'Mobility and health in the context of climate change: A systematic literature review and meta-synthesis of policy recommendations'

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Abstract: Changing mobility patterns combined with changes in the climate present challenges and opportunities for global health, requiring effective, relevant and humane policy responses. This systematic literature review sought to synthesize the existing policy recommendations related to the literature examining the intersection of climate change, migration and health to strengthen the evidence-base. Systematic searches were conducted in four academic databases (PubMed, Ovid Medline, Global Health and Scopus) and Google Scholar for empirical studies published between 1990 – 2020 that used any study design to investigate migration and health in the context of climate change. Studies underwent a two-stage protocol-based screening process and eligible studies were appraised for quality using a standardized mixed-methods tool. From the initial 2,425 hits, 68 articles were appraised for quality and included in the synthesis. Among the policy recommendations, six themes were discernible: (1) avoid the universal promotion of migration as an adaptive response to climate risk; (2) preserve cultural and social ties of mobile populations; (3) enable the participation of migrants in decision-making in sites of relocation and resettlement; (4) strengthen health systems and reduce barriers for migrant access to health care; (5) support and promote optimization of social determinants of migrant health; (6) integrate health into loss and damage assessments related to climate change. The results call for transformative policies that support the health and wellbeing of people engaging in, or affected by mobility responses, including those whose migration decisions and experiences are influenced by climate change, and to establish and develop inclusive migrant healthcare.

Keywords: Climate Change, Policy, Migration, Health, Governance.

1. INTRODUCTION

Extensive research has considered the consequences of climate change separately for: (i) human migration, and (ii) human health. Firstly, climate change and migration research dates back over three decades; it indicates that while climate impacts shape the scale and nature of human migration, climate change does not act in isolation to drive mobility (Future Earth, 2019). Local environmental conditions interact with socio-economic, political, demographic and cultural circumstances to influence migration decision-making and patterns of mobility (Myers, 1993; Tickell, 1990; Gemenne, 2011; Marchiori and Schumacher, 2011; Gray et al, 2012; Bohra-Mishra et al, 2014; McLeman, 2014; IPCC AR5, 2014; Zickgraf et al, 2016; Grace et al, 2018; Piguet et al, 2018). Studies have variously characterized climate-related migration as a last resort (Laczko & Piguet 2014), a successful adaptation strategy, or a failure to adapt in situ (Gemenne 2013; Bardsley and Hugo 2010; Tacoli, 2009). While climate change generally acts as a threat multiplier, this does not mean there will be mass cross-border migration. Much mobility will be within countries, and there is a growing concern for trapped or immobile populations who are unable or unwilling to move in the face of climate stressors (Zickgraf et al, 2016; Adams 2016; Hirvonen 2016).

Secondly, the literature on climate change and health is also extensive and increasingly sophisticated yet lacks coverage of contexts where capacity to address population health is low and exposure to climate risks is high (Sauerborn, 2017; Herlihy et al, 2016). The climate change and human health literature is also underdeveloped in terms of investigating policy and governance processes, as well as the role of different stakeholders in policy development (Bowen & Ebi, 2015).

It is helpful to consider the broad international policy context relevant to the areas of climate-migration and climate-health. A plethora of international agreements incorporate climate change and migration, and climate change and health. For example, central to the Sustainable Development Goals (SDGs) is the principle of leaving no one behind and universal health coverage can only be attained by ensuring migrant access to health systems (Vearey et al, 2019). In addition to the SDGs, various agreements have been developed to address climate-related displacement. These include at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP) 21 (UN, 2017a), the Nansen Initiative and the Platform on Disaster Displacement (UN, 2017b) and the Sendai Framework for Disaster Risk Reduction (UN, 2015; Grecequet et al, 2017). The Global Compact for Migration (UNHCR, 2018a) and the Global Compact on Refugees (UNHCR, 2018b) refer to people who move in the context of climate change and urge strengthened collaboration and solidarity with migrants and affected host countries. In terms of the policy context relevant to climate change and health, the Paris Agreement presents a firmer stance on the importance of health compared with The Kyoto Protocol, referring to "the right to health" in the preamble. Shifting from this international scale, there are also regional policy

contexts that address climate change and human health; for example the Pacific Islands Action Plan on Climate Change and Health (WHO, 2018a) and the WHO's Special Initiative on Climate Change and Health in Small Island Developing States (WHO, 2018b).

