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Climate change and health equity: A public health perspective on climate justice

Abstract

Background: The discourse on climate justice has developed from the theoretical approaches and discussions on environmental justice. It is central to the concept of environmental and climate justice that environmental and climate issues cannot be seen in isolation from issues of social justice.

Methods: For the systematic analysis of climate justice, a conceptual model of the relationship between climate change impacts, social dimensions, adaptive capacities, biological vulnerability and health equity was developed. Based on an exploratory literature review and the evaluation of the individual contributions to the Assessment Report on Climate Change and Health, the evidence in Germany on social inequalities in exposure to climate change impacts and vulnerability to their direct and indirect health effects was summarised.

Results: This article provides an overview of the international debate and examples of the evidence on climate justice in Germany. Climate justice in the sense of avoidable, unjust social inequalities in exposure, vulnerability and the effects of climate change mitigation and adaptation measures on health inequalities is still little discussed in Germany.

Conclusions: A consistent integration of justice issues into climate policy is necessary. With reference to the international literature, options for action and research needs are identified.

This article is part of the series of contributions to the Assessment Report Climate Change and Health 2023.

ENVIRONMENTAL JUSTICE - HEALTH EQUITY - HEALTH EQUITY IN ALL POLICIES

1. Introduction

Social inequalities in health opportunities and health risks are one of the greatest challenges facing Public Health. It is a central goal to reduce or avoid these inequalities, which are seen as unjust and avoidable [1]. The greatest potential is ascribed to public health measures that have a positive impact on the

underlying socio-economic conditions and environmental living conditions [2].

The broad spectrum of health effects of the consequences of climate change has been described comprehensively many times [3 - 7]. It is now recognised that climate change impacts can have long-term, exacerbating effects on social inequalities and, above all, on poverty [8]. Further research is needed in particular with regard to structural consequences (e.g. economic losses, political destabilisation of states or regions with effects on the individual socio-economic situation), destruction of infrastructure and at the same time increased demands on health care capacities and long-term consequences, especially for psychosocial health [3, 9]. Of particular importance are early signs of social tipping points in the process of destabilisation of societies due to climate change impacts [8].

Against the background of the findings of the environmental

According to equity research, climate change impacts are expected to exacerbate social inequalities in health at a global, national and regional level [10, 11]. Population groups living in poverty in particular are more severely affected by climate change impacts due to higher exposure and sensitivity as well as fewer opportunities to adapt [11]. At the same time, they contribute much less to greenhouse gas emissions. Public health measures in the context of climate change should therefore take into account the vulnerability of socially disadvantaged population groups and focus on eliminating health inequalities [10].

The aim of this article is to provide an initial overview of the evidence on climate justice in Germany from a public health perspective. Based on a conceptual model, social inequalities in exposure to climate change impacts and vulnerability (biological susceptibility, adaptive capacity) are considered in relation to the direct and indirect health effects of climate change impacts. Finally, recommendations for public health research and monitoring on climate justice are made and options for action for a just practice of climate adaptation in Germany are presented.

2. Conceptual framework: Climate justice from a public health perspective

2.1 Climate justice and environmental justice

In the global view of anthropogenic climate change, the concept of climate justice is about the fair distribution of the burdens caused by climate change in view of the unequal shares of causation,
i.e. the greenhouse gas emissions of countries, particularly in the Global North, both in the past and at present. It is also about providing support in coping with the consequences of climate change and structural change towards a climate-neutral, just social and economic order. Global climate justice therefore includes social justice and the recognition of human rights worldwide [12, 13].

The discourse on climate justice has developed from the concepts and discussions on environmental justice [14 - 16]. From an intersectionality perspective

Environmental and climate issues cannot be seen in isolation from questions of social justice.

the significance of the interaction of various dimensions of inequality for the social situation and processes of privilege or disadvantage [17]. It is central to the concept of environmental justice that environmental issues cannot be seen in isolation from issues of social justice.

The three central justice dimensions of the environmental justice discourse [18, 19], distributive justice, procedural justice and the recognition of the dignity and rights of all individuals and population groups as well as their cultures, values and perspectives (i.e. no stigmatisation or discrimination), can also be found in the climate justice debate [12, 20]. In addition, there is the aspect of the polluter pays principle [21] and the aspect of restorative justice in questions of fair compensation for the consequences of climate change and the protection of particularly vulnerable population groups [22].

Intergenerational equity refers to the unequal distribution of burdens between generations. Intragenerational equity refers to unequal distributions of the impacts of climate change, the costs and burdens of climate change mitigation and adaptation measures within a generation [23]. Both inter- and intragenerational equity are about fairness between population groups, states and generations [12].

According to Buse and Patrick [16], from a public health perspective, climate justice means recognising the existing imbalance between causation and harm, taking appropriate measures to correct this imbalance and finding solutions for climate protection and climate change mitigation. climate adaptation. Human rights, the empowerment and resilience of individuals and communities and the improvement of health and well-being should guide action.

Vulnerability is a key concept in many research and policy fields with different definitions [23, 24]. While exposure to climate change impacts is often considered a component of vulnerability in the climate change debate [16], in our concept we refer to the definition of vulnerability at the individual level in the field of environmental justice research [25, 26], to the definition in the current Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) [12] and to the definition of social vulnerability of the European Environment Agency [27]. Vulnerability at the individual level includes previous cumulative stress, previous illnesses, malnutrition, lack of resources or knowledge as well as other physiological aspects, i.e. adaptive capacity and biological sensitivity. An intersectionality approach is central to understanding the differences in vulnerability between social groups [8]. The conceptual distinction between vulnerability and current exposure is important for the planning of measures to reduce health inequalities in climate change impacts.

2.2 International evidence in the Global North

In addition to the global perspective on climate (in)justice described above, another perspective is the lack of climate justice in terms of social inequalities

Social inequalities in exposure to climate change impacts, biological sensitivity and adaptive capacities have a combined effect on health.

in individual exposure, in sensitivity to the health effects of climate change impacts or in the adaptive capacities within countries or societies.

An example of this can be found in countries of the Global North: In many European countries, socially disadvantaged population groups live in densely populated, urban areas with higher exposure to air pollutants, noise and heat. In the United Kingdom, for example, it has been shown for London and Manchester that low-income population groups are more likely to live in urban heat islands [27]. A study of 175 urban areas in the USA showed that the average surface temperature during the day in summer is higher in urban areas where people of colour or low-income population groups live [28]. Populations with a low socio-economic position often have a higher risk of heat-related morbidity and mortality [27, 29 - 32].

Social disadvantage can be associated with lower adaptations.

This can be linked to a lack of heat protection capacities, e.g. when socially disadvantaged population groups live in poorly insulated, overheating flats and have no opportunity to implement heat protection measures or move to better accommodation. Another example from the United Kingdom is the lack of insurance cover against flood risks for financial reasons [33].

The consequences of Hurricane Katrina on the US Gulf Coast in 2005 are a prominent example of how socially disadvantaged, marginalised population groups in The floods may not only have a direct impact on their residential areas, but also on inadequate disaster management and delays in aid [34].

Extreme weather events can impair the function of healthcare provision due to the impact on infrastructures of general interest (e.g. transport, social infrastructure) [35], which in turn particularly affects socially disadvantaged population groups due to higher morbidity and limited opportunities to move out.

