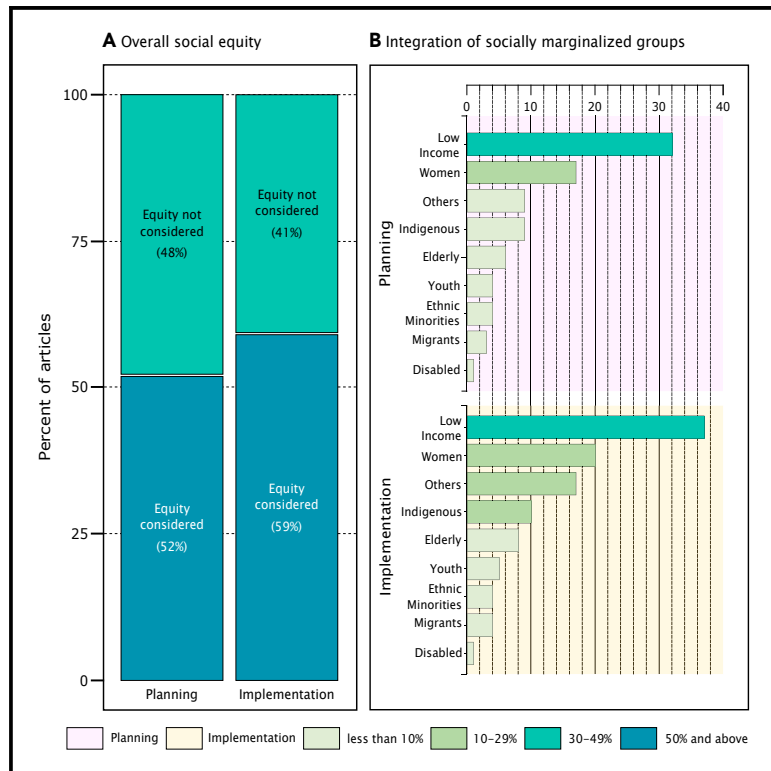


Equity in human adaptation-related responses: A systematic global review

Graphical abstract



Authors

Malcolm Araos, Kripa Jagannathan, Roopam Shukla, ..., Sienna Templeman, Lynée L. Turek-Hankins, the GAMI Team

Correspondence

malcolm.araos@nyu.edu

In brief

This paper presents the first large-n global assessment of how equity is integrated in planning and implementation of adaptation responses. By examining 1,682 peer-reviewed articles reporting on adaptation responses across the world, we find that attention to equity is not equal across geographic regions, topical sectors, or marginalized groups. Our paper calls on the adaptation community to foreground considerations of social equity and document social equity in empirical studies of adaptation responses in order to advance progress on social justice.

Highlights

- We present a large-n global assessment of equity in adaptation responses
- Paper examines the extent to which marginalized groups are considered in responses
- Responses in Africa and Asia are more likely to consider equity than other regions
- Increased attention to how equity is integrated into adaptation is urgently needed



Article

Equity in human adaptation-related responses: A systematic global review

Malcolm Araos,^{1,26,27,*} Kripa Jagannathan,^{2,26} Roopam Shukla,³ Idowu Ajibade,⁴ Erin Coughlan de Perez,⁵ Katy Davis,⁶ James D. Ford,⁶ Eranga K. Galappaththi,⁷ Caitlin Grady,⁸ A.J. Hudson,⁹ Elphin Tom Joe,¹⁰ Christine J. Kirchhoff,¹¹ Alexandra Lesnikowski,¹² Gabriela Nagle Alverio,¹³ Miriam Nielsen,¹⁴ Ben Orlove,¹⁴ Brian Pentz,¹⁵ Diana Reckien,¹⁶ A.R. Siders,¹⁷ Nicola Ulibarri,¹⁸ Maarten van Aalst,^{5,14,16} Thelma Zulfawu Abu,¹⁹ Tanvi Agrawal,²⁰ Lea Berrang-Ford,⁶ Rachel Bezner Kerr,²¹ Shaugn Coggins,²² Matthias Garschagen,²³ Alexandra Harden,¹¹ Katharine J. Mach,²⁴ Abraham Marshall Nunbogu,¹⁹ Pandey Spandan,²⁵ Sienna Templeman,¹⁴ Lynée L. Turek-Hankins,²⁴ and the GAMI Team

¹New York University, New York, NY, USA

²Lawrence Berkeley National Laboratory, Berkeley, CA, USA

³Potsdam Institute for Climate Impact Research, Potsdam, Germany

⁴Portland State University, Portland, OR, USA

⁵Red Cross Red Crescent Climate Centre, The Hague, Netherlands

⁶University of Leeds, Leeds, UK

⁷McGill University, Montreal, QC, Canada

⁸Penn State University, State College, PA, USA

⁹Yale Law School, New Haven, CT, USA

¹⁰World Resources Institute, Washington, DC, USA

¹¹University of Connecticut, Mansfield, CT, USA

¹²Concordia University, Montreal, QC, Canada

¹³Duke University, Durham, NC, USA

¹⁴Columbia University, New York, NY, USA

¹⁵University of Toronto, Toronto, ON, Canada

¹⁶University of Twente, Enschede, Netherlands

¹⁷University of Delaware, Newark, DE, USA

¹⁸University of California, Irvine, Irvine, CA, USA

¹⁹University of Waterloo, Waterloo, ON, Canada

²⁰Ashoka Trust for Research in Ecology and the Environment, Bengaluru, Karnataka, India

²¹Cornell University, Ithaca, NY, USA

²²University of Alberta, Edmonton, AB, Canada

²³Ludwig-Maximilians-Universität Munich, Munich, Germany

²⁴University of Miami, Coral Gables, FL, USA

²⁵Tata Institute of Social Sciences, Mumbai, Maharashtra, India

²⁶These authors contributed equally

²⁷Lead contact

*Correspondence: malcolm.araos@nyu.edu

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SCIENCE FOR SOCIETY As climate change adaptation actions are increasingly undertaken worldwide, it is imperative that responses integrate considerations of equity in their planning and implementation. Early case studies have shown that adaptive land-use planning in cities across the world, have reproduced uneven risk exposure and socio-economic vulnerability when it does not consider who benefits or loses from adaptation. Yet there are no large-scale systematic assessments of how social equity is being integrated into implemented adaptations. Through an extensive examination of peer-reviewed research documenting adaptation responses, this article analyzes the extent to which eight historically marginalized social groups were considered in planning or implementation of adaptation across regions and sectors. This large-n assessment examines the global status of where, how, and to what extent social equity is incorporated into adaptation, providing a baseline against which future progress can be measured.

SUMMARY

Growing evidence suggests that climate adaptation responses that do not incorporate equity considerations may worsen inequality and increase vulnerability. Using data from a systematic review of peer-reviewed

empirical research on adaptation responses to climate change ($n = 1,682$), we present an assessment of how social equity is considered in adaptation across regions, sectors, and social groups. Roughly 60% of peer-reviewed literature on adaptation responses considers social equity by reporting on which marginalized groups were involved in planning or implementation. Articles on responses in Africa and Asia and those focusing on poverty reduction most frequently considered social equity. Equity was less likely to be considered in adaptation responses in Europe, Australasia, and North America, as well as in literature focused on cities. Income-based inequity was more frequently considered than gender, age, or Indigenous status. Ethnic and racial minorities, migrants, and people with disabilities were rarely considered. Attention to the levels and forms in which equity is integrated into adaptation research and practice is needed to ensure just adaptation.