As the climate crisis accelerates, it is timely to examine how migration might be more effectively and humanely governed (UNHCR, 2018a). There is concern that people moving in the context of climate and environmental change may slip through the cracks of existing migration protection frameworks, creating risks to their health. Yet it is important to understand and address the health of climate-related migrants as well as the health of people who migrate into, or remain in sites with climate-related health risks: appropriate policy frameworks and responses are required. This paper presents policy recommendations emerging from 68 publications reporting the findings of research focused on the climate-migration-health nexus. These publications are reviewed and synthesized to identify broader, principle-based recommendations at the nexus of climate, migration and health.

The aim of this review is to identify, analyse, evaluate and synthesise the policy recommendations in the literature investigating the nexus between climate change, health and migration. The specific objectives are to: a) synthesize policy recommendations from empirical evidence about the climate change-migration-health nexus and present key themes; b) analyse key methods employed and appraise the quality of the evidence; c) summarize study settings, populations, climate hazards, mobility responses, and health outcomes; and (d) identify overarching knowledge themes and gaps in the evidence base.

2. METHODS

2.1 Protocol and Registration

The protocol for this systematic literature review was registered with the international platform PROSPERO on 29th August 2018 (Registration no: CRD42018095461). It was developed in consultation with the International Office for Migration (IOM), Migration Environmental and Climate Change Division. For reporting, we applied the RepOrting Standards for Systematic Evidence Syntheses (RoSES) Pro-forma and flow diagram. This framework integrates diverse methodologies and has been developed for environmental management and conservation research (Haddaway et al, 2017). In contrast, the PRISMA guideline (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Moher et al, 2009) has been created for systematic reviews and meta-analysis of clinical trials. Therefore, PRISMA was not applicable to the present study. The original search was conducted in December 2019 and was updated in August 2020 to capture current evidence.

2.2 Definitions

For the purposes of this systematic literature review, 'climate change' was defined as a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2018). 'Health' was defined according to the World Health Organization (WHO) as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1948). 'Migration' was defined according to International Organisation of Migration (IOM, 2019a) as movement of persons away from their place of habitual place of residence, either across an international border or within a state regardless of legal status, degree of choice, causes of movement, or length of stay.

Possible climate-related mobility responses comprise forced displacement, migration, and planned relocation (UN, 2017b) as well as immobility. Broadly, forced displacement refers to contexts of forced or involuntary movement of people within or across borders; migration refers to movement of people within or across borders and has an element of choice; and planned relocation refers to organised movement of people, typically with government support (UN, 2017b). Population immobility in contexts of climate risks is increasingly discussed (Foresight, 2011), yet lacks definitional clarity: it variously refers to 'trapped' populations that are unable to move away from sites of climate risk, and voluntary immobility where people are unwilling to leave their homes despite climate risks (Ayeb-Karlsson et al, 2018).

2.3 Search strategy and eligibility criteria

This systematic literature view includes studies exploring climate variability and any climate hazard or extreme weather event that could be plausibly linked to climate change. Studies were eligible if health was measured or reported, including as a consideration in migration decision-making, or as an impact at origin, en route or destination. The study populations include individuals, households and whole communities who engaged in, or were affected by climate-related mobility: i.e. sending communities, mobile people and populations, and host communities. Importantly, studies explicitly addressing immobility in contexts of climate risk are also included. Taken together, this review includes empirical evidence about health and migration in the context of a changing climate. Given that this nexus is interdisciplinary, the included articles originate from diverse research fields such as public health, demography, policy studies, climatology, human geography and international relations.