2.3 A conceptual model for climate justice

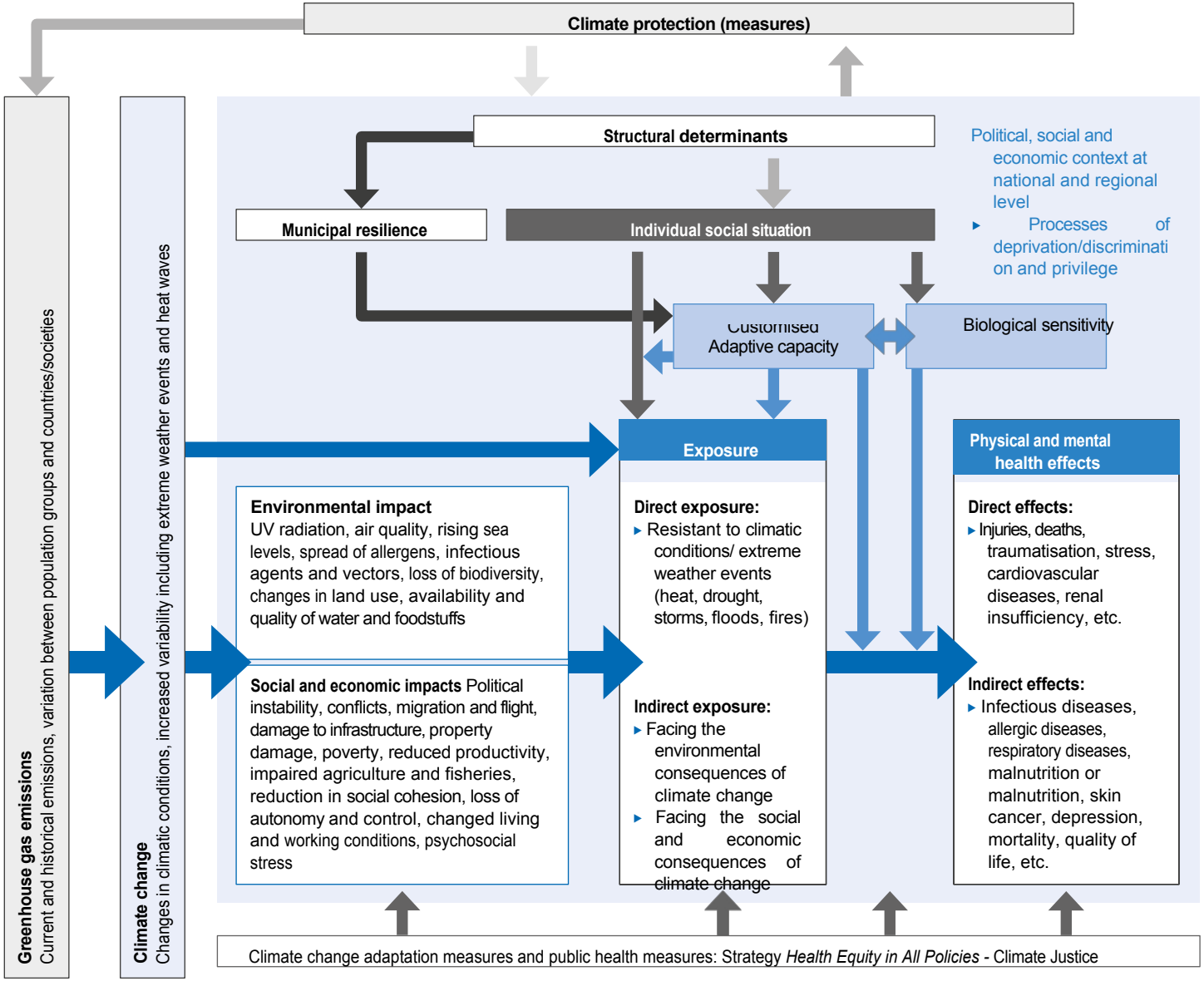
Understanding the interplay of social differences in exposure, biological susceptibility/sensitivity and adaptive capacity is crucial for assessing the effects of climate change impacts on human health in terms of health inequalities and equity. As a basis for our own conceptual model development, relevant and current concepts and models on climate justice and health effects and on the significance of structural and individual dimensions of social inequalities for the health effects of climate change impacts were identified in a literature search. For this purpose, a search was conducted in the MEDLINE database via PubMed on 7 February 2023 using a combination of keywords for the areas of climate change, health, social justice and models/concepts (Annex Table 1). Eight of the 113 hits were excluded due to

two due to the language. A total of 103 full texts were screened by one author (L.D.) for relevant graphic models containing aspects of social inequalities and social justice. In a first round, 15 articles with graphical models were included (Annex Figure 1), of which five models were considered particularly relevant after discussion by two authors (G.B. and L.D.) [36 - 40]. Further models (e.g. [41, 42]) were obtained from grey literature, reviews on climate change and health as well as references from publications. Furthermore, reference was made to the so-called risk propeller from the IPCC Sixth Assessment Report, which refers to the dynamic interactions between climate-related hazards, exposures and vulnerability [12]. A framework concept on vulnerability to health effects of climate change impacts published after the research [43] did not contribute any new aspects to climate justice.

Figure 1 shows the model we developed. It visualises the relationship between the direct effects of climate change, the environmental, social and economic impacts, social dimensions at a structural and individual level, vulnerability (adaptive capacity, biological sensitivity) and health effects with a focus on climate justice within a spatially limited area (e.g. state or region). The consequences of climate change, i.e. the changes in global climatic conditions including extreme weather events and heat waves, are categorised in the model as an overarching hazard (see [12, 44]) are understood. This affects larger spatial units, e.g. cities (heatwaves), regions (flood disaster in parts of North Rhine-Westphalia and Rhineland-Palatinate in 2021, in Thessaly, Greece in 2023) and countries (flood disaster in Pakistan in 2022). Individual exposure is decisive for health effects. It includes direct exposure to climatic conditions and extreme weather events, exposure to environmental climate change impacts and exposure to social and economic climate change impacts. Individual exposure varies according to the place and time of exposure as well as adaptation measures. In the case of a heatwave, the installation of sun blinds is an example of an individual adaptation measure. An example of a collective/communal adaptation measure is the provision of publicly accessible cool places.

Structural determinants that can be found in the political, social and The social and economic context and the associated processes of disadvantage/discrimination and privilege, which include, for example, the availability and accessibility of social care and healthcare, influence an individual's social situation and resilience at the municipal level. Municipal resilience is defined here in accordance with the definition "Urban resilience" understood in the sense of the "ability of an urban system and its population to respond resiliently to crises or disasters, while at the same time adapting and reshaping itself in terms of sustainable urban development" ([45], p. 2) with an extension to rural areas. Municipal resilience encompasses robustness and adaptability [46].

Figure 1
Relationship between climate change impacts, social dimensions at structural and individual level, adaptive capacities, biological sensitivity and health equity
Source: Own presentation



In our model (Figure 1), the social situation is viewed from an intersectional perspective. This means that people are discriminated against in several ways due to different dimensions of inequality and characteristics - depending on the context. For example, people with a history of migration and a physical disability can be particularly disadvantaged when looking for housing. The social situation is therefore understood as a combination of different dimensions of inequality [40], which leads to intersectional discrimination, unequal power relations and unequal access to social and material resources. Differences in the health effects of climate change impacts in the sense of effect modification can be caused by social differences in individual adaptive capacity and individual susceptibility. These in turn are influenced by the individual's social situation and, at a contextual level, by community resilience and structural determinants.

The individual adaptive capacity is constituted

This consists of skills, material and social resources as well as the knowledge to adapt to changing climate conditions and the associated ecological, social and economic impacts and to be able to respond to (disaster) events, i.e. both short-term responsiveness and long-term adaptability. Individual adaptive capacity also includes coping as a stress management strategy [47] and individual resilience as a variable psychological resistance based on personal and social protective factors [48]. The individual

Adaptive capacity influences the type and extent of individual exposure to given climatic conditions or extreme weather events, ecological, social and economic climate change impacts in the sense of exposure variation [49, 50]. It can also modify the health effects of exposures.

Individual biological sensitivity, also known as sensitivity or susceptibility, relates primarily to biological aspects such as altered physiological reactions to exposure due to previous illnesses, maturation or ageing processes or genetic factors. Social inequalities in the material and social environment influence biological sensitivity via mechanisms such as psychosocial stress and allostatic load as a result of chronic stress reactions or the regulation of gene expression (cf. embodiment concept of ecosocial theory) [51 - 54]. Physiological conditions due to previous illnesses or age can in turn influence individual adaptive capacity. Individual biological susceptibility acts as an effect modifier, i.e. modifies the health effects of an individual exposure [49, 50].

At a regional and national level, but still at the

More importantly at a global level, the social and economic effects of climate change influence the individual socio-economic position and social situation through impoverishment, loss of livelihoods and forced migration and flight. Added to this are the effects on the structural determinants, such as social destabilisation and deterioration of the infrastructure. The social and economic

The consequences of climate change therefore have far-reaching effects on health inequalities, regardless of individual exposure to direct and environmental climate change impacts.