INTRODUCTION

Climate change disproportionately affects the most marginalized groups in society while, in many cases, these groups have contributed the least to carbon emissions.^{1–5} Due to the systemic sources and mechanisms of marginalization, these groups tend to have greater resource needs and fewer means to cope with climatic impacts compared with social groups that hold economic, political, or social advantages.^{6,7} Without intentional and consistent attention to ensure equity in planning and implementation of adaptation for marginalized groups, climate change will likely exacerbate and reproduce existing inequities and vulnerabilities in society.^{8–10} For example, studies show that land-use planning for adaptation in cities across the world reproduces uneven risk exposure and socioeconomic vulnerability when it does not consider who benefits or loses from certain adaptation responses.^{9–11} Researchers further document how adaptation responses such as coastal protection infrastructure,¹² expansion of green spaces,¹³ and managed retreat¹⁴ can disproportionately benefit wealthy and otherwise advantaged individuals. These adaptation benefits often come at the expense of poor and marginalized groups if adaptations do not intentionally prioritize marginalized groups or do not involve them in the planning and decision-making processes.^{9,15} Moreover, the Paris Agreement establishes a mandate to consider marginalized groups in crafting adaptation responses.¹⁶ Tracking the equity dimensions not only of climate change impacts, but also of adaptation responses, is thus paramount to achieving climate justice.^{17,18}

Systematic tracking of global-scale adaptation efforts is complicated, however; there is no single database that documents adaptation responses across the world, and there is no standardized method for conducting such a global-scale analysis.¹⁹ In lieu of a single large database, data sources such as peer-reviewed research, national adaptation assessments, gray literature, and adaptation planning documents have been considered to be acceptable (although imperfect) proxies for adaptation efforts on the ground.¹⁹ Despite these complexities, there have been increasing efforts to track adaptation at large scales (e.g., globally), typically analyzing planned or top-down adaptation responses. These large- n efforts commonly use content analysis to scrutinize primary documents (e.g., policies,^{20–28} legislative records,²⁹ project summaries from global climate change funds, or national reports to United Nations bodies^{30,31}) that describe adaptation initiatives and yield detailed information about the design of adaptation responses. But these approaches tend to be resource intensive and are challenging to

scale up to a global level. Hence, systematic reviews of published research are becoming increasingly popular in the adaptation literature to assess emerging knowledge and gaps in the massive and rapidly expanding volume of research that examines responses to climate change impacts and vulnerability.³² Although published research alone may not be able to holistically capture all of the adaptation responses being undertaken worldwide, these reviews aim to achieve transparency and replicability in their methods and universal inclusion of published research based on a specific research question.¹⁹ Findings from existing global-scale content analyses and systematic reviews generally indicate that adaptation responses are still largely in the planning and early implementation stage and that high-income and/or larger cities and countries tend to report greater progress on adaptation than low-income and/or small cities and countries.^{20,33,34}

To our knowledge, no systematic review of peer-reviewed research has yet considered the question of whether and how equity is considered in adaptation responses across regions and sectors. Existing comparative research on the topic of equity relies on content analysis of adaptation plans and key planning documents, and tends to focus on one sector and/or region or specific implementation pathways.^{10,35} Scholars have also produced a large number of in-depth studies exploring social equity in relation to adaptation, which constitutes a rich body of literature examining equity-related processes and outcomes in different contexts. This research aims to expand on and complement the findings from these studies by developing a global picture of whether, where, and how equity is being considered in adaptation responses. By adopting a systematic review approach to this question, we are able to examine equity considerations across regions and sectors.

Drawing on data from the Global Adaptation Mapping Initiative (GAMI), an international collaborative project to systematically track and examine peer-reviewed research on human adaptation responses published since 2013 ($n = 1,682$ articles), we produced a large- n global assessment of how social equity is considered in peer-reviewed research on adaptation responses, providing a baseline against which future progress can be measured. GAMI asks: What is the evidence for human adaptation-related responses that can directly reduce risk, exposure, and/or vulnerability to climate change? To develop the dataset, the GAMI team identified about 50,000 articles from Scopus, Web of Science, and Google Scholar. The team then used a combination of machine learning and manual review to narrow the articles down for inclusion in the GAMI dataset. To be

included, the article needed to (1) be climate change related, (2) report empirical data on adaptation-related responses (not conceptual or theoretical information or simulated responses), (3) report findings on how human systems are responding to climate change, (4) go beyond examining vulnerability or impacts assessment to document responses, (5) be published between 2013, the cutoff for the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, and 2019, and (6) report tangible responses that people have taken to reduce risks and vulnerabilities. A total of 1,682 articles were included in the final GAMI dataset, which were then coded for 70 variables (see full codebook in the [supplemental information](#)).

We assessed aspects of equity and fairness in articles on adaptation responses through a justice framework composed of two components: procedural justice and distributive justice. Scholars have also identified additional components of justice, such as recognition justice, which are outside of this paper's scope. In the context of adaptation, procedural justice refers to the level and form of inclusion, participation, and influence of marginalized groups in all stages of the process, including decision-making, planning, implementation, and evaluation of initiatives.³⁶ Distributive justice refers to the fair allocation of impacts and benefits intended to arise from adaptation.^{25,27,37} Since the structurally and historically constructed marginalization of individuals and communities often runs along lines of class, race, ethnicity, gender, indigeneity, and political status, these identities are important considerations when it comes to who is included in decision-making, whose voices and experiences matter, and who is affected positively or negatively by adaptation plans.

We acknowledge the complexity in the equity and justice literature and recognize that the diversity of theories and definitions utilized across existing scholarship may not fit precisely within the categorizations presented in this framework. We also acknowledge the literature examining the causal relations and interconnected nature of these components and others, addressing issues such as whether broader participation in deliberations—a central element of procedural justice—leads to broader allocation of resources and reduction of harms—a central element of distributive justice.¹⁸ However, these examinations are outside of the scope of this paper.

In this paper, we operationalize consideration of procedural justice as a binary variable indicating whether the article on adaptation response included socially marginalized groups in the planning process. We operationalize consideration of distributive justice as a binary variable indicating whether the article on adaptation response included socially marginalized groups in the implementation of initiatives. This variable on implementation captures the role of marginalized groups as both recipients of intended benefits of planned adaptation and implementers of autonomous adaptation initiatives themselves. Our variables draw from prior research that has conceptualized distributive justice to refer to equitable and just distribution in the provision of goods and services, as a critical step (although not sufficient) toward ensuring equity in outcomes.^{38,39}

We apply the justice framework through a quantitative analysis of the extent to which eight social categories commonly understood to experience marginalization and vulnerability to climate impacts (low-income groups, women, Indigenous peoples,

elderly or young people, ethnic and racial minorities, and individuals with disabilities) are documented as intended participants in adaptation responses (distributive justice) and/or included as participants in the planning process (procedural justice). The eight categories of vulnerability used in this study are based on the groups identified by the IPCC reports, the United Nations Sustainable Development Goals prioritized groups, and existing academic literature on social marginalization and vulnerability (see [experimental procedures](#) for details). The quantitative analysis is supplemented with qualitative examples from the literature describing how these groups are included in responses. We also review how considerations of equity in peer-reviewed literature vary across regions of the world and across the following thematic areas identified as relevant categories by the IPCC:⁴⁰ “Poverty, livelihoods, and sustainable development;” “Health, well-being, and communities;” “Cities, settlements, and key infrastructure;” “Food, fiber, and other ecosystem products;” “Water quality and sanitation;” and “Ocean and coastal ecosystems.” Finally, we also document how social equity is considered across types of adaptation responses (“behavioral/cultural responses,” “ecosystem-based responses,” “technological/infrastructure responses,” and “institutional responses”) ([Table 1](#)).

While this paper examines how equity is considered in research on adaptation responses, this work does not directly measure or evaluate outcomes of adaptation responses. Through this dataset, we are not able to assess how adaptation responses bolster or hamper equitable outcomes for different social groups (or if they make no difference). Indeed, evaluating the effect of adaptation responses on vulnerability or equity is well documented to be methodologically complex and conceptually fraught.⁴¹ Further, since adaptation is long term and there is limited monitoring and evaluation of adaptation outcomes, a large-n assessment of the equity in adaptation outcomes is not feasible due to these reporting limitations. Our analysis, hence, offers a necessary first step in characterizing how social equity is intentionally considered and integrated into adaptation responses globally, as documented in peer-reviewed literature.