With this background and through consultation with a subject librarian, we selected four academic databases: CABI Direct - Global Health (1973 to present); Ovid Medline (1946 to present); PubMed (1966 to present), and Scopus (1970 to present). In addition, we searched Google Scholar applying the same search terms. Reference lists of selected articles were also

searched for relevant articles. Grey literature (likely to cover conceptual papers and editorials) was not included in this systematic literature review, because it focused on peer-reviewed research including empirical data. The search strategy was designed to capture primary studies included in important grey literature reports. Four independent authors used the custom systematic literature review software (Covidence ©) (PNS, JS, KB, CM) to complete the two-stage screening process.

The respective search terms are presented in Table 1. These terms were categorized using the Population-Exposure-Outcome (PEO) approach under three concepts. We applied the Boolean operators "AND" and "OR" to search with synonyms for the following key search terms: Climate Change, Health, and Migration. The search strategy consisted of free-text and MeSH (i.e. Medical Subject Headings) terms and was tailored to the search requirements of each database. Several preliminary pilot searches were conducted from September to November 2018 to test the search strategy. Test searches revealed very few publications on the topic before 1990. The chosen timeframe captured current and relevant evidence about the research aims and specific objectives. Test searches also revealed a multitude of studies examining plant and animal health and migration and led to a reconsideration of the selected databases. The actual search was conducted in December 2018 and was updated in August 2020. We only included studies published in English or German.

Table 1: Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Population	Engaging in/affected by mobility response. Any country. Any population.	Not human mobility: plant or animal.
Exposure	Climate change, variability or natural hazard influencing mobility responses.	Other migration drivers (e.g. political, economic, social, demographic) with no reference to climate or environmental change. Hazard not relatable to climate change (e.g. volcano/earthquake)
Outcome	Health related: either a direct measure of health outcome (i.e – disease prevalence) or an indirect measure of health (i.e food security and water/sanitation/hygiene –[WaSH]). Access to healthcare. Psychosocial health.	No health outcome. Not human health; animal/plant. Social determinants of health; income, livelihood, employment, education.
Nexus	Includes climate change, migration and health.	Focus on two elements (dyad) of the nexus (i.e climate-health, climate-migration). Focus

		on OneHealth, Planetary Health, Environmental Health.
Study Type	Peer-reviewed empirical research. All designs: quantitative, qualitative, mixed methods, modelling.	Not empirical, systematic review, viewpoint, editorial, book chapter, grey literature, dissertation, conference proceeding, report.
Time	1990 – 2020 (August).	Outside this timeframe.
Language	Full text available in English or German.	Other languages.

Table 2 outlines the eligibility criteria, which were strictly applied to each study. The assessment included research investigating populations worldwide engaging in, or affected by mobility responses. These responses were on a spectrum from displacement, encompassing forced movements, to migration, which is considered predominantly voluntary, and also immobility. Populations from sending communities as well as mobile and host populations were included. The review required a climate hazard as at least one driver of human migration/mobility. If migration drivers were economic, political, social, and/or demographic and there was no explicit or implied link to climate change or climate variability, the article was excluded. If the hazard was not related to climate change (e.g. volcano, earthquake) the article was excluded. The review required studies to focus on health including at least one measurable health outcomes (e.g. prevalence of disease) or immediate determinant of health (i.e. food and water security). Studies that referred to social determinants of health as outcomes of human migration (e.g. income, employment) were excluded. Studies were not excluded based on design or quality. We considered all empirical research, using either primary or secondary data. Due to methodological ambiguity in the search results, the 'empirical' criterion was further refined to require a methodological explanation and a description of the data used. Modelling and qualitative case studies were included but commentary, editorials, and literature reviews were not.

Table 2: Search Terms

Migration (Population)	Climate Change (Exposure)	Health (Outcome)
Population movement	Climate variability	Well being
Displacement	Global warming	Disease: NCD, Communicable, Infectious
Population displacement	Weather variability	
Forced displacement	Greenhouse effect	Epidemiolog*
Internal displacement	Sea level rise	Lifestyle
		Co-benefits

Seasonal migration	Environmental disaster	Mortality
Permanent migration	Natural disaster	Morbidity
Planned relocation	Drought	Climate sensitive disease
Migrant	Climate hazard	Nutrition: Malnutrition, Undernutrition
Mobility		Psychosocial
Internally Displaced Persons		Dehydration
Refugee		Health Services: Water and Sanitation, Food Security

