities of developing countries for decades, they are largely regarded as migrants, and their alleged migrant status deprives them of health care and other basic services in urban settlements [9].

As rapid rates of urbanization are bound to cause further alterations to land use patterns, the urban poor may be subjected to increased frequency and intensity of deleterious health effects stemming from climate change [3]. Using the notion of environmental justice is important in deliberations linked to the climate change-induced impact on health of the urban poor. Since the urban poor are exposed to insurmountable degrees of environmental disamenities such as land degradation, toxic air, hazardous waste and contaminated water due to their low SES, the environmental justice approach offers a framework for safeguarding the fundamental interests of the most vulnerable communities, including the right to life [10,11].

Given that health of the urban poor is anticipated to be disproportionately impacted by the risks of a rapidly changing climate, this paper emphasizes the need for focusing on environmental justice. Despite a dearth of literature in the context of developing countries, this paper provides a rationale behind introducing the environmental justice approach. We restrict the scope of present analysis to developing countries and urban settings.

Section 2 of this paper details the methods used. Section 3 undertakes an assessment of possible mechanisms through which health of the urban population, particularly those living in informal settlements, is affected as a result of climate change, enhancing urban health inequities. Section 4 advocates for mainstreaming the approach of environmental justice to remedy the adverse impact of climate change on health of the poor and vulnerable sections in urban areas and Section 5 concludes and presents a way forward.

Methods

Search strategy

The literature referred to in this narrative review was first identified in May and June 2021 on Google Scholar and PubMed. A second round of literature selection was conducted in December 2022 on the same electronic databases. The literature search was performed using combinations of keywords including 'climate change', 'human health', 'health', 'urban poor', 'cities', 'environmental justice', 'inequities', 'developing countries', 'social determinants of health' and 'environmental determinants of health'. Only peer-reviewed, English

language articles published between 2000 and 2022 were shortlisted in both rounds of the literature search.

The two rounds of literature search yielded 48 full-text references. Additional literature was identified from the reference lists of the shortlisted articles. This included gray literature encompassing crucial reports on climate change and health. Empirical studies measuring ambient pollutant concentrations in urban settings were eliminated from the present analysis. Screening of title, abstracts and introductions of 54 references was conducted and 37 references were considered appropriate for inclusion in the current review.

Quality assessment

All the 37 references met the minimum threshold scores. Narrative review articles were assessed using the Scale for the Assessment of Narrative Review Articles (SANRA) criteria (Table A.1) [12]. Qualitative studies and systematic reviews were assessed using the Critical Appraisal Skills Program (CASP) checklists (Tables A.2 and A.3) [13,14]. CASP scores were adapted from a prior study on factors governing HIV-self testing in Africa [15]. Quality of mixed-method studies was assessed using the Mixed Methods Appraisal Tool (MMAT), version 2018 [16]. Although the MMAT does not provide cut-off scores, a scoring scheme was developed to appraise the quality of mixed-method studies (Table A.4). The AACODS checklist was used to assess the quality of grey literature (Table A.5) [17]. Finally, a modified version of ISPOR Task Force on Good Research Practices was used to review the quality of modeling-based empirical studies (Table A.6) [18].

Climate change and urban health

Climate change impacts human health through a number of pathways. However, since SEDH play a decisive role in determining the direct and indirect impact of climate change on human health, these pathways lead to differential health impacts. This section discusses these mechanisms:

High temperatures and heat waves

One of the most profound and straightforward implications of climate change has been the rise of average surface temperatures. While the Paris Agreement envisaged the reduction of global warming to below 2-degree Celsius, and preferably below 1.5-degree Celsius, compared to pre-industrial levels, current projections indicate that global average temperature could rise by 3 to 5 degrees Celsius by the end of the century, given the existing pace of emissions of greenhouse gases [19,20].