RESULTS

Over half of the articles in the GAMI assessment included social equity considerations in the adaptation response, either identifying at least one marginalized group in implementation (59%) or incorporating at least one group in planning (52%) (see [Figure 1A](#)) or both (48%). Low-income groups are the most frequently considered group (reported in 37% of articles, see [Figure 1B](#)), followed by women (20%), Indigenous peoples (10%), the elderly (8%), youths (5%), racial and ethnic minorities (4%), and migrants (4%). Individuals with disabilities are the least considered, with only 1% of articles including this group. The “Other” category captures characteristics of social disadvantage that are distinct from the eight categories and do not appear as frequently in the peer-reviewed literature. This includes, for example, groups marginalized due to marital status or assets (education, farm size, and land tenure).

We also found a strong correlation between marginalized groups being integrated into planning and being included in implementation of adaptation responses in the peer-reviewed

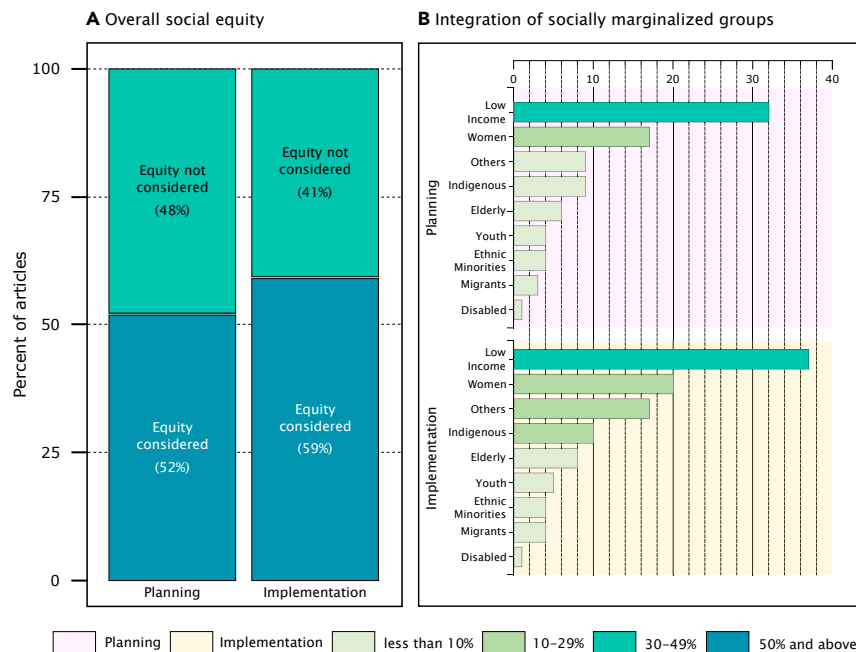


Figure 1. Social equity consideration in global adaptation responses

(A) Percentage of overall articles that include a marginalized group (“Equity considered”) or leave out all marginalized groups (“Equity not considered”) in planning and implementation. (B) Percentage of overall articles that integrate each of the different socially marginalized or marginalized groups into adaptation. Counts are not mutually exclusive, since one adaptation response can include multiple groups in planning or implementation.

adaptation responses reported. Further, logistic regression indicates that articles documenting adaptation in Africa are 2.3 times more likely to include equity in implementation of responses than articles documenting adaptation outside of Africa ($p < 0.0001$) (refer to the [supplemental information](#) for scores for other regions).

In Asia and Small Island States, over half of the articles (59%) report responses that

include at least one marginalized group in implementation of adaptation. In Asia, low-income groups (37%) are again most frequently reported, followed by women (17%), but all other marginalized groups appear in less than 10% of articles. Over half of the articles in Central and South America (56%) report at least one marginalized group in implementation of adaptation responses. Integration into planning displays similar patterns in addressing equity, with Africa (67%), Small Island States (56%), Asia (53%), and Central and South America (53%) most frequently addressing equity (see [Figure 2B](#)).

Articles documenting responses in Australasia (28%), Europe (29%), and North America (42%) are least likely to report including a marginalized group in implementation. Europe and Australasia are 0.4 and 0.3 times less likely than non-Europe or Australasia articles to include equity ($p < 0.001$) in implementation. For planning, the same pattern is evident, as the number of articles incorporating equity in Europe (22%), Australasia (26%), and North America (38%) lag behind those of Africa, Asia, and Small Island States. Notably, in Europe, only 11% of responses report including low-income groups, and all other groups were reported in less than 6% of articles in the region.

Global South adaptation most likely to integrate equity

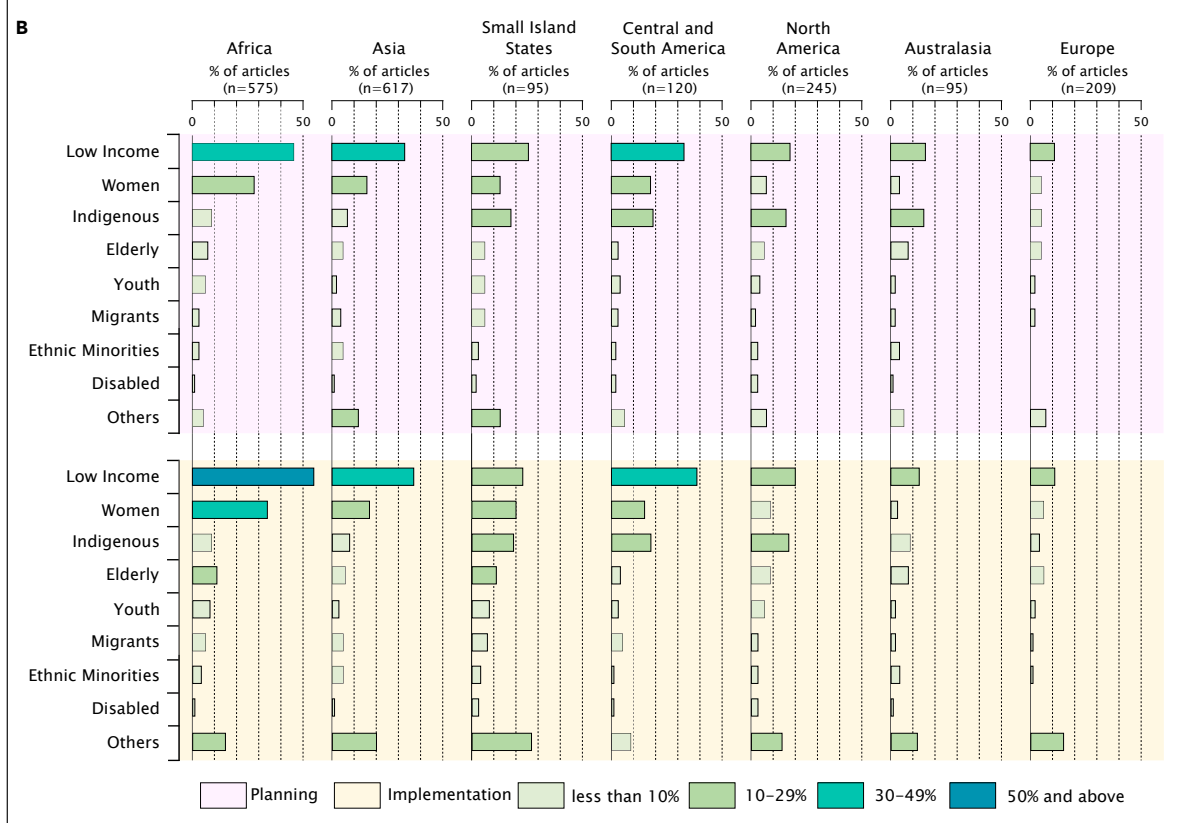
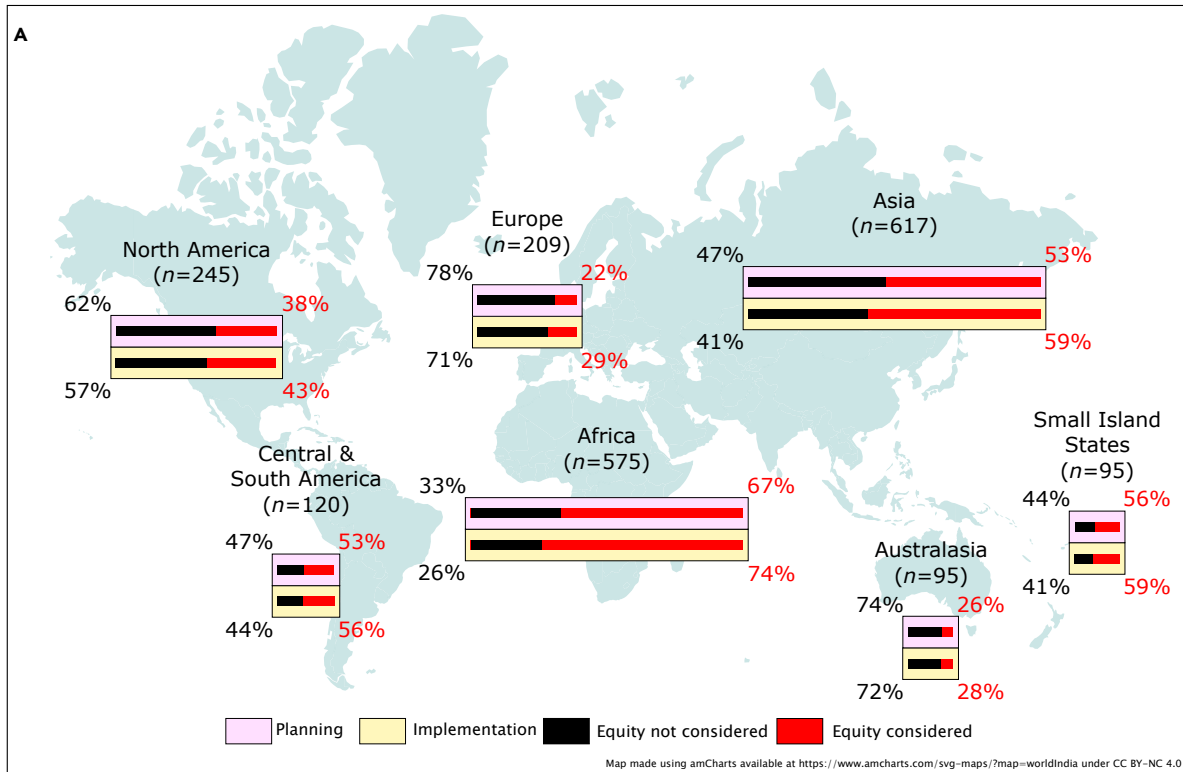
Articles documenting adaptation responses in Africa report marginalized groups as included in the implementation of adaptation more frequently than in other regions. Seventy-four percent of articles from Africa report at least one marginalized group as included in implementation of adaptation (see [Figure 2A](#)). Among these, low-income groups are most frequently included (in 55% of articles), followed by women (34%) and the elderly (11%) (see [Figure 2B](#)). Youth, migrants, ethnic minorities, and individuals with disabilities are considered in under 10% of