2.5 Literature selection

In the first stage of screening, two authors decided whether the article was eligible by title and abstract review. Two votes were required to continue with the second stage of full-text screening. Inconsistencies between paired authors at both stages were resolved by an independent third author. No authors could individually decide about including their own work, because each study was reviewed by at least two independent reviewers. The screening process was blinded using the Covidence platform so that 'votes' to include or exclude could not be seen by the partner reviewer. Reference lists of included and excluded studies were scanned for relevant studies, which were then added to the Covidence platform for full-text review to reduce the likelihood that eligible studies were missed. Figure 1 presents the screening process. The key reasons for exclusion in order of prevalence of occurrence were: type of study not empirical (i.e. commentary, editorial, opinion), research looks at a dyad rather than the climate-migration-health nexus (e.g. no health outcome, population not affected by mobility and exposure not climate-related.
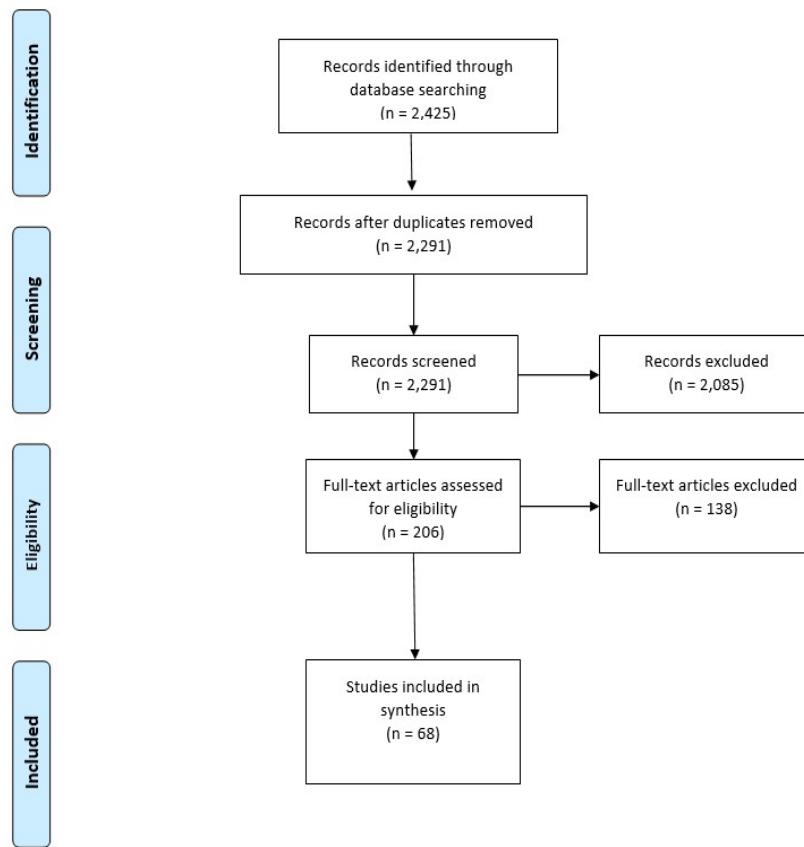
Figure 1: Screening Process

2.4 Data extraction

We used the Mixed Method Appraisal Tool (MMAT) to concomitantly describe and appraise the selected studies. The MMAT tool has been specifically developed for systematic mixed studies reviews that include both qualitative, quantitative, and mixed methods studies (Hong et al, 2018). Therefore, this tool was considered better suited than Cochrane tools for clinical studies. Extraction codes were predetermined by reviewers and aligned with the aims and objectives. In this review, recommendations for policy, practice or further research were the focus but climate hazard, mobility response, health outcomes, study design, population and study setting were extracted. Due to the heterogeneity of the results, a meta-analysis was not feasible (even of the quantitative studies because the health outcomes and measurements were diverse) and a meta-synthesis was conducted using thematic analysis methodology (Braun & Clarke, 2006). The data were extracted in separate word documents and uploaded to N-VIVO (version 12) and analyzed. Two authors (PNS, JS) reviewed all 68 selected studies in full-text and simultaneously conducted the quality appraisal and data extraction. When consensus could not be reached regarding extraction coding or quality appraisal, a third independent author (CM) was consulted. When data were incomplete, unclear, or missing, an attempt was made to contact the authors of eligible studies.