Cities are particularly vulnerable to the impact of extreme heat in summers because of the urban heat island (UHI) effect. The UHI effect in cities is regarded as a result of higher population density, limited vegetation and green cover, and concentration of concrete structures. Cities on marginal lowlands are more prone to hot and humid conditions, which makes residents vulnerable to several health risks associated with higher temperatures [5]. As much of the day heat is retained by concrete buildings in the absence of vegetation and green cover, night temperatures are likely to rise in cities with temperate and tropical climates. It is due to the UHI effect that temperatures in the interiors of cities are higher than areas on the outskirts [21].

While climate change may cause marginal changes in average temperatures, changes in temperature extremes are likely to be substantial [21]. Evidence indicates that the UHI effect is correlated with more intense impact of heat waves on populations, which is anticipated to be more severe for cities that are witnessing a rise in population. This implies that populations living in developing countries are particularly vulnerable to the adverse health impact of heat waves [22]. A recent study based on India demonstrated that while 3014

men and 849 women died due to heat-related causes in 2001–05, the corresponding estimates had increased to 5157 and 1254 in 2011–15. Further, the study concluded that the number of deaths attributable to heat-related causes were more than the number of deaths caused by other natural calamities such as avalanches, earthquakes and floods [23].

Since there is a rise in the level of ambient air pollution during heat waves, heat-related causes of mortality, such as hyperthermia and heat stroke, are often accompanied by a rapid surge in deaths due to non-communicable diseases like respiratory, cardiovascular, cerebrovascular, nervous and endocrine diseases [24,25]. Certain studies have also indicated that compared to higher income groups, the urban poor are more vulnerable to chronic respiratory conditions following air pollution exposure due to their overall suboptimal health status [26]. Moreover, since a considerable fraction of urban poor fulfill their daily energy needs for cooking and heating by combustion of solid fuels, indoor air pollution may worsen the human health impact of climate change [27].

Given that heat is associated with both environmental and occupational hazards, the impact of heat waves on health of the urban poor is likely to be much more significant vis-à-vis economically privileged individuals because the urban poor are less insulated against the effects of heat both in their living and occupational environments. The urban poor are often daily wage earners and are engaged in informal jobs that require them to stay outdoors [21] and generally have insufficient means to escape the impact of heat waves by purchasing air conditioners. Extreme heat may compel them to forego incomes by working outdoors for shorter durations, thereby pushing them further into poverty and exposing them to health-damaging impacts of climate change [28].

Climate change and water, sanitation and hygiene (WASH)

Informal settlements in cities face acute water shortages, which may be exacerbated as a result of a changing climate. Climate change may adversely impact water availability through extreme rainfall events, i.e., droughts and floods, which can both overwhelm urban amenities and pose sizable health risks [29]. An increase in the occurrence of droughts has been registered both in cities which depend on perennial rivers for their water supply, and in those which rely on aquifers. While a rise in temperature has accelerated the pace of melting of glaciers and led to an increase in the flow of water in rivers, this impact may cease to exist in the long run. Rapidly melting and disappearing glaciers will no longer contribute water to some of the perennial rivers, making these rivers seasonal and causing acute water shortages in cities. Furthermore, cities which source their water from coastal and inland aquifers are increasingly experiencing groundwater depletion and salinization [21]. Water scarcity presents serious challenges from the perspective of the urban poor who may not be able to purchase water from other sources [29]. The incidence of heavy rainfall and floods is also anticipated to increase as a result of climate change.

Summer droughts can also lead to a deterioration in water quality because an abnormal rise in water temperature can restrict the dilution of pollutants [30]. Similarly, flooding causes contamination of both surface water and groundwater [31]. While the extent of water contamination during floods depends on the duration and intensity of rainfall, water contaminants may include toxic substances like heavy metals and pesticides [21]. In fact, water pollution is a leading environmental risk factor for cities and a surge in the incidence of water-borne diseases, such as diarrhea and cholera, during and post the occurrence of extreme rainfall events, has been observed in developing countries. Vulnerability to water-borne diseases is exacerbated by a lack of good hygiene practices, such as handwashing with soap before meals and after defecation. Lack of proper sanitation facilities is often associated with fecal contamination of water

sources, which is regarded as an important cause for endemic diarrheal disease and cholera [32,33].