literature. That is, if members of groups experiencing vulnerabilities were involved in planning adaptation responses, then they were also highly likely to be included in the implementation of those responses (phi correlation coefficient [ϕ] = 0.699, $p < 0.001$). Correlations between integration in planning and inclusion in implementation were high across all groups (refer to the [supplemental information](#) for all scores).

We also measured the extent to which adaptation responses reported in the literature consider multiple social groups. We computed ϕ coefficients in cases where articles reported at least two marginalized groups identified as involved in planning or included in implementation. Elderly and youth groups appear together most frequently in articles on adaptation responses ($\phi = 0.355$ for being included in implementation), followed by the elderly and individuals with disabilities ($\phi = 0.308$). Youth and women are similarly correlated ($\phi = 0.307$), as are the elderly and women ($\phi = 0.301$). Although low-income individuals are the most frequently discussed in the responses, income is only occasionally discussed in conjunction with another social group ($\phi < 0.1$ for all groups except women and elderly). Further, while low-income and women are the two most frequently discussed groups in responses independently, they do not appear to be reported within the same adaptation response as much as other groups ($\phi = 0.201$ for being included together in implementation).

Poverty sector most frequently integrates equity

Sectorally, articles documenting adaptation responses in “Poverty, livelihoods, and sustainable development” most frequently report at least one socially marginalized group in the implementation of the action (75% of articles, see [Figure 3B](#)), and responses in this sector are 2.3 times more likely to include equity in implementation than others ($p < 0.001$). Although the responses in this sector are primarily related to matters of poverty, livelihoods, sustainable development, wealth, etc., only 52% of articles explicitly discuss including low-income groups (see [Figure 3A](#)). The “Ocean and coastal ecosystems” sector is 2.7 times more likely to include equity in implementation than non-oceans ($p < 0.001$), with 70% of articles documenting responses



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considering at least one marginalized group. While 27% of articles include low-income groups, the largest group included in implementation is “Other,” which includes coastal households exposed to high risk living on coastal edges, as well as fishers who depend on the stability and quality of ocean ecosystems for livelihoods.

Around two-thirds (67%) of articles documenting adaptation responses in the “Health, well-being, and communities” sector include at least one marginalized group in implementation. Consistent with findings across regions, low-income groups, women, and Indigenous peoples are the most frequently considered groups. About 12% of articles report adaptation responses that focus on elderly individuals (see Figure 3A), possibly highlighting the relationship between climate change and the marginalized physiology of older adults.^{42,43} Over half of the articles in the sectors of “Food, fiber, and other ecosystem products” (64%), “Water and sanitation” (53%), and “Terrestrial and freshwater ecosystems” (53%) include at least one marginalized group in implementation, again most frequently low-income groups and women. The focus on women in these sectors may reflect the widely recognized burden faced by women for adaptation in food production and watershed conservation actions in the Global South.⁴⁴ Strikingly, articles in the “Cities, settlements, and key infrastructure” sector least frequently report that adaptation responses integrate social equity. Only 44% of articles in this sector include any discussion of social equity in the implementation of responses (see Figure 3B), and 23% include low-income groups, while only 8% consider women. Similar to our regional findings, the results for integration of equity in the different sectors for planning are very similar to those for implementation (see experimental procedures for a discussion on potential reasons for this similarity).

Behavioral/cultural responses most likely to integrate equity

We also analyzed the integration of socially marginalized groups across types of adaptation responses: “Behavioral/cultural,” “Institutional,” “Ecosystem-based,” or “Technological/infrastructure” (refer to experimental procedures for definitions). Logistic regression results show that “Behavioral/cultural” adaptation responses are 1.9 times more likely to include a marginalized group in implementation than other types of responses ($p < 0.0001$). We also found that “Institutional” responses are 0.7 times less likely ($p < 0.001$) to include a marginalized group in implementation than other types of responses. “Ecosystem-based” or “Technological/infrastructure” adaptation responses do not yield statistically significant patterns for inclusion of marginalized groups (Figure 4).

How is equity integrated into adaptation?

Many articles in the GAMI database lacked sufficient detail to quantitatively assess how different marginalized groups were involved in adaptation (see “Data limitations” in the experimental

procedures); to answer this question, we performed a qualitative review of a subset of articles that provided sufficient detail (see “Data analysis” in the experimental procedures for details). While it is difficult to ascertain whether the subset of articles is representative of the total sample, the qualitative review offered valuable insights into how equity was integrated in adaptation articles. From the total number of articles that considered social equity, only 32% contained sufficient detail to glean how marginalized groups were included in planning or identified as participants. From this subset, we used inductive coding⁴⁵ to identify four broadly illustrative ways in which adaptation responses integrated social equity: equity through “self-organization” (61% of total articles with enough detail to code), “focused targeting” (20%), “co-development” (16%), and “local participation” (9%—coding is not mutually exclusive). While these mechanisms are not neatly demarcated in the peer-reviewed literature, the mechanisms of “focused targeting” align with dimensions of distributive justice, while “co-development” and local participation relate to procedural justice dimensions. “Self-organization” has elements of both procedural and distributive justice. These results show that when equity considerations are discussed in the peer-reviewed literature, it is most frequently in the context of distributive rather than procedural justice. In other words, discussions concerning the fair allocation of resources for adaptation are reported more frequently in peer-reviewed literature than discussions about the involvement of marginalized groups in decision-making for adaptation.