2.5 Quality assessment

The quality appraisal tool MMAT version 2018 was chosen a priori and used to identify threats to internal and external validity for all eligible studies. MMAT provides five custom questions for each study design (qualitative, quantitative randomized controlled trials, quantitative non-randomized, quantitative descriptive, and mixed methods), pertaining to both study and reporting quality (Hong et al, 2018). Quality appraisal results were recorded in the results spreadsheet along with other coded findings in the overview table (Table 3). Five modelling studies could not be appraised by the MMAT and this remains a limitation of this systematic assessment (marked no category in the overview Table 3).

Table 3: Overview of selected studies with quality appraisal

Study no.	Author(s)	Title	Journal	Research setting	Mobility response	Climate hazard(s) experienced	Health outcome(s)	MMAT category and Quality Appraisal	Scoring
1	Abah & Petja (2016)	Assessment of potential impacts of climate change on agricultural development in the Lower Benue River Basin	Environmental Monitoring & Assessment	Nigeria & Cameroon	Rural - Urban migration	Rainfall & temperature variability, floods & droughts, heat stress, surface water trends	Infectious diseases, HIV/ AIDS	No cat.	
2	Adams (2016)	Why populations persist: mobility, place attachment and climate change	Population & Environment	Peru	Trapped populations/ immobility	Temperature extremes, excessive precipitation, abrupt seasonal weather changes & drought, glacial retreat	Food insecurity, diseases of animals & humans, burns & headaches, water availability	Quant. desc. ***	1, 1, 0, 0, 1

3	Afifi, Liwenga & Kwezi (2014)	Rainfall-induced crop failure, food insecurity and out-migration in Same-Kilimanjaro, Tanzania	Climate & Development	Tanzania	Seasonal migration (< 6 months) & temporal migration (> 6 months)	Rainfall variability, floods & droughts, water shortages	Food insecurity	MM **	1, 0, 1, 0, 1; 1, 1, 0, 0, 0; 1, 1, 0, 0, 1
4	Ahmed, Kelman, Kamruzzaman… Shamsudduha (2019)	Indigenous people's responses to drought in northwest Bangladesh	Environmental Development	Bangladesh	Seasonal migration	Drought	Food security, Water security, Water-borne disease	MM ****	1, 1, 0, 0, 1. 1, 1, 1, 1, 1. 1, 1, 1, 1, 0.
5	Albert, Bronen, Tooler… Grinham (2018)	Heading for the hills: climate-driven community relocations in the Solomon Islands and Alaska provide insight for a 1.5 °C future	Regional Environmental Change	Solomon Islands & Alaska	Relocation: Supported and Unsupported.	Sea level rise, reduced Arctic sea ice, melting permafrost, sea-level rise, erosion & flooding	Access to health care facilities, health & safety risks, water borne disease, vector borne disease, dietary adaptation	Qual. ****	1, 0, 1, 1, 1