As rapidly urbanizing cities are incapacitated in providing equitable access to improved water and sanitation facilities, the urban poor are likely to suffer from WASH-related ill-effects of climate change. Moreover, informal settlements in cities are situated in low-lying areas that increase their vulnerability to floods and the ensuing health risks. Several informal settlements may also face perennial water shortages because of their unrecognized status [6].

Vector-borne diseases

Climate change is known to cause an increase in the burden of vector-borne diseases such as dengue, malaria and lymphatic filariasis. A rise in the incidence of vector-borne diseases may be attributed to a number of meteorological and man-made factors. For instance, an increase in temperatures, precipitation and humidity is associated with enhancing the reproductive rate, biting propensity and longevity of vectors, and shortening the development span of pathogens that are carried by vectors [34]. Climate change has also increased the occurrence of droughts in several parts of the world. This has led people to adopt a range of coping strategies including water storage and migration with drastic alterations in vector ecology. While significant gains have been achieved in terms of reducing global mortality from vector-borne diseases, emergence and re-emergence of vector species, and rapidly increasing insecticide and drug resistances pose serious threats, particularly for developing countries [35].

Vector-borne diseases are endemic in developing countries due to their tropical climates and unfavorable SES of a vast proportion of the population. For instance, a rising incidence of dengue in urban areas is considered an outcome of substandard housing structures and inadequate provision of safe water, sanitation and waste management services [21,35]. Furthermore, poor drainage systems, a common feature of informal settlements, facilitate breeding of vectors which may lead to potentially life-threatening conditions such as filariasis, dengue and malaria [36].

Undernutrition

Climate change may severely impact the nutrition levels of the urban poor, primarily by increasing global average temperatures and causing extremes in rainfall patterns. These factors are vital to agricultural productivity as they affect the conditions conducive for agriculture and impact the availability and quality of water required for irrigation [5,37]. An increase in the frequency of droughts and floods has already started impacting crop yields in different parts of the world. Combined with the rise in global population and reduced availability of agricultural land and water, a decline in crop yields could pose significant risks to global food security. The urban poor are likely to face the brunt of the global food crisis as unlike subsistence farmers, they procure food supplies from markets. Surges in food prices can adversely affect the budget of the urban poor and compel them to reduce their food consumption, thereby impacting their nutritional status [5] (Fig. 1).

The urban poor are also more vulnerable to the aforementioned health risks resulting from climate change due to their limited capacity to access appropriate health care in urban settings. Health care access in developing countries is impeded by factors such as limited public sector funding, growing privatization of health care, catastrophic health care expenditures and reduced efficiency and quality of public health care [38]. Combined with these barriers to health care access, the climate change-induced health risks discussed above could pose disproportionate health care and human costs on the urban poor and increase health inequities in developing countries. Furthermore, as the urban poor often become victims of