Equity through “self-organization” occurs when marginalized groups are included in the population that organizes and undertakes the responses. One article, for example, details how “[d]iverse community groups [age-based, gender-based, political, and religious groups] across six communities were responsible for implementing collective actions that helped their community adapt or respond to climatic events.”⁴⁶ This example shows how, in some cases, the marginalized groups themselves self-organize to implement adaptation responses. Self-organization, or autonomous responses, may either represent affected groups building on their own experiences and knowledge to undertake adaptation actions (including self-organization as an act of sovereignty) or result from climate injustice, as exclusion from benefits of existing adaptation responses or lack of support from the state and other institutions may force individuals, households, or communities to adapt on their own.^{47–49}

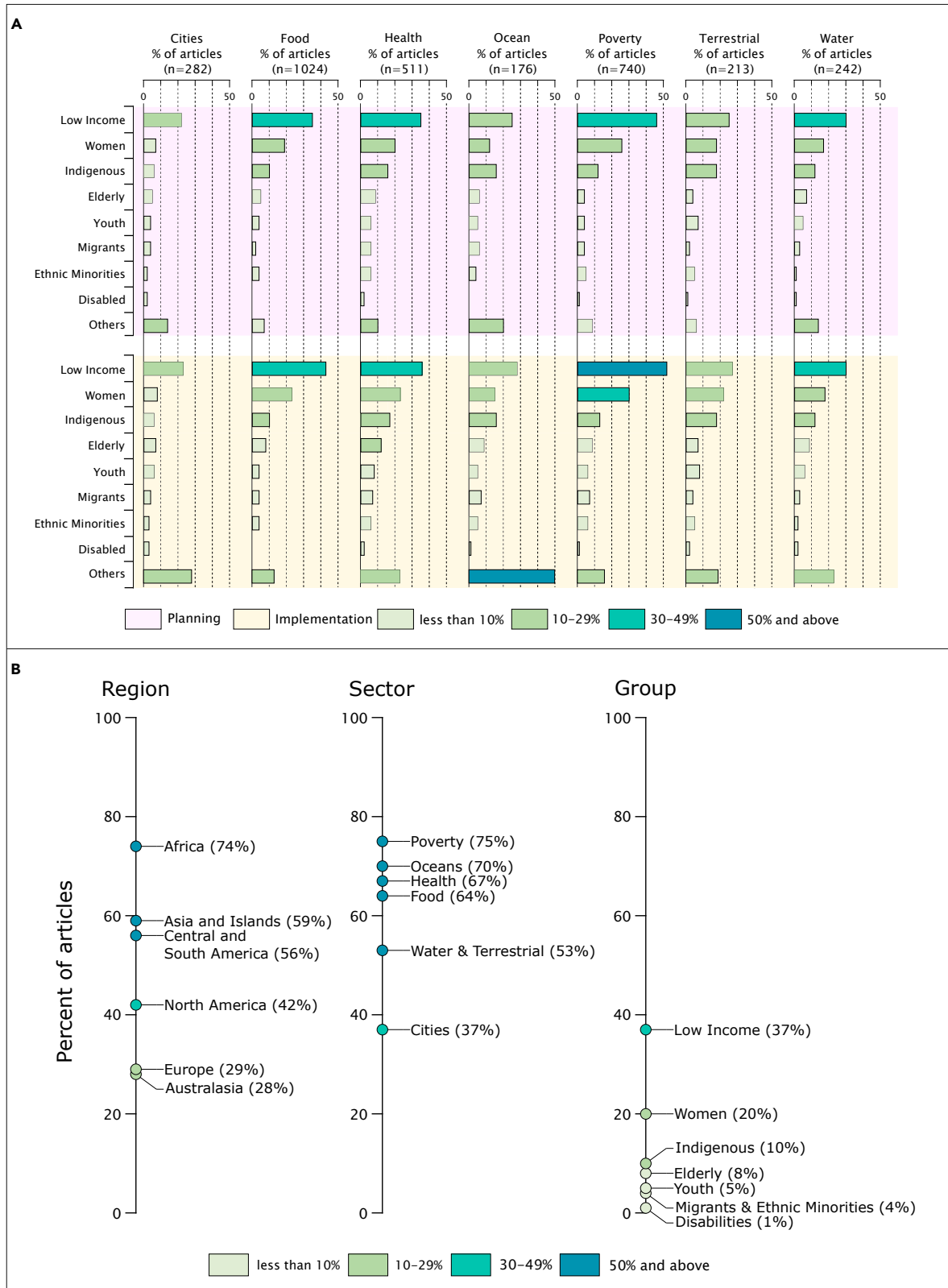
Equity can also be integrated through “focused targeting” in cases where adaptation schemes, policies, or actions focus on specific marginalized groups as included in implementation or provide evidence of risk reduction in specific marginalized populations. One article shows how an adaptation initiative sought to prioritize socially marginalized groups explicitly: “[T]he Enhancing Community Resilience Programme (ECRP) sought to improve the lives of over 600,000 Malawians whose predominantly agriculture-based livelihoods are acutely threatened by regular and worsening climate shocks and stresses (including

Figure 2. Consideration of socially marginalized groups across regions

When at least one marginalized group is included in the response it is termed as “Equity considered” and if the responses do not consider any marginalized groups it is termed as “Equity not considered.”

(A) Consideration of equity across regions (planning and implementation).

(B) Consideration of each social group across regions (planning and implementation).



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dry spells and drought, heavy rains and flooding, windstorms). The projects professed to include particularly marginalized households in implementation (e.g., the extremely resource-poor, elderly-headed, female-headed, those with disabled or chronically ill adult members) whose capacity to adapt to climate shocks and stresses is extremely low.⁵⁰ Some articles in this category focus on documenting evidence of risk reduction or reduced vulnerability, wherein marginalized groups are shown to successfully take up or benefit from adaptation responses. One study explains how “initiatives have also improved family wellbeing, particularly for women. In addition to the direct employment created within the communities for those who are responsible for the operation and maintenance of the systems, women have considerably reduced the time spent doing house chores, especially laundry. Furthermore, micro-hydro systems have positively impacted the children and youth, who have improved education opportunities through more time to study and access to communication technologies.”⁵¹

“Co-development” occurs in cases where governmental or non-governmental organizations (NGOs) deem involving specific marginalized groups directly in a decision-making capacity as essential for the development and implementation of responses. An example shows how “Rangpur Dinajpur Rural Services [in Bangladesh] has been working on climate change adaptation through forming community-based groups like the Village Disaster Management Committee (VDMC) ... The VDMC group committee is formed and validated in consensus of community people.”⁵² The article also details specific criteria for VDMC formation, such as maintaining a gender balance in the committee and in leadership, having at least half of the members from the most marginalized households, and including youth representatives.

Finally, equity can be integrated through “local participation,” wherein marginalized groups are encouraged to take part in participatory processes for the planning and implementation of responses but may or may not have decision-making power. For example, in an adaptation response in Guatemala, international donors, local NGOs, and other partners undertook adaptive watershed management by identifying and declaring protected ecological areas. Here, “the communities [that included low-income and indigenous groups] were involved in participatory assessments of areas with the highest ecological value along with the identification of sacred or ceremonial sites and areas with potential for economic activities based on ecotourism ... municipal authorities acknowledged the need to protect the area and started a long consultative process with the communities, represented by five grassroots farmer organizations.”⁵³ In this case, marginalized groups had opportunities to express their opinions and were involved to some extent in the planning process, but their ultimate influence on shaping the responses was unclear.