With regard to greenhouse gas emissions, the model points out that population groups and countries contribute and have contributed differently to emissions. For example, the average greenhouse gas emissions per year of the wealthiest 10% of households in Germany are around six times higher than the emissions of all households with an income below the median income [55]. The type and scope of climate protection measures implemented by a country are influenced by the political, social and economic context. Climate protection measures can in turn affect social inequalities and have a co-benefit for health (e.g. nature conservation areas as CO_2 sinks as well as recreational and leisure areas, see section 4 Integration of the equity perspective).

Figure 1 shows schematically that climate adaptation and public health measures can address the different levels of exposure, adaptive capacity, vulnerability and health. In the context of structural social inequalities, a health equity-in-all-policies approach [24] is an essential prerequisite for achieving climate justice.

3. Evidence in Germany

To determine the evidence in Germany regarding climate justice, i.e. social inequalities in the expo-

The following literature searches and analyses were carried out in order to assess the position with regard to climate change impacts, vulnerability and health effects: (1) a systematic literature search of peer-reviewed publications, (2) an exploratory search for grey literature and (3) an evaluation of all other thematic articles in the context of the Assessment Report on Climate Change and Health [56 - 65]. The authors of these articles published in the Journal of Health Monitoring in 2023 were also asked for further literature references on studies in Germany.

3.1 Systematic literature research on studies in Germany

The systematic search of published peer-reviewed studies in Germany was conducted on 15 February 2023 in the MEDLINE database via PubMed. Keywords were used for the areas of social justice, climate change and Germany (Annex Table 2) and the search was limited to title and abstract as well as MeSH terms. There was no limitation in terms of publication year or type. One author (S.L.L.) conducted the data search, two authors (G.B. and S.L.L.) independently screened the title and abstract of the identified publications. All studies investigating the significance of social dimensions for exposure to climate change impacts or their health effects in Germany were included. Discrepancies in the selection of studies were discussed by the entire team and a decision on inclusion was made by consensus.

The systematic search in PubMed yielded 150 hits. After title and abstract screening, two studies were included as suitable for the analysis (Annex Figure 2). Both studies investigated subjective heat stress and were conducted in the cities of Cologne [66] and Dresden [67].

In both studies, residents of selected urban areas were asked about their perceived heat stress and adaptation strategies. In Cologne, four urban areas were selected based on the criteria of socio-economic and urban climatic living conditions. Within the urban areas, people aged 65 and over were surveyed [66]. In Dresden, two urban neighbourhoods were selected on the basis of development and social structure data [67]. In Cologne, 258 people - 131 women and 127 men - aged between 65 and 93 took part in the surveys; in Dresden, 661 people with an average age of 47 (neighbourhood A, 45 % women) and 48 years (neighbourhood B, 51 % women).

The Dresden study showed that people from an urban neighbourhood with very high social stress (according to the social index of the Dresden Education Report), with closed buildings, a low proportion of neighbourhood greenery and only one park in the catchment area felt more frequently subjectively stressed by heat in general, heat in the urban neighbourhood and heat in the home during the day than people from an urban neighbourhood with low social stress according to the social index, open buildings, a medium to high proportion of neighbourhood greenery and three parks in the catchment area. Furthermore, the first group rated their subjective state of health as good less often [67]. Heat-related symptoms during summer heatwaves were mentioned more frequently in the first-mentioned neighbourhood. There were also differences in the adaptation strategies of the participants: In the neighbourhood with very high social stress according to the social index, the choice of clothing, avoidance/protection from heat, visiting green spaces, visiting cool rooms in the home and avoiding the midday sun were mentioned less frequently than in the neighbourhood with low social stress [67].

In a comparison of four selected urban areas, the Cologne study [66] found no differences in the subjective heat stress of the participants between the two urban areas with high versus the two urban areas with low objective heat stress. A further analysis in combination with socio-economic parameters of the urban areas was not reported. Differences were observed at the level of individual social parameters: Women, people with lower incomes, less education and people with poorer health were more likely to feel subjectively stressed by heat. Age differences were not observed in this study population, which only included people aged 65 and over. Subjective heat stress correlated positively with the number of adaptation strategies implemented. The study reported differences in the type of adaptation strategies between different groups, for example women were more likely than men to report using thinner bed linen or cooling their arms with water in the heat, and people with a higher level of education were more likely to report increasing their fluid intake. Further interpretations of the study results are not possible, as the

The baseline prevalences for the individual groups were not given and were not corrected for multiple testing in the statistical analysis.

3.2 Further evidence from an exploratory literature search for Germany

The exploratory search for grey literature and references from lists of publications only yielded isolated information on the relevance of social dimensions for exposure to climate change impacts, for their health effects or for adaptation capacities in Germany. This information is briefly presented below.

Darabi et al [68] used data from the Environmental Justice Atlas of Berlin from 2009 - 2011 to investigate whether environmental stressors including heat mediate the effect of poverty on mental health. Individual-level data on socio-demographic characteristics and health were obtained from 478 people, 244 women and 234 men aged between 18 and 68, from eleven planning areas in Berlin-Mitte by means of personal interviews in 2011. At the level of the eleven planning areas analysed, thermal stress (physiologically equivalent temperature) did not correlate with chronic poverty (recorded as the proportion of the resident population receiving unemployment benefit II), in contrast to air pollution and the availability of public green spaces. The publication did not provide any information on the variation in thermal pollution between the eleven planning areas. The environmental factors analysed were not associated with mental health.

The 2019 baseline report on environmental justice for Berlin describes that 228 out of 447 planning areas were affected by high bioclimatic pollution. 65 of 228 planning areas with high bioclimatic pollution also had a disadvantaged social structure. The overall "social inequality" index included data on the status and dynamics of the four indicators unemployment, long-term unemployment, transfer payments (Social Code Book II and XII) and child poverty (transfer payments SGB II for under 15-year-olds). Areas with a disadvantaged social structure, in which cumulative social problems were observed, were labelled "areas with a special need for attention" [69]. There were 40 planning areas with this double burden in the extended city centre area. In the updated report from 2022, only the integrated multiple burden of environmental and social deprivation was presented; information on social differences in the bioclimatic burden alone was not provided in an overview of all planning areas [70].

A spatial analysis of data from the health insurance funds The multivariable analysis conducted by the German Federal Association of Statutory Health Insurers in Germany from 2009 to 2015 showed a positive association between the proportion of employees with an academic degree and household income at district level with the prevalence of malignant melanoma of the skin (International Classification of Disease ICD-10: C43), adjusted for the average regional sunshine duration [71]. Household income at county level was associated with the prevalence of basal cell carcinoma and

squamous cell carcinoma (ICD-10: C44), adjusted for the regional average UV radiation exposure. The authors hypothesise that one cause is higher travel activity among people with higher incomes in recent decades [71]. When interpreting these data, however, it must be taken into account (1) that these are prevalences of diagnosed and treated cases of the disease and not prevalences of the resident population as a whole in Germany and (2) that socio-economic data aggregated at district level were used for the year 2014.

Bubeck and Thieken [72] investigated the subjective recovery of affected people 18 months after the 2013 Elbe and Danube floods by conducting telephone interviews with 710 households. The significance of event characteristics (e.g. flood depth, duration), circumstances of the reconstruction process (e.g. condition of buildings, duration of compensation payments), socio-economic characteristics (e.g. age, gender, education, income, insurance cover, property ownership) and psychological factors (e.g. mental preoccupation with the flood, stress resilience, perceived safety from future events, trust in others) were analysed. The analysis of socio-economic characteristics revealed a lower subjective recovery among women compared to men, among people in poorer health or with a disability and among people with property ownership. Overall, socio-economic characteristics and psychological factors were of greater importance for long-term subjective recovery than event characteristics or circumstances of the reconstruction process.

Based on their results, Bubeck and Thieken [72] conclude that reconstruction processes after flood events should not be focussed exclusively on particularly damaged areas, but that the socio-economic characteristics of the affected population should be taken into account. Reconstruction measures should primarily support socially vulnerable groups, i.e. people with disabilities, poor health and low financial resources [72].