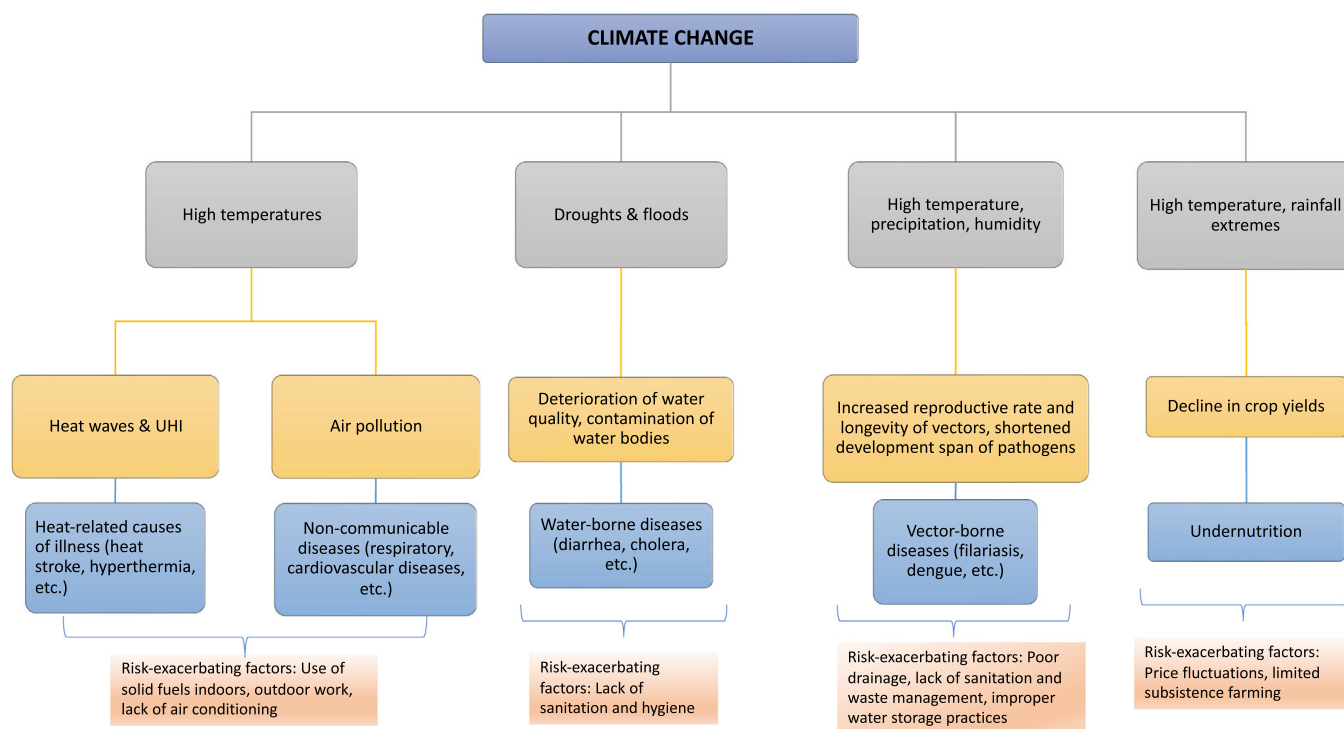


Fig. 1. Associations between climate change and health of the urban poor.

recognitional injustice in cities, their access to health care may be further curtailed [6].

The case for environmental justice

The principle of environmental justice provides a normative framework to ensure that disadvantaged population groups do not suffer from the disproportionate human health impact of environmental hazards (such as industrial pollution) and unintended environmental impacts of laws and policies. According to the U.S. Environmental Protection Agency (EPA), environmental justice is 'the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies' [39].

The notion of environmental justice originated in the early 1980s when vulnerable African-American groups in North Carolina protested against a proposal that sought to designate an area as a dumping site for toxic waste in their neighborhood. Subsequently, a substantial amount of evidence established how the impact of pollution was being disproportionately borne by impoverished and marginalized households and communities [40]. For instance, in a landmark study that was published in 1983, the US General Accounting Office highlighted the linkages between race and location of sites for toxic waste and observed that three out of four hazardous waste landfills were located close to minority community households in the Southeastern part of the United States. In 1987, another study led by the United Church of Christ Commission for Racial Justice demonstrated that environmental disamenities were also excessively concentrated in communities of color [11].

The concept of environmental justice has had a long history. For instance, Taylor traced the origins of environmental justice to the seventeenth century and showed that environmental concerns in urban areas have been a major source of distress for the poor residing

in rapidly industrializing cities [41]. Simply put, scholars in the realm of environmental justice have shown that socioeconomic determinants such as race, ethnicity and income of households influence the spatial design of cities by governing the development of their commercial and residential structures. Furthermore, while the less affluent areas in cities endure an inordinate burden of environmental hazards such as air pollution and inadequate management of waste, recent scholarly work has shown that these areas seldom have sufficient access to environmental benefits such as parks, tree cover and playgrounds, which are associated with significant health benefits for residents [10].