DISCUSSION

Through an extensive examination of peer-reviewed research documenting implemented adaptation responses worldwide,

this article evaluates the global status of where, how, and to what extent social equity concerns are considered in adaptation responses. We find that a substantial fraction (roughly 60%) of articles documenting climate change adaptation responses address equity by involving marginalized groups in planning or including them in implementation. Yet the attention to equity is not equal across geographic regions, topical sectors, or marginalized groups. Articles from Africa and Asia report a greater percentage of adaptations addressing equity, while Australasia, Europe, and North America report fewer. The prominence of equity in adaptation responses from Africa, and to a lesser extent from Asia and Central and South America, appears to be driven by consideration of low-income groups, compared with adaptations reported in Australasia and Europe, where the consideration of low-income and other marginalized groups is reported comparatively less frequently. Our analysis suggests that these results may be explained, at least in part, by the prevalence of autonomous or self-organized adaptations in many regions of Africa and Asia, although further direct examination of these relationships is needed. Articles focusing on the sector of “Poverty, livelihoods, and sustainable development” are most likely to address equity and, unsurprisingly, are also the most likely to address low-income communities. The limited consideration of equity in cities emerged as a notable finding. Adaptation responses in cities had the lowest number of articles addressing equity and inclusion of marginalized groups (44% implementation, 37% planning), suggesting that urban adaptation has significant scope for improvement. Overall, across regions and sectors, our analysis shows that adaptation practices rarely consider age, disability, or migrant status in the planning or implementation stages.

A number of plausible explanations exist for why equity in adaptation responses differ between the Global South and the Global North, but we are not able to provide a comprehensive or conclusive analysis here. Our findings suggest that in the Global South, responses are more likely to involve the autonomous adjustment of behaviors by individuals, households, or groups in response to climate-related changes. In Europe, Australasia, and, to a lesser extent, North America, articles are more likely to present top-down institutional planned responses. These differences may reflect varying climate risk needs, financing availability, and/or governance priorities and capacities. For example, comparatively lower rates of poverty in high-income regions might warrant less focus on social equity than in the Global South, while lower governance capacity in the Global South may limit planned top-down initiatives, instead leaving marginalized groups themselves undertaking adaptation responses. However, we also note the increasing prevalence of disproportionate, inequitable, and wide-ranging impacts of climate-related changes on low-income groups and ethnic and racial minorities globally, including Indigenous peoples, ethnic minorities, and migrants, among other groups in the Global North, despite relative national-level wealth. Indigenous groups in particular are affected across colonized countries in the Global

Figure 3. Consideration of socially marginalized groups across sectors

(A) Socially marginalized groups across sectors (planning and implementation).

(B) Percentage of articles documenting responses that include one or more marginalized groups in implementation in a geographic region or topical sector, and percentage of articles including each marginalized group in implementation.

Color thresholds		Total #	Equity not addressed	At least one vulnerable group addressed	Low income	Women	Indigenous	Elderly	Youth	Migrants	Ethnic minorities	Disabled	Others
less than 10%													
10–29%													
30–49%													
50% and above													
Implementation	Behavioral/Cultural	1259	35%	65%	40%	22%	12%	9%	5%	5%	5%	1%	18%
	Ecosystem-based	840	37%	63%	42%	23%	12%	9%	5%	3%	5%	1%	14%
	Technological/Infrastructure	1048	40%	60%	40%	20%	9%	9%	4%	3%	4%	1%	17%
	Institutional	707	47%	53%	34%	18%	11%	7%	5%	5%	4%	1%	18%
Planning	Behavioral/Cultural	1259	42%	58%	36%	19%	10%	6%	4%	4%	4%	1%	10%
	Ecosystem-based	840	43%	57%	36%	19%	11%	6%	4%	2%	4%	1%	8%
	Technological/Infrastructure	1048	46%	54%	35%	17%	8%	6%	3%	2%	3%	1%	10%
	Institutional	707	49%	51%	32%	17%	11%	6%	4%	3%	4%	1%	10%

Figure 4. Integration of socially marginalized groups in planning and inclusion in implementation of adaptation across types of responses

North, e.g., Australia and Canada, and the legacy of colonialism has left Indigenous groups marginalized in many countries of the Global South as well.^{54,55} Future empirical research could investigate these relationships between regions and different types of responses in greater depth.

Overall, our findings indicate an urgent need to promote integration of equity in adaptation planning and implementation, and we identify here a first step where these gaps are shown to exist globally and for which groups. While our examination yields a robust and extensive understanding of equity considerations in global adaptation, it has at least three limitations. First, the analysis is based on peer-reviewed literature and does not capture adaptation responses documented elsewhere, such as project reports or gray literature. We hence acknowledge that the findings in this paper may underreport adaptation in practice. Further, adaptations by low-income or Indigenous groups may not be well documented in academic literature due to limited priority funding or inaccessible regions. On the other hand, some regions or cities may appear overreported in academic literature due to a “spotlight effect” wherein researchers are attracted to locations where documented scholarship already exists. Despite this limitation, analyses of the fast-growing peer-reviewed literature documenting on-the-ground adaptation efforts are providing an appropriate dataset and proxy to assess the status of gaps and strengths of research on adaptation responses in a broader, larger-scale, and more systematic manner than was previously possible, even if these data are an incomplete representation of adaptation taking place globally.

Second, we note that the large-n research strategy of this article presents a broad, baseline characterization of the status of social equity considerations and adaptation, and does not shed detailed light in a systematic manner on the quality of involvement that results from integrating marginalized groups into adaptation. The degree to which marginalized groups are incorporated in the planning or implementation process in a way that participants recognize as meaningful or as having an

influence on adaptation responses is a question for future exploration. In addition, this research is insufficient to evaluate the outcomes—whether or how adaptation addresses social equity when marginalized groups are included in implementation or in the planning process; that is, to what degree have adaptation responses reduced socioeconomic vulnerability for those groups most in need? Such challenges bedevil adaptation-tracking research writ large, and have been identified as grand challenges.⁴¹

Finally, our analysis also reflects a troubling shortcoming of existing peer-reviewed empirical research on adaptation actions. Although a substantial number of scientific papers offer evidence on inclusion of marginalized groups, most do not take the additional step of providing details that could answer more complex questions about the quality of outcomes, specifically in terms of procedural and distributive justice, the extent to which marginalized groups influence the planning process, and whether their vulnerability is reduced. By illuminating the inadequate empirical depth of how equity is incorporated into adaptation research, we call on the adaptation community to do more to advance understanding of equity in adaptation: to foreground considerations of social equity and document social equity in empirical studies of adaptation responses, with the goal of strengthening the knowledge base and advancing progress on social justice for those groups most in need.

EXPERIMENTAL PROCEDURES

Resource availability

Lead contact

Any correspondence or requests for further information should be directed to the lead contact for this study, Malcolm Araos (malcolm.araos@nyu.edu).

Materials availability

This study did not generate new unique materials.

Data and code availability

The complete list of articles included in the analysis, with bibliographic information, the complete raw dataset, statistical analysis results, the codebook,

Table 1. Regions and thematic areas

Region	Sector/system
Africa	Terrestrial and freshwater ecosystems
Asia	Ocean and coastal ecosystems
Australasia	Water quality and sanitation
Central and South America	Food, fiber, and other ecosystem products
North America	Cities, settlements, and key infrastructure
Europe	Health, well-being, and communities
Small Island States	Poverty, livelihoods, and sustainable development
Adapted from GAMI protocol available at the <i>Nature</i> Protocol Exchange ^{57–59}	N/A

and figures in table form can be downloaded at https://osf.io/gb8x2/?view_only=8a38453a859d4971a7dc7e78a34d024d.

The Global Adaptation Mapping Initiative

This paper reviews social equity dimensions of adaptation-related responses to climate change that were documented through the GAMI, a global research collaboration concerned with systematically documenting adaptation-related responses described in peer-reviewed articles published between 2013 and 2019. GAMI asks: What is the evidence relating to human adaptation-related responses that can directly reduce (or are reducing) risk, exposure, and/or vulnerability to climate change? The GAMI team consists of over 150 individuals from around the world possessing expertise in adaptation research and practice. Full details on the GAMI methodology are available through a series of protocols via the *Nature* Protocol Exchange (currently in prescreening).

GAMI adopts the PICoST approach to systematic reviews, which is oriented around understanding a population or problem (P), interest (I), context (Co), time (T), and scope (S). The initiative considers the “population,” or problem, to be human or natural systems that are affected by climate change and of importance to humans. The “interest” is observed and documented human adaptation-related responses to climate change. This scope includes human-assisted adaptation in natural systems, but not evolutionary or autonomous adaptation in natural systems. To be included, responses had to be initiated by humans; both autonomous and planned adaptations were included. We use the term “adaptation-related responses” to include the full range of effective, maladaptive, or ineffective adaptation efforts documented in the literature. The “context” is empirically documented adaptation-related responses in the recent peer-reviewed literature, and the “time/scope” is articles published between 2013 and 2019. This time period reflects the IPCC’s publication cutoff for inclusion in the Sixth Assessment Report.