Based on data from the socio-economic panel for over 10,000 households in Germany in the period 2012 - 2020, Osberghaus and Abeling [73] investigated whether there are differences in exposure to heat and vulnerability between households in relative income poverty and households without relative income poverty. There were no social differences in the extent of heat stress at the place of residence (recorded as mean daily minimum outdoor temperature in summer at the place of residence) and in exposure parameters for urban heat islands (population density, living in the attic). However, it must be borne in mind that no distinction was made between urban and rural regions in the analysis. The authors were able to show differences in vulnerability parameters (age, gender, household size, health status) and adaptive capacity (heat protection measures already taken in the home, potential for future implementation, including self-efficacy, control beliefs, expected costs (asked in relation to the installation of air conditioning)) between households with and without relative income poverty. The results of the study support the approach of taking a holistic approach to the assessment of

climate justice should not only consider differences in exposure.

In their report on gender aspects of climate policy from an intersectionality perspective, Spitzner et al [74] point out that single mothers and pensioners in Germany in particular are more likely to live in housing that is poorly equipped in terms of heat protection. The reasons for this could be income poverty, but also discrimination on the housing market.

3.3 Evaluation of the articles in the Assessment Report on Climate Change and Health

The third step of the analysis involved evaluating the articles in the status report on climate change and health with regard to vulnerable population groups and the influence of social determinants on the health effects of climate change impacts. Two authors (L.D. and S.G.) extracted all statements from the articles on the effects of climate change on infectious diseases [56 - 59] and on non-communicable diseases [60 - 65]. A distinction was made between exposure to climate change impacts (Table 1), sensitivity to health effects (Table 2) and adaptive capacity (Table 3). Social determinants were defined according to the PROGRESS-Plus Framework [75, 76]. The PROGRESS acro- nym comprises eight dimensions:
(1) Place of residence,
(2) Experience of racism/ethnicity/culture/language, (3) Occupation/
Employment, (4) gender, (5) religion, (6) education,
(7) socio-economic status and (8) social capital. The
"Plus" stands for further determinants that are linked to social
Discrimination, marginalisation and exclusion can be associated with factors such as age or the presence of a disability. Pregnant women and people with pre-existing conditions were included in the tables as particularly sensitive population groups for physiological reasons. In addition, lifestyle factors, e.g. sporting activity, were included in the analysis, which may be associated with the social situation but are not social determinants in the narrower sense.

The results tables (Tables 1 - 3) only show the social dimensions according to PROGRESS-Plus that were included in the analysed articles. For example, education was not mentioned as a social indicator in the analysed articles and is therefore not listed as a separate column in the tables. In the tables, it was also noted whether the source for the extracted statements in the respective articles contains German evidence (DE), European evidence (EE) or further international evidence (IE). Review articles were labelled with the additional abbreviation "-R" as the cited source. Statements without reference to references were included in the tables without an additional note. Decisions on the inclusion and exclusion of certain statements and the allocation to the aspects of exposure, sensitivity or adaptive capacity were made by the entire team of authors. The result of this evaluation was submitted to the authors of the articles [56 - 65] for review. Decisions on additions or changes based on the feedback were again made by the entire team of authors. At this point, we would like to explicitly point this out once again,

that this third step of the analysis only includes the evaluation of the information in these articles and no further analysis of the references cited there. For example, the article by Baldermann et al [62] on UV radiation refers to the S3 guideline Prevention of skin cancer, which contains further information on social inequalities with reference to various dimensions such as education, socioeconomic status, age and gender. This evaluation therefore provides an initial insight, but not a comprehensive presentation of the evidence in Germany.

Differences in exposure

Above all, the occupation practised is associated with exposure to climate change impacts and their health consequences, for example when working outdoors (Table 1). Leisure behaviour was also often cited as a reason for higher exposure, e.g. to infectious diseases, heat and UV radiation.

Vulnerability - differences in susceptibility Table 2

shows which social determinants play a role in relation to differences in susceptibility to the effects of climate change. In most articles, age (children, older people) and previous illnesses as well as pregnancy are cited as reasons for increased susceptibility.

Vulnerability - differences in adaptive capacity

Social dimensions for which there is evidence of differences in adaptive capacity are shown in Table 3.

listed. Socially different adaptive capacities are particularly relevant with regard to the health consequences of heat and extreme weather events, and statements were only made on these topics in the articles of the status report. Socio-economic status, social networks and the presence of a disability as well as age are named as relevant social determinants for both exposures.

One aspect not shown in Tables 1 - 3 is the psychological processing of climate change impacts. Gebhardt et al [65] point out that children and adolescents are particularly vulnerable to the development of mental illness due to knowledge of climate change impacts (DE). They also state that women report greater anxiety about climate change than men (DE). According to international evidence, groups of people with pre-existing structural disadvantages and vulnerabilities are particularly affected by the direct and indirect psychological effects of climate change (IE-R), while social family structures and education levels are considered resilience factors after extreme weather events and have a protective effect against psychological stress (IE-R). Resilience factors in relation to the indirect psychological effects of climate change, i.e. the stress caused by knowledge about it, are still largely unresearched (IE-R). For factors such as socioeconomic status, ethnicity, migration history, spatial marginalisation and intersectional discrimination, there are currently no studies from Germany on the relationship between climate change impacts and mental health, according to Gebhardt et al [65].

Table 1

Social differences in exposure according to articles in the Assessment Report on Climate Change and Health

Source: Own presentation

	Social determinants according to PROGRESS-Plus							Pregnant women and unborn babies	People with pre-existing conditions	Lifestyle factors
	Place of residence	Profession	Gender	Social capital	Socio-economic status	Age	People with disabilities			
Impact of climate change on communicable diseases caused by...										
Vector-borne diseases [56]	↑ Certain vector-borne diseases occur in risk areas (DE, EE)	↑ Including among professionals working in nature, e.g. in the forest, among employees in pest control companies	↑ Hantaviruses and tick-borne diseases in men (DE)			↑ Hantaviruses in adults between 20 and 60 (DE)				↑ People who spend more time in nature, e.g. on walks (DE), collecting mushrooms, the scouting scene, the geocaching scene, etc. Scene
Waterborne infections and intoxications [57]						↑ Cyanobacteria in children				↑ For leisure activities, e.g. water sports
Food-borne infections and intoxications [58]										↑ Campylobacter during barbecuing and bathing in surface waters (IE) ↑ Salmonella during barbecues and picnics
Impact of climate change on non-communicable diseases caused by...										
Temperature changes (heat) [60]	↑ In urban areas, e.g. due to heat island effects (DE)	↑ For people working outdoors, e.g. in agriculture or the construction sector (EE) ↑ For healthcare personnel (EE, IE-R)			↑ Due to an unfavourable housing situation or homelessness (EE)					↑ For outdoor sports enthusiasts (EE)

↑ = higher exposure, DE = German evidence, EE = European evidence, IE = international evidence, -R = review article, NO_x = nitrogen oxides, PM = particulate matter

In the table, only the PROGRESS Plus dimensions are listed in the columns for which there was at least one statement on differences in exposure, differences in susceptibility or adaptive capacity. In the article on antimicrobial resistance, no statements were made regarding social differences in exposure.

Continued on next page

Table 1 *continued*

Social differences in exposure according to articles in the Assessment Report on Climate Change and Health

Source: Own presentation

	Social determinants according to PROGRESS-Plus							Pregnant women and unborn babies	People with pre-existing conditions	Lifestyle factors
	Place of residence	Profession	Gender	Social capital	Socio-economic status	Age	People with disabilities			
Extreme weather events [61]	↑ Risk areas for certain types of extreme weather events (e.g. storm surges near the coast)	↑ Hazards for emergency services (IE-R) ↑ For people working in agriculture during droughts (IE-R)	↑ Risks due to the loss of public order among women (IE-R)		↑ For people with a low socio-economic status	↑ Risks due to the loss of public order among children and the elderly (IE-R)			↑ Hazards due to the inaccessibility of healthcare facilities (IE-R)	
UV radiation [62]		↑ For employees with external activities (DE)								↑ For people who spend a lot of time outdoors (DE)
Allergen exposure [63]		↑ For workplaces in forestry and landscape maintenance (DE) ↑ Of mould fungal allergens in employees carrying out renovation work after flood events (IE)								
Air pollution [64]	↑ PM and NO_x in urban agglomerations and places with heavy traffic (DE) ↑ Ozone in suburban and rural areas (DE)									

↑ = higher exposure, DE = German evidence, EE = European evidence, IE = international evidence, -R = review article, NO_x = nitrogen oxides, PM = particulate matter

In the table, only the PROGRESS Plus dimensions are listed in the columns for which there was at least one statement on differences in exposure, differences in susceptibility or adaptive capacity. In the article on antimicrobial resistance, no statements were made regarding social differences in exposure.