Within the purview of environmental justice, climate justice has recently originated as a popular subfield [10]. While environmental justice has conventionally emphasized the need to address the inequitable distribution of environmental disamenities, concerns related to the unequal impact of global climate change have assumed center stage in the climate justice approach. The climate justice approach has given thrust to the idea that nations which have contributed the most to climate change to achieve economic gains should be held responsible for causing climate change and compensate for its consequences. Thus, unlike environmental justice, advocates of climate justice have argued for restorative justice, i.e., resource transfer from those who have caused climate change to those who bear its cost [11].

Even though it is widely asserted that climate justice has largely conceptualized the issue of climate change and its ramifications at the international level, the fact that climate change has local manifestations suggests that it is impossible to conceive the notion of climate justice without consolidating both local and global perspectives associated with climate change [10,11]. Still, the environmental justice framework is criticized for being overly preoccupied with local environmental concerns that have limited relevance in the context of global climate change. However, there is sufficient evidence to show that movements supporting environmental justice have given due recognition to global policies and have also developed linkages with disadvantaged communities in other parts of the world. Moreover, the focus of environmental justice on local procedures and policies

seems justified from the perspective of dealing with the impact of climate change and formulation of effective policies to cater to adaptation and mitigation needs at the local level. In fact, the environmental justice framework not only facilitates adaptation to climate change but also focuses on addressing risk factors that affect vulnerability [11]. Therefore, it may be argued that in addition to encompassing vital aspects that are relevant to climate change, environmental justice promotes the climate justice approach which further reinforces the environmental justice movement.

Concluding observations

Using a narrative review, this paper makes a case for addressing SEDH and mainstreaming environmental justice to protect the health of the urban poor from climate change-induced consequences. Given that an estimated 1 billion people live in informal settlements of urban areas in developing countries, the human health risks posed by climate change could be substantial without tackling SEDH [4,42]. Local governments should ensure the provision of improved living and working conditions, safe drinking water, waste management, and drainage. However, a major impediment associated with provision of such amenities is that these are situated outside the legal framework of land ownership and use. In view of such challenges, upgradation of informal settlements is increasingly regarded as a promising solution from the perspective of mitigating health risks for the urban poor and increasing their overall resilience to climate change [4,43]. Therefore, in addition to addressing SEDH, the role of participatory and transparent urban governance is integral to safeguarding the health of the urban poor from climate change-induced impacts [43]. Furthermore, state governments could play a vital role in strengthening health care systems in cities, which could significantly reduce human health risks associated with climate change.

Although the environmental justice framework has been extensively used in the context of developed countries, it has been rarely referred to for addressing human health risks posed by climate change in developing countries. In order to deal with the climate change-induced impact on health of the urban poor, mainstreaming the environmental justice approach is of utmost importance. Given that governments in developing countries are often challenged by financial bottlenecks, policy measures to support environmental justice should explore the potential of public-private-partnerships (PPPs). PPPs have shown promise in solid waste management in developing countries like Lebanon [44]. Moreover, since developing countries are largely dependent on fossil fuels for meeting their energy needs, PPPs could help exploit the potential of renewable energy sources, which could reduce carbon footprints and limit the pace of climate change.

A major challenge in the implementation of policy alternatives recommended above is that both SEDH and climate change are dynamic systems that are constantly changing and interacting with each other. Therefore, developing countries may find it challenging to establish the impact and estimate the economic and welfare gains achieved from these policies. This is important because initial trade-offs between the status quo and recommended policy alternatives could deter governments from pursuing alternatives that could accrue long-term economic, environmental and health gains. From this perspective, systems thinking approaches that consider the complexity of dynamic systems and analyze ways in which such systems are interconnected are crucial in the long-run to inform evidence-based policymaking.