GAMI was conducted through a series of stages: (1) article screening and database construction, (2) article coding, (3) data reconciliation and synthesis, and (4) expert elicitation of results. The following sections describe the screening, coding, and reconciliation stages of GAMI. Results from the synthesis and expert elicitation are not used in this paper and so are not described here, but further information can be found via the *Nature* Protocol Exchange (currently in prescreening).

Article screening and database construction

Only articles that met the PICoST criteria described above were included in the GAMI dataset. To find relevant articles, the GAMI screeners identified a series of search terms that drew on key words from 10 representative publications on adaptation. The terms were then used to construct a search string to retrieve articles combining the concepts of climate change and adaptation or adaptation-related responses. Articles referring to weather, climatic variability, or meteorological variability without explicitly referencing climate change were excluded. Literature that used the terms “resilience” or “risk management” was included to reflect the broad scope of adaptation-relevant literature. Articles written in all languages were retained as long as they were indexed in English.

About 50,000 articles were identified from Scopus, Web of Science, and Google Scholar using the GAMI search string. The screening team then

used a combination of machine learning and manual review to narrow the articles down for inclusion in the GAMI dataset. To be included, the article needed to (1) be climate change related, (2) report empirical data on adaptation-related responses (not conceptual or theoretical information, or simulated responses), (3) report findings about how human systems are responding to climate change, (4) go beyond vulnerability or impact assessment to document responses, (5) be recent or current in time (between 2013, cutoff for IPCC’s Fifth Assessment Report, and 2019), and (6) report tangible responses that people have taken to reduce risks and vulnerabilities.

To sift efficiently through the large volume of documentation retrieved from the search, a machine-learning classifier developed by the APSIS group at the Mercator Research Institute on Global Commons and Climate Change⁵⁶ was trained to recognize papers that met the GAMI inclusion criteria based on article titles and abstracts. The training dataset was created by randomly sampling and manually classifying titles and abstracts from the 50,000 initial documents. This training dataset was used to teach the machine-learning algorithm how to recognize GAMI-relevant documents. The algorithm then assigned each non-training document a probability of relevance score. High-probability documents were manually screened by two screeners and used to retrain the algorithm to improve the accuracy of the algorithm. This process continued until the algorithm stopped predicting any new, highly relevant documents. A total of 4,300 articles of 48,816 non-duplicate documents retrieved from the search string were manually screened.

Two additional screening questions were answered by GAMI coders at the beginning of the coding stage: (1) is the document relevant based on the inclusion criteria, and (2) does the document have sufficient information to code? The first question was used as a final check on articles considered borderline relevant by the algorithm, and the second was used to screen out documents that had relevant content in the title or abstract but insufficient documentation in the main text of the article. Documents were retained for analysis only if they contained sufficient substantive and interpretable information about adaptation responses to satisfactorily complete the coding process.

GAMI systematic review protocol and coding processes

A total of 1,682 articles were included in the final GAMI dataset and coded for 70 variables (see full codebook in the [supplemental information](#)). Data extraction was conducted in Sysrev, an online systematic review application. Sysrev links full-text documents to bibliographic information and data extraction forms and enables tracking of intercoder conflicts. The GAMI dataset was divided into 13 regional and sectoral thematic groups based on the chapters included in Working Group II of the IPCC, and coders were assigned to at least one of these specific groups (Table 1).

Coder training materials were made available online, which included methodological information on systematic reviews, background on the IPCC Risk Framework, and a detailed codebook that guided data extraction. The codebook was structured around three fundamental questions about who was responding, what responses were documented, and what was the extent of adaptation-related responses, and also included three evaluative questions about whether responses were reducing risks, adaptation limits, and coder confidence in the quality of evidence (see full codebook in the [supplemental information](#)). The questions and their corresponding codes included both

closed and open questions, and additional fields were included for coders to attach key quotes that supported their coding choices. Nearly every article was coded by at least two coders; articles that were assigned to multiple thematic groups were coded by up to four coders. Over 100 volunteer coders coded over 2,500 articles. After duplicates were eliminated and articles were excluded for not meeting the GAMI inclusion criteria during manual checks, 1,682 articles were left.

To ensure the quality of coder responses, the GAMI administrative team asked coders to verify their codes at the end of the coding stage and identified any coders who had missed entries on significant questions. Any coder with more than 10% missed entries was asked to revisit and complete his or her coding. Any remaining coders with more than 10% missing entries after this check were marked as unreliable. Articles were required to be coded by at least two reliable coders; when one or both coders were unreliable the article was coded by additional coders.

Data reconciliation and synthesis

The multiple codes for each article were reconciled using a series of if/then statements. The full R script for this process and its rationale are available on GitHub (doi.org/10.5281/zenodo.4010763). The reconciliation protocol was deliberately inclusive of coder answers, and so likely overestimates the amount of adaptation being documented. The reconciliation protocol accepted all coder answers for open-ended questions and closed questions with non-mutually exclusive answers. For closed mutually exclusive questions, the GAMI team assumed that false negatives were more likely than false positives. If coders disagreed on true/false questions, true answers were accepted when selected by at least one coder. In the final GAMI dataset, all codes were compiled into single-line entries for each article. Duplicate entries from different thematic groups were merged, and any errors in GAMI-assigned regions were corrected.

Additional coding of equity planning and implementation in the GAMI database

Two equity-related questions were coded in the GAMI dataset: (1) is there evidence that particular marginalized groups were included in the implementation of the adaptation responses, and (2) is there evidence that particular marginalized groups were included in response planning? (See full codebook in the [supplemental information](#) for details.) Both questions had closed categories but were non-mutually exclusive: youth, elderly, low income, disabled, migrants, Indigenous, ethnic minorities, other, and none. Coders were also asked to identify representative quotes from the articles and copy and paste those quotes into an open field in the database to substantiate their coding. These two questions formed the empirical foundation of this paper.

Two of the authors of the paper, K.J. and R.S. (who are also GAMI coders), conducted a specific review of the coding pertaining to equity planning and implementation, which added an additional step to the reconciliation process described above that is specific to this paper. For each article, K.J. and R.S. verified all of the question fields and open fields containing quotes against the codes in the equity-planning and equity-implementation questions. Where marginalized groups were identified in other question fields but had not been coded in response to the equity questions, codes for those groups were added to the equity-planning and equity-implementation fields. This process was supplemented by reviews of the original manuscripts in which the relevance of particular marginalized groups was unclear from the GAMI codes. If the article's text provided substantive description of the marginalized group, as well as evidence and explanation that the group was a part of the population that was planning or benefiting from the response, then that group was included in the equity planning or implementation fields as appropriate. In cases where it was evident that a marginalized group was considered in the adaptation response, but there was no explicit discussion of planning or implementation, then it was included in both. This issue mostly came up for cases of autonomous adaptation or self-organized responses; there was often no explicit discussion of planning or implementation, but we could infer that the marginalized groups who undertook responses both were making decisions about the response and stood to benefit from it as well. If there was no substantive description or explanation of how specific marginalized groups were included in adaptation responses or included in implementation, then the article was coded as not addressing equity.

Data analysis

Based on these corrected codes, basic counts and descriptive statistics were used to generate global, region, and sector tables. In addition, the marginalized groups were cross-tabulated with the type of adaptation responses. ϕ correlations—a measure of association between two binary variables⁶⁰—were run to assess the relationship between equity in planning and equity in implementation and between each marginalized group and planning and implementation. The ϕ coefficients can be interpreted in the same manner as a Pearson correlation coefficient for continuous data. Finally, logistic regressions including all region-, sector-, and response-type variables were conducted to assess the relative influence of each variable on the presence or absence of equity considerations, holding all covariates constant. The four illustrative ways in which responses integrated social equity were identified through a qualitative thematic synthesis of representative quotes on equity, which GAMI coders extracted from each article. Quotes were reviewed by K.J. and R.S. using an inductive approach based on which emergent descriptive themes or conceptual categories were identified. These themes were cross-reviewed by M.A. Comprehensive coding for these thematic categories was not conducted, since many articles in the GAMI database lacked detail on how different groups were involved in the adaptations. This qualitative review includes only articles that provided sufficient detail on how social equity was integrated into the responses, and hence is meant to serve as an illustrative description rather than as strict categorizations or coding.