Table 2

Social differences in sensitivity according to articles in the Assessment Report on Climate Change and Health

Source: Own presentation

	Social determinants according to PROGRESS-Plus							Pregnant women and unborn babies	People with pre-existing conditions	Lifestyle factors
	Place of residence	Profession	Gender	Social capital	Socio-economic status	Age	People with disabilities			
Impact of climate change on communicable diseases caused by...										
Vector-borne diseases [56]						↑ In older people for a neuroinvasive form of disease after West Nile virus infection (IE-R) ↑ In adults for severe early summer meningoencephalitis (TBE) after tick bites		↑ Malformations in the foetus with Zika virus infection	↑ In people with a history of a neuroinvasive form of the disease after West Nile virus infection (IE-R)	
Waterborne infections and intoxications [57]			↑ In older people, especially males, for pneumonia caused by Legionella (Legionnaires' disease)			↑ In older people for severe wound and soft tissue infection and sepsis following infection with non-cholera vibrios (DE) ↑ In older people for pneumonia caused by legionella (legionnaires' disease)			↑ In people with a history of severe wound and soft tissue infection and sepsis following infection with non-cholera vibrios (DE) ↑ In people with a history of pneumonia caused by Legionella (Legionnaires' disease)	↑ In case of smoking for pneumonia caused by Legionella (Legionnaires' disease)

↑ = increased sensitivity, DE = German evidence, EE = European evidence, IE = international evidence, -R = review article
In the table, only the PROGRESS Plus dimensions are listed in the columns for which there was at least one statement on differences in exposure, differences in susceptibility or adaptive capacity. In the article on antimicrobial resistance, no statements were made regarding social differences in susceptibility.

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Table 2 *continued*

Social differences in sensitivity according to articles in the Assessment Report on Climate Change and Health

Source: Own presentation

	Social determinants according to PROGRESS-Plus							Pregnant women and unborn babies	People with pre-existing conditions	Lifestyle factors
	Place of residence	Profession	Gender	Social capital	Socio-economic status	Age	People with disabilities			
Food-borne infections and intoxications [58]						↑ In young and elderly people after ingestion of pathogenic vibrios ↑ In infants, small children and the elderly after ingesting parasites (IE-R)		↑ For pregnant women after ingestion of pathogenic vibrios	↑ In people with previous illnesses after ingestion of pathogenic vibrios ↑ In immunocompromised persons after ingestion of parasites (IE-R)	
Impact of climate change on non-communicable diseases caused by...										
Temperature changes (heat) [60]			↑ Different effects of heat on the cardiovascular system in women and men with pre-existing conditions (DE)			↑ For older people (> 65 years EE; > 75 years DE), infants and young children (EE) ↑ In children and adolescents for psychological effects of heat (IE-R)		↑ For pregnant women during heatwaves, as these can lead to premature births and low birth weight (EE, IE-R)	↑ In the case of pre-existing conditions, especially cardiovascular diseases, respiratory diseases, kidney diseases, obesity, diabetes (DE, EE, IE-R) ↑ In people with pre-existing mental illness for psychological effects of heat (IE-R)	

↑ = increased sensitivity, DE = German evidence, EE = European evidence, IE = international evidence, -R = review article,
In the table, only the PROGRESS Plus dimensions are listed in the columns for which there was at least one statement on differences in exposure, differences in susceptibility or adaptive capacity. In the article on antimicrobial resistance, no statements were made regarding social differences in susceptibility.

Continued on next page

Table 2 *continued*

Social differences in sensitivity according to articles in the Assessment Report on Climate Change and Health

Source: Own presentation

	Social determinants according to PROGRESS-Plus							Pregnant women and unborn babies	People with pre-existing conditions	Lifestyle factors
	Place of residence	Profession	Gender	Social capital	Socio-economic status	Age	People with disabilities			
Extreme weather events [61]			↑ For persons of the female sex for psychological effects of extreme weather events (IE-R)	↑ In people with inner-family conflicts, with low social support, with loss of social environment for psychological effects of extreme weather events (IE-R)	↑ For people with low socio-economic status for psychological effects of extreme weather events (IE-R)	↑ In children and adolescents for psychological effects of extreme weather events (IE)	↑ For people with physical limitations due to physical stresses that occur	↑ In the case of pregnancies caused by stressful experiences, as these can lead to postnatal complications and long-term observable developmental delays in children (IE-R)	↑ For people with pre-existing mental illness for psychological effects of extreme weather events (IE)	
UV radiation [62]						↑ In children for damage to the eyes and skin (DE)				
Allergen exposure [63]									↑ In people with pre-existing allergic rhinoconjunctivitis (high risk of developing allergic rhinoconjunctivitis) Asthma) (IE)	
Air pollution [64]					↑ For people with low social status (IE-R)	↑ For infants, children and the elderly (IE-R)		↑ For pregnant women, i.e. an increased risk of premature birth and low birth weight (IE-R)	↑ For people with chronic pre-existing conditions, especially chronic respiratory diseases and cardiovascular diseases (IE-R)	↑ Smoking status and other lifestyle factors (IE-R)

↑ = increased sensitivity, DE = German evidence, EE = European evidence, IE = international evidence, -R = review article,
In the table, only the PROGRESS Plus dimensions are listed in the columns for which there was at least one statement on differences in exposure, differences in susceptibility or adaptive capacity. In the article on antimicrobial

resistance, no statements were made regarding social differences in susceptibility.

Table 3

Social differences in adaptive capacity according to articles in the Assessment Report on Climate Change and Health

Source: Own presentation

	Social determinants according to PROGRESS-Plus							Pregnant women and unborn babies	People with pre-existing conditions	Lifestyle factors
	Place of residence	Profession	Gender	Social capital	Socio-economic status	Age	People with disabilities			
Impact of climate change on non-communicable diseases caused by...										
Temperature changes (heat) [60]	↓ For people living in a heavily sealed environment	↓ For people working outdoors		↓ For people in social isolation, especially in old age (EE)	↓ For people with a low socio-economic status (EE)	↓ For people in social isolation, especially in old age (EE)	↓ For people with impairments (physical or mental) or with functional limitations (bedridden or placed in a care facility) (EE)			
Extreme weather events [61]			↓ In men, as they are more susceptible to risk during events (DE) ↓ In women, as the long-term recovery is lower (DE)	↑ Social networks increase resilience and rapid emergency aid in the event of a disaster (IE)	↓ For people with a low socio-economic status ↓ For people with a lower financial status, as the long-term recovery is lower (DE)	↓ For elderly people and children, as they may not be able to get to safety on their own (DE)	↓ For people with physical or mental disabilities, as they may not be able to get to safety on their own (DE)		↓ For people with pre-existing conditions, as healthcare facilities are often not accessible (IE-R)	

↓ = lower adaptive capacity, ↑ = higher adaptive capacity, DE = German evidence, EE = European evidence, IE = international evidence, -R = review article
In the table, only the PROGRESS-Plus dimensions are listed in the columns for which there was at least one statement on exposure differences, differences in sensitivity or adaptive capacity.
The articles on the effects of climate change on communicable diseases and on effects on non-communicable diseases caused by UV radiation, allergen exposure and air pollution did not contain any statements regarding adaptive capacity.

Aspects of migration/refuge were also highlighted [59, 61]. Forced (trans- national) migration or flight due to extreme weather events has a significant impact on health, vulnerability and social situation.