Author agreement statement

I the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. I confirm that the manuscript has been read and

approved and that there are no other persons who satisfied the criteria for authorship but are not listed. I understand that as the Corresponding Author, I am the sole contact for the Editorial process. I am responsible for communication concerning progress, submissions of revisions and final approval of proofs.

Declaration of Competing Interest

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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References

- [1] Discover Society. Climate change: the ultimate class conflict, <https://archive-discoverysociety.org/2019/03/06/climate-change-the-ultimate-class-conflict/>; 2019 [accessed 24 August 2023].
- [2] Graham H, White PC. Social determinants and lifestyles: integrating environmental and public health perspectives. *Public Health* 2016;141:270–8. doi: 10.1016/j.puhe.2016.09.019.
- [3] Revi A, Satterthwaite DE, Aragón-Durand F, Corfee-Morlot J, Kiunsi RBR, Pelling M, et al. Urban areas editors.. In: Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, editors. *Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change*, Cambridge, United Kingdom and New York, USA: Cambridge University Press; 2014. p. 535–612.
- [4] International Institute for Environment and Development (IIED). An urbanising world, <https://www.iied.org/urbanising-world>; 2020 [accessed 24 August 2023].
- [5] Friel S, Hancock T, Kjellstrom T, McGranahan G, Monge P, Roy J. Urban health inequities and the added pressure of climate change: an action-oriented research agenda. *J Urban Health* 2011;88:886–95. doi: 10.1007/s11524-011-9607-0.
- [6] Chu E, Michael K. Recognition in urban climate justice: marginality and exclusion of migrants in Indian cities. *Environ Urban* 2019;31:139–56. doi: 10.1177/0956247818814449.
- [7] Locke JT. Climate change-induced migration in the Pacific Region: sudden crisis and long-term developments. *Geogr J* 2009;175:171–80. doi: 10.1111/j.1475-4959.2008.00317.x.
- [8] Reuveny R. Climate change-induced migration and violent conflict. *Political Geogr* 2007;26:656–73. doi: 10.1016/j.polgeo.2007.05.001.
- [9] Bhan G. The impoverishment of poverty: reflections on urban citizenship and inequality in contemporary Delhi. *Environ Urban* 2014;26:547–60. doi: 10.1177/0956247814542391.
- [10] Mitchell BC, Chakraborty J. Urban heat and climate justice: a landscape of thermal inequity in Pinellas County, Florida. *Geogr Rev* 2014;104:459–80. doi: 10.1111/j.1931-0846.2014.12039.x.
- [11] Schlosberg D, Collins LB. From environmental to climate justice: climate change and the discourse of environmental justice. *Wiley Interdiscip Rev Clim Change* 2014;5:359–74. doi: 10.1002/wcc.275.
- [12] Baethge C, Goldbeck-Wood S, Mertens S. SANRA—A scale for the quality assessment of narrative review articles. *Res Integr Peer Rev* 2019;4:1–7. doi: 10.1186/s41073-019-0064-8.
- [13] Critical Appraisal Skills Programme. Critical appraisal Checklists: CASP qualitative studies checklist, <https://casp-uk.net/casp-tools-checklists/>; 2018 [accessed 28 September 2023].
- [14] Critical Appraisal Skills Programme. Critical appraisal Checklists: CASP systematic review checklist, <https://casp-uk.net/casp-tools-checklists/>; 2018 [accessed 28 September 2023].
- [15] Njau B, Covin C, Lisasi E, Damian D, Mushi D, Boule A, et al. A systematic review of qualitative evidence on factors enabling and deterring uptake of HIV self-testing in Africa. *BMC Public Health* 2019;19:1–6. doi: 10.1186/s12889-019-7685-1.
- [16] Hong QN, Pluye P, Fàbregues S, Bartlett G, Boardman F, Cargo M, et al. Mixed methods appraisal tool (MMAT), version. Registration of Copyright (#1148552). Canadian Intellectual Property Office, Industry Canada; 2018. Available from http://mixedmethodsappraisaltoolpublic.pbworks.com/w/file/attach/146002140/MMAT_2018_criteria-manual_2018-08-08c.pdf.
- [17] Monash University. Grey literature: evaluating grey literature. AACODS Checklist 2010 <https://guides.lib.monash.edu/grey-literature/evaluatinggreyliterature/2010> [accessed 27 September 2023].