6	Amstislavski, Zubov, Chen, Ceccato, Pekel & Weedon (2013)	Effects of increase in temperature and open water on transmigration and access to health care by the Nenets reindeer herders in northern Russia	International Journal of Circumpolar Health	Northern Russia	Inhibition (delaying) regular transmigration	Temperature increase, reduction of ice-rich permafrost & glaciers, changes in hydrological cycles	Access to health care facilities, risks of injury	Quant. non-rand. ***	0, 1, 1, 0, 1
7	Anastario, Shehab, & Lawry (2009)	Increased Gender-based Violence Among Women Internally Displaced in Mississippi 2 Years Post–Hurricane Katrina	Disaster Medicine and Public Health Preparedness	Mississippi, USA	Forced displacement	Hurricane	Sexual & physical violence, suicidal ideation & attempts, depression	Quant. non-rand. *****	1, 1, 1, 1, 1
8	Anupama, Deb, Bantilan & Vajjha (2016)	Seasonal Migration and Moving Out of Poverty in Rural India: Insights from Statistical Analysis	Asian Journal of Agriculture and Development	Rural India	Temporary / seasonal migration	Drought	HIV/ AIDS, water-borne disease, general & sexual health, social issues	Quant. non-rand. **	1, 1, 0, 0, 0
9	Assan, Caminade & Obeng (2009)	Environmental variability and vulnerable livelihoods: Minimising risks and optimising opportunities for poverty alleviation	Journal of International Development	North Eastern Ghana	Temporary migration, circular migration	Erratic and declining mean rainfall	Food insecurity	MM ***	1, 0, 1, 0, 1; 1, 1, 0, 1, 1; 1, 1, 1, 0, 0

10	Atta Ur Rahman, Akhtar & Siddiqui (2013)	Psychological Effects among Internally Displaced Persons (IDPS) residing in two districts of Sindh	Medical Forum Monthly	Sindh, Pakistan	Forced displacement	Flood	Mental disorders	Quant. desc. *	0, 0, 0, 0, 1
11	Ayeb-Karlsson, Kniveton, Cannon (2020)	Trapped in the prison of the mind: Notions of Climate-induced (im)mobility decision-making and wellbeing from an urban informal settlement in Bangladesh	Palgrave Communications	Bangladesh	Immobility	Multiple climate-hazards	Sense of belonging and mental health	MM ****	1, 0, 1, 0, 1. 1, 1, 1, 1, 0. 1, 0, 1, 0, 1.
12	Baker (2020)	Climate change drives increase in modeled HIV prevalence	Climate Change	Sub Saharan Africa	Migration	Climate change. Temperature	HIV	No cat.	
13	Bayar and Aral (2019)	An Analysis of Large-Scale Forced Migration in Africa	Int Journ. Env. Res.Public Health	African region	Forced Migration	Multiple climate-hazards	Public health and well being as a component of human security	No cat.	

14	Behr & Diaz (2013)	Disparate Health Implications Stemming From the Propensity of Elderly and Medically Fragile Populations to Shelter in Place During Severe Storm Events	Journal of Public Health Management and Practice	North Carolina, USA	Forced displacement, immobility	Hurricane	Access to the support system, medical records, medical regimens, nutrition	Quant. desc. **	1, 0, 1, 0, 0
15	Carney & Krause (2020)	Immigration/migration and healthy publics: the threat of food insecurity	Palgrave communications	USA, Dominican Republic, Italy	International migration	Climate change	Food Insecurity	Qual. **	1, 1, 0, 0, 0
16	Chen, Lai, Chen, Hsu, Wu, Wang & Chen (2011)	Risk factors for PTSD after Typhoon Morakot among elderly people in Taiwanese aboriginal communities	International Psychogeriatrics	Taiwan	Relocation	Typhoon	PTSD, injury/death, self perceived health	Quant. desc. *****	1, 1, 1, 1, 1
17	Coker, Hanks, Eggleston, Risser… Franzini (2006)	Social and Mental Health Needs Assessment of Katrina Evacuees	Disaster Management & Response	Houston, USA	Forced displacement/ evacuation	Hurricane	NCDs, PTSD	Quant. desc. **	0, 0, 1, 0, 1

18	Craven (2015)	Migration-affected change and vulnerability in rural Vanuatu: Migration-affected change in rural Vanuatu	Asia Pacific Viewpoint	Vanuatu	Seasonal migration	Rainfall variability	Health financing, food security	Qual. ***	1, 1, 0, 1, 0
19	Di Giorgi, Michielin & Michielin (2020)	Perception of climate change, Loss of social capital and mental health in two groups of migrants from African countries	Annali dell'Istituto Superiore di Sanità	Italy	International migration	Climate Change	Social Capital. Mental Health	Quant. non-rand. **	0, 1, 1, 0, 0
20	Dinkelman (2017)	Long-Run Health Repercussions of Drought Shocks: Evidence from South African Homelands	The Economic Journal	South Africa	Multiple types of migration, internal migration, labour migration	Drought	Disability (visual, hearing, speech, mental, physical)	Quant. non-rand. ***	1, 1, 0, 1, 0
21	Edwards (2013)	The Logistics of Climate-Induced Resettlement: Lessons from the Carteret Islands, Papua New Guinea	Refugee Survey Quarterly	Carteret Islands, PNG	Forced displacement, relocation	Sea-level rise, King tides, storm surge, floods	Food insecurity, mental health	Qual. *	0, 0, 0, 0, 0