3.4 Conclusion on the evidence situation in Germany

The evidence base on the various aspects of climate justice in Germany with reference to health appears to be inadequate overall. Differences in biological sensitivity with regard to direct and indirect health effects have been studied more frequently in comparison to social differences in exposure, adaptive capacity or opportunities to participate in decision-making processes. Heat stress is in the foreground. A view of cumulative stresses (e.g. occupational heat stress and heat stress in the home at the same time) and an intersectional view of inequalities appear to be lacking. Analyses of this kind require data at an individual level.

In the global view of climate justice and in particular the situation in LMIC countries (low- and middle-income countries), it is assumed that women are more vulnerable to the health effects of climate change impacts. This is justified by the social, cultural and economic conditions, i.e. structural disadvantage and discrimination based on gender [8, 77]. Although some of the studies analysed in this review describe differences between women and men, a reference to the social dimensions of However, gender and aspects of gender equality are not established.

Limitations

It should be critically noted here that a systematic literature search was only carried out in a database for health-related publications for this article. The exploratory search also revealed individual studies that could not be found in this database. It can be assumed that there are more studies on social differences in exposure and adaptive capacity from Germany that do not evaluate the results from a public health perspective. The studies identified via the various searches were not subjected to a systematic quality assessment in this review; only individual references to problems such as multiple testing are given.

It should also be borne in mind that the articles in the Assessment Report on Climate Change and Health [56 - 65] did not systematically collate the evidence on social determinants and social inequalities in the respective topic area. In this respect, the results from these articles summarised in tabular form in this article only represent a section of the evidence presumably available in Germany.

4. Integrating the equity perspective into climate change mitigation and adaptation measures - International discussion

"Climate adaptation and mitigation measures necessary to protect human society,

must be planned in such a way that they also protect human rights, promote social justice and avoid creating new problems or exacerbating existing problems for vulnerable population groups." (Levy and Patz [78], p. 310, own translation)

According to the Lancet Countdown group of experts in Europe, the greatest health policy opportunity of this century is to design and implement climate change mitigation and adaptation measures in a way that puts health, well-being and equity at the centre [5]. Without appropriate climate mitigation and adaptation measures, there is a risk that the negative impacts of climate change, which primarily affect the social determinants of health, will further increase social inequalities in health [11]. In view of the impact of climate change on livelihoods and social determinants of health, rapid and comprehensive implementation of a climate policy geared towards social justice, protection of human rights and sustainability is crucial [6, 8, 11, 78]. Care must be taken to ensure that climate change mitigation and adaptation measures do not contribute to the emergence or widening of existing social inequalities [78 - 80].

The consistent integration of the justice perspective
tive makes it easier to go beyond incremental adaptation to climate change impacts and increase resilience and sustainability [81]. A climate-resilient health system is characterised by the fact that all people have access to social and health services, vulnerabilities and inequalities are reduced and a health-in-all-policies approach is pursued in cross-sectoral cooperation, e.g. with urban planning [82]. Another example is disaster management strategies for extreme weather events, which should take into account the different vulnerabilities of population groups, especially at the local community level [4].

Economic development needs to change, prioritising health-promoting urban development, the use of more efficient and renewable energy sources and a more sustainable and equitable food system. Ecological and social determinants of health must be addressed together in order to reduce poverty, increase health equity and enable all people to live within planetary boundaries [83].

Friel [84] proposes the concept of "Planetary Health Equity". It contains the following elements:

(1) Anchoring political norms of social justice, ecological sustainability and well-being,
(2) Application of these policy standards and implementation in cross-sectoral policy,
(3) Implementation of a national climate strategy,
Justice and health and
(4) Re-orientation of the governance of planetary health equity to ensure that no vested interests are pursued and that civil society is involved.

Anchoring climate justice in climate protection and climate adaptation requires an intersectionality perspective.

Internationally, the need for community-based, place-based approaches to climate adaptation is emphasised. Climate justice principles can be integrated into public health strategies and climate adaptation measures at the community level to increase the resilience of marginalised populations to climate change impacts and other stressors [16, 17]. Interactions between exposures, biological sensitivity, adaptive capacity and the social determinants of health should be considered from an intersectional perspective in order to better understand differences in the health effects of climate change impacts and climate adaptation measures and to be able to develop differentiated measures in a participatory manner with population groups [16, 17, 74].

An essential component of municipal climate
Urban greening is a key element of climate adaptation strategies and sustainable, climate-friendly urban development. Urban greenery not only improves urban climatic parameters, but also the pollution situation in terms of air pollutants and noise. Public green spaces also have health-promoting potential in terms of social interaction in public spaces and physical activity [85]. There is extensive evidence that the availability of and access to urban green spaces are socially unequally distributed [86, 87]. Urban greening measures can reduce these social inequalities, but can also have unintended negative effects: There is a risk of gentrification, i.e. the displacement of poor and socially disadvantaged population groups from neighbourhoods enhanced by urban greening [88, 89]. First Analyses in 28 cities in North America and Europe show that there can be temporal correlations between urban greening and gentrification [90]. This makes it all the more important to methodically assess the influence of such interventions on the extent of (new) climate and environmental injustices and to incorporate suitable instruments for countermeasures as early as the planning phase [24].

The Sixth Assessment Report of the IPCC emphasises the topics of social justice, different forms of knowledge, e.g. of the local population and science, the role of power and participation in the implementation processes of climate adaptation measures [8, 12]. The expected effects of adaptation measures on equity issues should be assessed as early as the planning stage, and implementation should be accompanied by equity-related monitoring and evaluation. An analysis of the climate action plans of the 100 largest cities in the USA provides examples of implementation [91]: Equity aspects have been increasingly taken into account in the cities in recent years, particularly for the energy and land use and transport sectors. Measures anchored in the climate action plans to achieve greater climate justice included, for example, cooperation with local actors and vulnerable population groups, the establishment of an advisory body for justice issues, the development of instruments to record justice aspects in the planning, implementation and evaluation of measures and justice indicators to quantify the effects of the measures on justice.

5. Recommendations for action and need for research

The public health perspective on climate change and health equity adopted in this article shows the need to fundamentally anchor equity issues in Germany's national and international climate policy.

The German Strategy for Adaptation to Climate Change (DAS), which was adopted in 2008, pursues the long-term goal of reducing the vulnerability of natural, social and economic systems and maintaining and increasing their adaptability. The DAS ties in with the goal of the national sustainability strategy for Germany to harmonise the sustainability dimensions of economy, ecology and social issues [92]. In the health cluster, the measures listed in the second progress report on the DAS include

"the development of access routes to particularly vulnerable population groups (e.g. older people, people with previous illnesses, children)" [93, p. 55] and better dovetailing of health and environmental monitoring. In the 2021 climate impact and risk analysis for Germany, the sub-report on risks and adaptation in the economic and health clusters [94] in the "Human health" field of action mentions measures from the German government's Adaptation Action Plan III [93], such as effectiveness analyses of health adaptation measures as part of heat action plans (HAPs), the establishment of an integrated health and environmental monitoring system, evaluation of the implementation and effectiveness of recommendations for action and preventive measures as well as measures aimed at vulnerable groups.

information materials tailored to the target groups. Vulnerability is predominantly understood as biological susceptibility. For the "Human health" field of action, the 2021 climate impact and risk analysis for Germany in the sub-report

"Integrated Evaluation - Climate Risks, Action Requirements and Research Needs" [95] identified a lack of research with regard to socio-spatially differentiated analyses of heat stress and the small-scale analysis of heat-related excess mortality. This lack of knowledge on socio-economic risk constellations in Germany with regard to heat and health was also emphasised in the current analysis of HAP and adaptation measures to heat extremes in Germany [96]. Monitoring the stress situation with regard to social and environmental multiple stresses is an essential basis for an adequate assessment by decision-makers. Climate-change-just urban development requires the integration of aspects of demographic change and environmental justice [97].