- [18] Weinstein MC, O'Brien B, Hornberger J, Jackson J, Johannesson M, McCabe C, et al. Principles of good practice for decision analytic modeling in health-care evaluation: report of the ISPOR task force on good research practices—modeling studies. *Value health* 2003;6:9–17. doi: [10.1046/j.1524-4733.2003.00234.x](https://doi.org/10.1046/j.1524-4733.2003.00234.x).
- [19] Masson-Delmotte V, Zhai P, Pörtner HO, Roberts D, Skea J, Shukla PR, et al. *Global warming of 1.5 C. An IPCC special report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty editors*. Cambridge, UK and New York, USA: Cambridge University Press; 2022.
- [20] World Health Organization (WHO). *COP24 special report: health and climate change*. Geneva: WHO; 2018.
- [21] Kovats S, Akhtar R. Climate, climate change and human health in Asian cities. *Environ Urban* 2008;20:165–75. doi: [10.1177/0956247808089154](https://doi.org/10.1177/0956247808089154).
- [22] Campbell S, Remenyi TA, White CJ, Johnston FH. Heatwave and health impact research: a global review. *Health Place* 2018;53:210–8. doi: [10.1016/j.healthplace.2018.08.017](https://doi.org/10.1016/j.healthplace.2018.08.017).
- [23] Kumar A, Singh DP. Heat stroke-related deaths in India: an analysis of natural causes of deaths, associated with the regional heatwave. *J Therm Biol* 2021;95:102792. doi: [10.1016/j.jtherbio.2020.102792](https://doi.org/10.1016/j.jtherbio.2020.102792).
- [24] Matthies F, Menne B. Prevention and management of health hazards related to heatwaves. *Int J Circumpolar Health* 2009;68:8–12. doi: [10.3402/ijch.v68i1.18293](https://doi.org/10.3402/ijch.v68i1.18293).
- [25] Scovronick N, Lloyd SJ, Kovats RS. Climate and health in informal urban settlements. *Environ Urban* 2015;27:657–78. doi: [10.1177/0956247815596502](https://doi.org/10.1177/0956247815596502).
- [26] Véron R. Remaking urban environments: the political ecology of air pollution in Delhi. *Environ Plan A* 2006;38:2093–109. doi: [10.1068/a37449](https://doi.org/10.1068/a37449).
- [27] Kjellstrom T, Friel S, Dixon J, Corvalan C, Rehfuess E, Campbell-Lendrum D, et al. Urban environmental health hazards and health equity. *J Urban Health* 2007;84:86–97. doi: [10.1007/s11524-007-9171-9](https://doi.org/10.1007/s11524-007-9171-9).
- [28] Islam SN, Winkel J. Climate change and social inequality, 152. UN Department of Economic & Social Affairs (DESA); 2017. https://www.un.org/esa/desa/papers/2017/wp152_2017.pdf.
- [29] Satterthwaite D, Archer D, Colenbrander S, Dodman D, Hardoy J, Mitlin D, et al. Building resilience to climate change in informal settlements. *One Earth* 2020;2:143–56. doi: [10.1016/j.oneear.2020.02.002](https://doi.org/10.1016/j.oneear.2020.02.002).
- [30] Zwolsman JJ, Van Bokhoven AJ. Impact of summer droughts on water quality of the Rhine River – a preview of climate change? *Water Sci Technol* 2007;56:45–55. doi: [10.2166/wst.2007.535](https://doi.org/10.2166/wst.2007.535).
- [31] Andrade L, O'Dwyer J, O'Neill E, Hynds P. Surface water flooding, groundwater contamination, and enteric disease in developed countries: a scoping review of connections and consequences. *Environ Pollut* 2018;236:540–9. doi: [10.1016/j.envpol.2018.01.104](https://doi.org/10.1016/j.envpol.2018.01.104).