22	Etzold, Ahmed, Hassan & Neelormi (2014)	Clouds gather in the sky, but no rain falls. Vulnerability to rainfall variability and food insecurity in Northern Bangladesh and its effects on migration	Climate and Development	Northern Bangladesh	Labour migration (permanent, seasonal, temporary), immobility	Rainfall variability	Food insecurity	MM *	0, 1, 0, 0, 0; 1, 1, 0, 1, 0; 0, 1, 1, 0, 0
23	Grawert (1992)	Impacts of male outmigration on women: A case study of Kutum/ Northern Darfur/ Sudan	The Ahfad Journal	Western Sudan	Out-migration	Drought	Food insecurity	Qual. *	0, 0, 0, 0, 0
24	Grecequet, DeWaard, Hellmann & Abel (2017)	Climate Vulnerability and Human Migration in Global Perspective	Sustainability	Global	Multiple types of migration	Multiple climate-hazards	Mortality from climate-sensitive diseases, vector-borne disease, health (together with food, water, ecosystem services, human habitat, and infrastructure)	No cat.	

25	Gautam (2017)	Seasonal Migration and Livelihood Resilience in the Face of Climate Change in Nepal	Mountain Research and Development	Nepal	Seasonal migration, labour migration	Drought, rainfall variability	Food insecurity	MM ****	0, 1, 1, 1, 1; 1, 1, 1, 1, 1; 1, 1, 1, 0, 1
26	Haque, Parr, Muhidin (2019)	Parents' healthcare-seeking behavior for their children among the climate-related displaced population of rural Bangladesh	Social Science and Medicine	Bangladesh	Forced Displacement	Multiple climate-hazards	Child health care. Parental health-seeking behaviour	Quant. non-rand. *****	1, 1, 1, 1, 1
27	Haque, Parr, Muhidin (2020a)	Climate-related displacement, impoverishment and healthcare accessibility in mainland Bangladesh	Asian Population Studies	Bangladesh	Forced Displacement	Flood and riverbank erosion	Access to health care. Access to WASH.	Quant. non-rand. *****	1, 1, 1, 1, 1
28	Haque, Parr, Muhidin (2020b)	The effects of household's climate-related displacement on delivery and postnatal care service utilization in rural Bangladesh	Social Science and Medicine	Bangladesh	Forced Displacement	Multiple climate-hazards	Delivery at a health centre. Post-natal care service utilization	Quant. non-rand. *****	1, 1, 1, 1, 1

29	Heaney & Winter (2016)	Climate-driven migration: an exploratory case study of Maasai health perceptions and help-seeking behaviour	International Journal of Public Health	Tanzania	Rural - urban migration	Drought	Help seeking behaviour, health care utilisation, food insecurity, water insecurity	Qual. *****	1, 1, 1, 1, 1
30	Hori & Schafer (2010)	Social costs of displacement in Louisiana after Hurricanes Katrina and Rita	Population and Environment	Louisiana, USA	Forced Displacement/ evacuation	Hurricane	Access to primary health care	Quant. non-rand. ***	1, 1, 1, 0, 0
31	Hunter & Simon (2017)	Might climate change the "healthy migrant" effect?	Global Environmental Change	Mexico & USA	International migration	Rainfall variability	Self-assessed health, adult height (early life nutritional & health conditions)	Quant. non-rand. **	1, 0, 0, 1, 0
32	Hutton & Haque (2003)	Patterns of Coping and Adaptation Among Erosion-Induced Displacees in Bangladesh: Implications for Hazard Analysis and Mitigation	Natural Hazards	Bangladesh	Forced displacement	Riverbank erosion	Psychological distress	Quant. desc. *	1, 0, 0, 0, 0