In the DAS, the issues described in this article were The dimensions of distributive, procedural and recognition justice have not yet been explicitly addressed. However, with reference to the concept of environmental justice, equal living conditions and justice in the availability of and access to ecological resources as well as the burdens caused by the consequences of climate change are currently being increasingly focussed on. The Federal Government's draft bill for a Federal Climate Adaptation Act (KAnG) lists these as overarching goals:

"The resilience of ecological systems and the

The aim is to increase society's resilience to future climate change in order to preserve equal living conditions and to contribute to national and international efforts to adapt to climate change. The increase in social inequalities due to the negative

The effects of climate change should be prevented." (§1 of the KAnG [98])

The state of knowledge and conceptual considerations on climate justice from a public health perspective result in the recommendations for action and research needs for Germany shown in Table 4.

Info box 1
Heat action plans as an instrument for climate justice

Heat action plans (HAPs) are a key municipal instrument for protecting human health from heat. In 2020, the Conference of Health Ministers decided to draw up HAPs at municipal level in Germany within five years. One basis for this are the guidelines developed by the ad hoc working group "Health-related adaptation to the consequences of climate change (GAK)" developed by the federal and state governments and published in 2017 by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety "Recommendations for the preparation of heat action plans to protect human health" [108]. The short-, medium- and long-term measures of municipal HAPs should take into account the specific local conditions. In recommendations and working aids for municipal HAPs, the focus has so far been on biological sensitivity to heat. Socially disadvantaged population groups are not the focus, with the exception of homeless people as a group that is particularly affected by heat and at the same time vulnerable.

If future HAPs are designed from the outset to address social inequalities in both heat exposure and vulnerability with regard to health consequences from an intersectionality perspective, and the evaluation of HAPs is carried out systematically with regard to inequality effects, this could be an important step towards greater climate justice in Germany.

Relative preventive measures for heat prevention, especially in cities, require interdisciplinary and intersectoral cooperation. The need to integrate the various subject areas, especially health, environment and social issues, which was recently emphasised in a discussion paper by the German Association of Cities 2023 [109], opens up the opportunity to combine heat prevention with health equity as a co-benefit.

Recommendation for action	Explanation
Systematically consider climate justice and anchor it as a cross-cutting issue in climate change mitigation and adaptation	▶ Systematically integrate social justice and health equity into the design and implementation of political programmes and measures for climate protection and climate change mitigation. adaptation from an intersectionality perspective [17, 80] ▶ Use intervention-orientated guiding principles from environmental justice [24] and gender justice [74] as starting points As early as 2017, the Sixth Ministerial Conference on Environment and Health called for equity to be considered as a cross-cutting dimension in all measures [99]. Municipal heat action plans have the potential to act as an instrument for climate justice (Infobox 1).

Continued on next page

Table 4
Recommendations for action and research needs for greater climate justice
Source: Own presentation

Table 4 *Continuation*
***of* recommendations for action and research needs for greater climate justice**
Source: Own presentation

Recommendation for action	Explanation
Use established instruments to integrate climate and environmental justice into all spatially effective and socially relevant fields of action and to counteract social segregation in municipalities	▶ Use informal spatial planning instruments in particular, such as integrated urban development concepts, to achieve greater climate and environmental justice; instruments, housing policy, for example, can help to minimise segregation effects ▶ At a strategic level, expand the health-in-all-policies approach to include overall societal responsibility for health, climate and environmental justice [24]; practi- The environmental justice toolbox [100], for example, provides guidance on how to build on established instruments
Increase the adaptive capacities and participation opportunities of socially disadvantaged population groups	Socially disadvantaged population groups, who are often more frequently or more severely affected by climate change impacts and are more susceptible and have less capacity to adapt, enable participation in development and decision-making processes on climate adaptation strategies ▶ upport these population groups in strengthening their adaptive capacities and participation These include target group-specific approaches to increasing opportunities for participation and strengthening health literacy, as well as measures to adapt working conditions, housing, cities, etc. in a climate-friendly way for all people.
Countering socially unequal biological sensitivity	Socially disadvantaged living situations associated with multiple environmental burdens, psychosocial stress, lack of material resources and access to healthcare and thus increase sensitivity to the adverse effects of climate change, with political measures for more social justice, environmental justice and health care for all
Establish integrated monitoring for decision support	▶ Approaches for integrated health, climate, environmental and social monitoring at municipal, state and federal level to support decision-making in interdepartmental cooperation. Develop, test and stabilise cooperation in line with the Health in All Policies approach ▶ Through integrated monitoring, the identification of (small-scale) multiple burdens, social inequalities in adaptive capacity and in participation in decision-making enable the development processes ▶ Anchoring an intersectionality perspective in integrated monitoring to capture the interaction of different inequality situations This can build on a wide range of activities in Germany, such as the Environmental Justice Atlas in Berlin (Info box 2).
Systematically evaluate inequality effects	▶ ystematically evaluate the implementation and impact of climate change mitigation and adaptation measures from an equity perspective (equity impact assessment) and, in the case of unfinished negative effects on social inequalities and health equity [101, 102] The starting point can be health impact assessment instruments focussed on equity [103]. Data from the above-mentioned integrated health, climate, environmental and social monitoring can be utilised.

Continued on next page

Table 4 *Continuation*
***of* recommendations for action and research needs for greater climate justice**
Source: Own presentation

Recommendation for action	Explanation
Counteracting the stigmatisation of population groups	▶ In research and measures in the context of climate change and health, avoid possible stigmatisation of socially disadvantaged population groups or due to climate change. Actively meeting the consequences of change for refugees
Develop and expand research approaches on mechanisms of climate injustice and to quantify the effects of climate measures on health justice	▶ Interdisciplinary and intersectionality-informed [17, 74, 104] research on processes of disadvantage and discrimination in exposure to climate change impacts and in measures of climate change mitigation. carry out climate change mitigation and adaptation activities to understand the effects of climate action on health equity (examples from research on heat action plans: [105, 106]), the mechanisms of climate injustice and social destabilisation caused by climate change impacts [107]

Info box 2
Environmental justice strategy of the state of Berlin

The model programme "Environmental Justice in the State of Berlin" was launched in 2008 with the aim of creating a basis for socio-spatial policy decisions. The environmental justice strategy consists of three levels of action:
(1) monitoring, (2) planning and (3) implementation. It aims to analyse the socio-spatial distribution of environmental pollution and resources and to reduce or avoid pollution through compensation concepts. At a small-scale neighbourhood level, the monitoring system records three indicators for harmful exposures (noise pollution, air pollution, thermal pollution), an indicator for a health-promoting resource (green space supply) and a social index indicator to determine social disadvantage, which is calculated from indicators on unemployment and transfer payments (non-unemployed and children under 15). In the Berlin Environmental Justice Atlas, these indicators are mapped spatially and intersected with each other. This makes those urban areas visible that are particularly or multiply burdened. The data in the Environmental Justice Atlas was last updated in 2021/2022 [70]. The Berlin Senate and the Berlin boroughs use the findings of the environmental justice monitoring to develop measures in various areas (mobility, urban greenery, construction and housing). These measures are intended to help improve the quality of life and reduce environmental pollution. The environmental justice strategy of the state of Berlin thus creates a data-based starting point for further advancing socially just, health-promoting and environmentally friendly urban planning. In the Friedrichshain-Kreuzberg district, for example, the environmental justice atlas was used to prioritise applications for residential areas without through traffic. In the 2021 - 2026 coalition agreement, the Berlin Senate refers to its intention to reduce the number of heavily polluted areas by the end of the election period.

In future, the environmental justice strategy could benefit from integrating further environmental justice indicators, such as pro- cedural and participatory justice or recognition justice, into the monitoring process. Other dimensions could also be included, such as the proportion of very old and chronically ill people or the density of social facilities such as daycare centres.

▶ Environmental justice □□□□□□□ of the Berlin Senate Department for Mobility, Transport, Climate Protection and the Environment

It is time for a transformation towards resilient, climate-friendly, sustainable and health-promoting living environments for all.

6. Conclusion

Climate justice in the sense of avoiding or at least reducing social inequalities in exposure to climate change impacts, in vulnerability in relation to the direct and indirect health effects of climate change impacts and in the effects of climate change mitigation and adaptation measures on health inequalities is still little addressed in Germany. Systematic studies on this and the consistent integration of social justice and health justice into climate policy are still largely lacking. In this article, overarching recommendations for action in Germany are derived from the international discourse and examples of the integration of justice aspects into the planning, implementation and evaluation of climate measures from an intersectionality perspective. Even if specific data and evidence are often still lacking for Germany, it is possible to start acting in line with the precautionary principle on the basis of knowledge on environmental justice and health equity in order to achieve a transformation to resilient, climate-friendly, sustainable and health-promoting living environments for all.