- [32] Hashizume M, Wagatsuma Y, Faruque AS, Hayashi T, Hunter PR, Armstrong B, et al. Factors determining vulnerability to diarrhoea during and after severe floods in Bangladesh. *J Water Health* 2008;6:323–32. doi: [10.2166/wh.2008.062](https://doi.org/10.2166/wh.2008.062).
- [33] Jones N, Bouzid M, Few R, Hunter P, Lake I. Water, sanitation and hygiene risk factors for the transmission of cholera in a changing climate: using a systematic review to develop a causal process diagram. *J Water Health* 2020;18:145–58. doi: [10.2166/wh.2020.088](https://doi.org/10.2166/wh.2020.088).
- [34] Ng V, Rees EE, Lindsay LR, Drobot MA, Brownstone T, Sadeghieh T, et al. Climate change and infectious diseases: the challenges. Could exotic mosquito-borne diseases emerge in Canada with climate change? *Can Commun Dis Rep* 2019;45:98–107. doi: [10.14745/ccdr.v45i04a04](https://doi.org/10.14745/ccdr.v45i04a04).
- [35] Campbell-Lendrum D, Manga L, Bagayoko M, Sommerfeld J. Climate change and vector-borne diseases: what are the implications for public health research and policy? *Philos Trans R Soc B* 2015;370:20130552. doi: [10.1098/rstb.2013.0552](https://doi.org/10.1098/rstb.2013.0552).
- [36] Parkinson J. Drainage and stormwater management strategies for low-income urban communities. *Environ Urban* 2003;15:115–26. doi: [10.1177/095624780301500203](https://doi.org/10.1177/095624780301500203).
- [37] DeNicola E, Aburizaiza OS, Siddique A, Khwaja H, Carpenter DO. Climate change and water scarcity: the case of Saudi Arabia. *Ann Glob Health* 2015;81:342–53. doi: [10.1016/j.aogh.2015.08.005](https://doi.org/10.1016/j.aogh.2015.08.005).
- [38] Yip W, Mahal A. The health care systems of China and India: performance and future challenges. *Health Aff* 2008;27:921–32. doi: [10.1377/hlthaff.27.4.921](https://doi.org/10.1377/hlthaff.27.4.921).
- [39] United States Environmental Protection Agency (US EPA). Environmental justice, <https://www.epa.gov/environmentaljustice/learn-about-environmental-justice>; 2023 [accessed 19 August 2023].
- [40] Menton M, Larrea C, Latorre S, Martinez-Alier J, Peck M, Temper L, et al. Environmental justice and the SDGs: from synergies to gaps and contradictions. *Sustain Sci* 2020;15:1621–36. doi: [10.1007/s11625-020-00789-8](https://doi.org/10.1007/s11625-020-00789-8).
- [41] Taylor DE. Introduction: the evolution of environmental justice activism, research, and scholarship. *Environ Pract* 2011;13:280–301. doi: [10.1017/s1466046611000329](https://doi.org/10.1017/s1466046611000329).
- [42] Prochaska JD, Nolen AB, Kelley H, Sexton K, Linder SH, Sullivan J. Social determinants of health in environmental justice communities: examining cumulative risk in terms of environmental exposures and social determinants of health. *Hum Ecol Risk Assess* 2014;20:980–94. doi: [10.1080/10807039.2013.805957](https://doi.org/10.1080/10807039.2013.805957).
- [43] Sverdluk A, Mitlin D, Dodman D. *Realizing the multiple benefits of climate resilience and inclusive development in informal settlements*. New York: C40 Cities Climate Leadership Group; 2019.
- [44] Massoud MA, El-Fadel M. Public-private partnerships for solid waste management services. *Environ Manage* 2002;30:0621–30. doi: [10.1007/s00267-002-2715-6](https://doi.org/10.1007/s00267-002-2715-6).