Data limitations

The GAMI database includes only sources from the peer-reviewed empirical studies and hence does not capture adaptation projects that may be reported in the gray literature. While a systematic review of project reports and gray literature would help to supplement this work, considering the massive volunteer effort involved in conducting such a global systematic review, this additional work was out of the scope of the GAMI effort. The database captures only articles that self-identify as addressing climate adaptation, resilience, or climate risk reduction. While not exhaustive, the GAMI screening exercise showcased that there are a significant number of on-the-ground adaptation activities identified in the peer-reviewed literature, which provide a starting baseline to understand adaptation responses, although it presents an incomplete picture. The unit of analysis for the database is a peer-reviewed article. While some articles include large adaptation responses spanning many countries and thousands of people, other articles describe adaptation responses that are smaller in scale, e.g., a town or a village, or of a narrower focus, e.g., water or forest managers, involving a few dozen to a few hundred people. However, each of these articles is given the same weight in the database.

Another limitation of this research is that the peer-reviewed literature did not always provide nuanced details on planning and design of adaptation responses, but rather focused on outcomes from adaptation. While this finding in itself is an interesting result that we report in the paper, this focus meant that, while there was robust evidence on the types of populations that were included or were undertaking responses, many articles failed to provide detailed evidence about how different individuals or groups were included in the planning process, how that inclusion affected the process or outcomes, and whether and how they were specifically included in implementation among broader populations.

Researchers writing the articles also chose to study specific types of groups; the coding for equity may reflect this bias. Also, because the adaptations in GAMI include coping mechanisms, where we see higher proportions of marginalized groups involved in planning or included in implementation, part of the explanation may be that marginalized groups are taking autonomous action to cope with climate risks, as well as being involved in planned adaptation response actions or being included in implementation. Further, the fact that papers did not address or include socially marginalized groups explicitly does not necessarily mean that the underlying adaptation activity did not consider equity. Papers might address technical details of adaptation activities or deal with other partial aspects.

Climate justice framework and its operationalization

The aim of coding for equity in the GAMI dataset was to gather empirical evidence on the extent to which adaptation responses globally are informed by and contribute to achieving climate justice. Here, we assess aspects of equity

and fairness in adaptation by employing a justice framework composed of two components: procedural justice⁶⁶ and distributive justice.⁶¹ We outline the two components we analyzed in the context of climate justice, and we describe how this study produced an empirical characterization of the extent to which adaptation responses describe or consider these two dimensions of climate justice:

- **Procedural justice.** In the context of adaptation, procedural justice refers to the inclusion and participation of different stakeholders in all stages of the process, including decision-making, planning, implementation, and evaluation of outcomes. In the GAMI dataset, we operationalized procedural justice as a binary variable indicating whether the adaptation response integrated socially marginalized groups in the planning process. In addition, we gathered the relevant text from articles to qualitatively characterize how marginalized groups were included in the planning process.
- **Distributive justice.** Since the outcome of adaptation is unevenly distributed across a variety of stakeholders and communities, an identification of impacts and benefits from adaptation responses is crucial to discussions about equity and justice (i.e., distributive justice). In the GAMI dataset, we operationalized distributive justice as a binary variable indicating whether the adaptation response included socially marginalized groups in implementation. In addition, we gathered the relevant text from articles to qualitatively characterize how marginalized groups were included in the response.

Categories of marginalization

We used categories of marginalization as defined by the GAMI protocol. These categories are based on the groups identified by IPCC reports, the United Nations Sustainable Development Goals groups, and existing academic literature on social vulnerability.⁶² For each scientific article in the GAMI database, coders evaluated whether these socially marginalized groups were included in the implementation of the adaptation response documented in the article, or if these groups were included in the planning process for the response.

The groups we coded for are low-income individuals or households, women, Indigenous peoples, the elderly, youth, ethnic and racial minorities, and individuals with disabilities. Here, we acknowledge that the low-income category is not mutually exclusive from other marginalized groups who may, on average, be poorer. That is, there is a possibility that if an adaptation response includes low-income individuals in implementation, these same individuals may also belong to other categories, e.g., women, elderly individuals, or migrants, even if not explicitly mentioned. However, explicit recognition of the different forms of marginalization and discrimination is an important step in addressing inequities. Particularly, as research on gender and racial inequity has borne out, the lack of naming these groups in the research articles suggests that these intersectional forms of marginalization may not have been taken into consideration.

In addition, we acknowledge that some categories of social vulnerability are absent from this list, notably, marginalized castes in South Asia, religious minorities, people living in conflict-affected areas, and LGBTQ people, as well as incarcerated individuals and immobile groups more generally. We do not argue that the groups considered here are the most important or should be prioritized, but that they appear most frequently in empirical literature on adaptation, and we encourage more research on the groups that do not appear in this paper. This section briefly summarizes how each group is particularly marginalized to climate change due to social factors (see the [supplemental information](#) for more a detailed description of each group):

- **Low income.** Low-income and poor populations are marginalized to the impacts of climate change based on the structural and sociopolitical systems that marginalize poor people and reproduce power imbalances. In addition, low-income groups lack adaptive capacity, that is, poor people lack the financial resources to take advantage of many feasible adaptive responses, such as moving to a safer location.⁶³
- **Women.** The organization of most societies creates specific and diverse gender roles, norms, and relations across the globe that may be culturally specific, but which consistently disadvantage women, trans, and non-binary people and amplify the negative impacts of climate change.^{64,65}

- **Indigenous.** Indigenous peoples are more marginalized to climate change than non-Indigenous people due to their strong links to the land for livelihoods, culture, and well-being. These links can provide resilience and adaptive capacity. When these links are broken, Indigenous peoples can be more marginalized to climate change impacts.⁶⁶
- **Youth.** Children and youth experience disproportionate climate vulnerability because of the relationships between childhood development and climate impacts. Physiologically and metabolically, youth have more difficulty adapting to climatic extremes, like heat waves; have lower functional immunity, making climate-related diseases more fatal; and are more likely to be killed or injured during disasters.⁶⁷
- **Elderly.** The elderly, people age 65 and older, account for the highest proportion of mortality from extreme weather associated with climate change.^{24,25} Elderly adults are more sensitive to changes in the environment because aging reduces the body's physical capacity for tolerating stress and impairs cognitive function, and because many older adults lack social and economic resources to avoid or mitigate risks.^{43,68–70}
- **Disability.** Persons with disabilities can be especially marginalized due to lessened mobility and hearing and cognitive impairments.⁷¹
- **Migrants.** Migrants face challenges in accessing health, jobs, and housing and lack social integration with the resident communities. Migrants are concentrated in the informal sector with poor social protection and have limited political power in various economic and institutional settings.^{72,73}
- **Ethnic and racial minorities.** Long-standing systemic inequities and global histories of colonialism, imperialism, enslavement, apartheid, and genocide depress the adaptive capacity of racial and ethnic minorities, increasing vulnerability to climate change worldwide.^{74–78}

SUPPLEMENTAL INFORMATION

Supplemental information can be found online at <https://doi.org/10.1016/j.oneear.2021.09.001>.

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AUTHOR CONTRIBUTIONS

M.A. and K.J. led the conceptual development of the study, coordination among co-authors, organization of the manuscript, writing process, and revisions. K.J. and R.S. led the equity-specific review and recoding process. E.T.J., C.G., A.R.S., and R.S. designed and produced figures. N.U. produced the logistic regression and correlations statistical analysis. All co-authors contributed to the conceptual development of the study, provided analytical input, and aided in the writing and editing of the manuscript.

DECLARATION OF INTERESTS

The authors declare no competing interests.

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