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Conflict of interest

The authors declare that there is no conflict of interest.

Contributions by the authors

G.B. and L.D. carried out the research on concepts and models. G.B. developed the model for this article. S.L.L. carried out the systematic literature research with the support of C.H. and G.B. G.B. processed the explorative literature analysis. L.D. and S.G. analysed all individual contributions to the status report on climate change and health. G.B. contributed Infobox 1,
S.L.L. and C.H. wrote Infobox 2. G.B. wrote the first draft of the manuscript and coordinated the content editing process for the article. All authors contributed

comments, additions or suggestions for changes and were involved in the approval of the final version of the manuscript.

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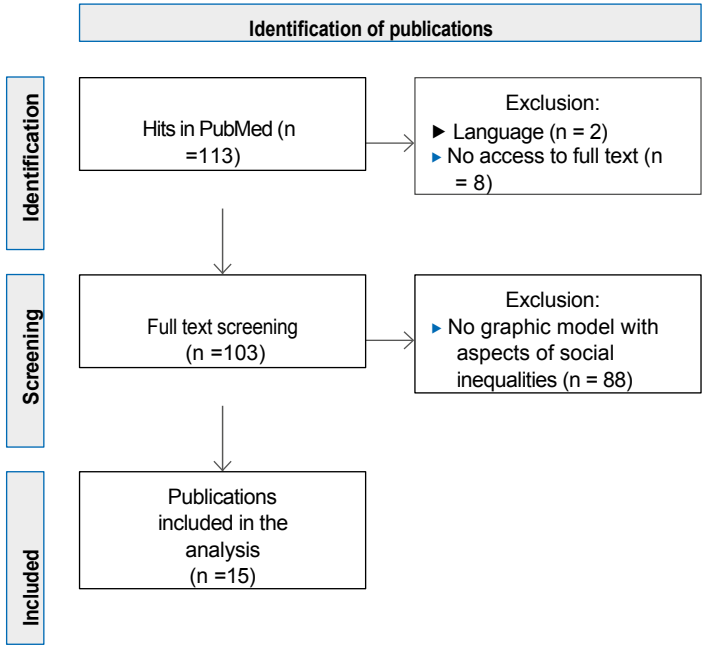
(as at 24/09/2023)

Annex Table 1 (left) **Search query for the literature search on models/concepts in the field of climate change, health and social justice in the database Medline via PubMed**

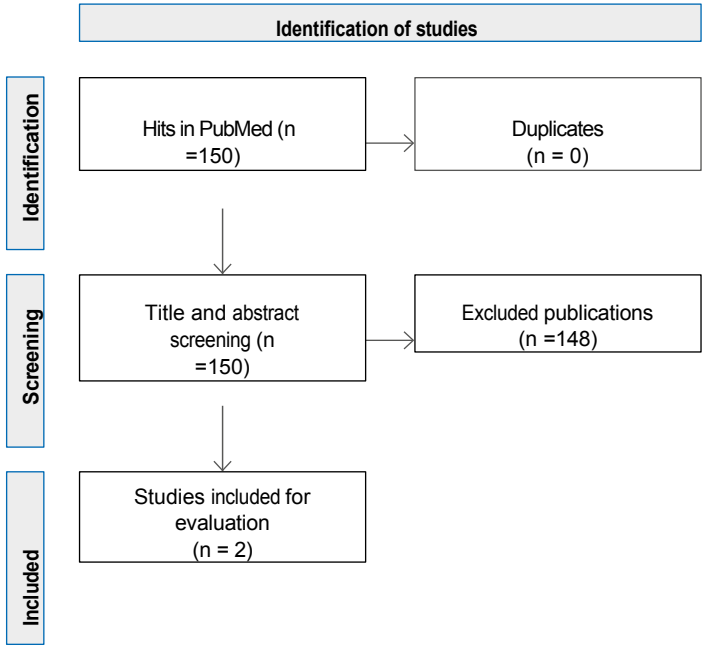
Database	Search strategy
PubMed	"climate change"[Title/Abstract] AND health[Title/Abstract] AND (soci*[Title/Abstract] AND (justice[Title/Abstract] OR injustice[Title/Abstract] OR inequit*[Title/Abstract] OR equit* [Title/Abstract] OR inequalit*[Title/Abstract] OR equalit* [Title/Abstract])) AND (model [Title/Abstract] OR framework [Title/Abstract] OR concept* [Title/Abstract])

Annex Figure 1 (right) Flow chart for identifying publications with graphical representations of Concepts or models on climate justice and health Source: Own presentation



Annex Table 2 (left)
Search query for the systematic literature search for evidence in Germany in the Medline database via PubMed.
Keywords between the areas were connected with AND.

Range	Search strategy
Social justice	equit*[Title/Abstract] OR inequ*[Title/Abstract] OR "social advantage"[Title/Abstract] OR "social disadvantage"[Title/Abstract] OR "social exclusion"[Title/Abstract] OR "social inclusion"[Title/Abstract] OR "social status"[Title/Abstract] OR equal*[Title/Abstract] OR "social position"[Title/Abstract] OR "social gradient"[Title/Abstract] OR "social determinant" [Title/Abstract] OR social discrimination[MeSH Terms] OR deprivation[Title/Abstract] OR deprived[Title/Abstract] OR "socioeconomic advantage"[Title/Abstract] OR "socioeconomic disadvantage"[Title/Abstract] OR "socioeconomic exclusion"[Title/Abstract] OR "socioeconomic inclusion"[Title/Abstract] OR "socioeconomic status"[Title/Abstract] OR "socioeconomic position"[Title/Abstract] OR "socioeconomic gradient"[Title/Abstract] OR "socioeconomic determinant" [Title/Abstract] OR "socioeconomic discrimination"[Title/ Abstract] OR "socio-economic advantage"[Title/Abstract] OR "socio-economic disadvantage"[Title/Abstract] OR "socio-economic exclusion"[Title/Abstract] OR "socio-economic inclusion"[Title/Abstract] OR "socio-economic status"[Title/ Abstract] OR "socio-economic position"[Title/Abstract] OR "socio-economic gradient"[Title/Abstract] OR "socio-economic determinant"[Title/Abstract] OR "economic advantage"[Title/Abstract] OR "economic disadvantage"[Title/Abstract] OR "economic exclusion"[Title/Abstract] OR "economic inclusion" [Title/Abstract] OR "economic status"[Title/Abstract] OR "economic position"[Title/Abstract] OR "economic gradient" [Title/Abstract] OR "economic determinant"[Title/Abstract] OR "economic discrimination"[Title/Abstract] OR just*[Title/ Abstract] OR injust*[Title/Abstract]
Climate change	climat*[Title/Abstract] OR climate change[MeSH Terms] OR "global warming"[Title/Abstract] OR extreme weather [MeSH Terms] OR "environmental change"[Title/Abstract] OR "ecological change"[Title/Abstract] OR greenhouse effect [MeSH Terms] OR cold[Title/Abstract] OR cool[Title/Abstract] OR cooling[Title/Abstract] OR heat[Title/Abstract] OR humid* [Title/Abstract] OR ice[Title/Abstract] OR temperature[Title/ Abstract] OR "thermal comfort" [Title/Abstract] OR "thermal stress" [Title/Abstract] OR rain* [Title/Abstract] OR season* [Title/Abstract] OR snow* [Title/Abstract] OR "carbon emission" [Title/Abstract] OR warm [Title/Abstract] OR warming [Title/Abstract] OR wind [Title/Abstract] ultraviolet rays [MeSH Terms] OR clouds [Title/Abstract] OR flood* [Title/Abstract] OR drought [Title/Abstract] OR storm [Title/Abstract]
Germany	Germany[MeSH Terms] OR Germany[Title/Abstract] OR Germany[Other Term]



Annex Figure 2 (right)
Flowchart identifying studies on the importance of social dimensions for exposure to climate change impacts, or their health effects in Germany Source: Own presentation

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