33	Hutton & Haque (2004)	Human Vulnerability, Dislocation and Resettlement: Adaptation Processes of River-bank Erosion-induced Displacees in Bangladesh	Disasters	Bangladesh	Involuntary migration, erosion-induced displacement, rural-urban migration	Flooding/ river-bank erosion	Health problems, household hunger	Quant. desc. ***	1, 1, 1, 0, 0
34	Iqbal, Donjadee, Kwanyuen & Liu (2018)	Farmers perceptions of and adaptations to drought in Herat Province, Afghanistan	Journal of Mountain Science	Herat province, Afghanistan	Labour migration	Drought	Food insecurity, malnutrition	Quant. desc. ****	1, 1, 1, 0, 1
35	Islam & Hasan (2016)	Climate-induced human displacement: a case study of Cyclone Aila in the south-west coastal region of Bangladesh	Natural Hazards	Bangladesh	Forced displacement	Cyclone Aila	Access to WASH, access to basic health services	MM *	1, 0, 1, 0, 1; 1, 1, 0, 0, 0; 1, 0, 0, 0, 0
36	Islam, Sallu, Hubacek & Paavola (2014)	Migrating to tackle climate variability and change? Insights from coastal fishing communities in Bangladesh	Climatic Change	Bangladesh	From island to mainland (Rural – Urban migration)	Climate variability	Physical fitness, access to WASH	MM ***	1, 1, 0, 0, 1; 1, 1, 1, 1, 1; 1, 1, 1, 1, 0, 1

37	Jacobson (2019)	When is migration a maladaptive response to climate change?	Regional Environmental Change	Cambodia	Migration	Multiple climate-hazards: rainfall variability, drying, increased mean average temperature	Food security	Quant. desc. *****	1, 1, 1, 1, 1
38	Kabir, Rahman, Smith, Lusha & Milton (2016)	Climate change and health in Bangladesh: a baseline cross-sectional survey	Global Health Action	Bangladesh	Forced displacement, homelessness	Cyclones, floods, salinity	Infectious diseases, malaria, dengue, pneumonia, diarrhoea, height & weight, access to health care facilities	Quant. non-rand. **	1, 0, 0, 1, 0
39	Loebach &Korinek (2019)	Disaster vulnerability, displacement, and infectious disease: Nicaragua and Hurricane Mitch	Population and Environment	Nicaragua	Forced displacement	Hurricane	Infectious disease: Respiratory & Gastrointestinal	Quant. non-rand. *****	1, 1, 1, 1, 1
40	Loevinsohn (2015)	The 2001-03 Famine and the Dynamics of HIV in Malawi: A Natural Experiment	PLOS ONE	Malawi	Rural - urban migration	Climate change and variability	HIV	Quant. desc. ****	1, 1, 1, 0, 1

41	Low, Frederix, McCracken… Schwitters (2019)	Association between severe drought & HIV prevention & care behaviors in Lesotho: A population-based survey 2016–2017	PLOS Medicine	Lesotho	Internal, labour and circular migration	Drought	HIV	Quant. desc. *****	1, 1, 1, 1, 1
42	McElfish, Moore, Woodring, Purvis, Maskarinec, Bing, Kohler & Peter (2016)	Social Ecology and Diabetes Self-Management among Pacific Islanders in Arkansas	Journal of Family Medicine and Disease Prevention	Arkansas, USA	Migration to the hosting community	Climate change	Type 2 diabetes (language, translation, treatment, diabetes self-management)	Qual. *****	1, 1, 1, 1, 1
43	Mertz, Mbow, Reenberg & Diouf (2009)	Farmers' Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel	Environmental Management	Senegal (savanna)	Migration	Climate variability (wind, rain, dust storms)	Health, reduced solidarity	Qual. *****	1, 1, 1, 1, 1
44	Messias & Lacy (2007)	Katrina-Related Health Concerns of Latino Survivors and Evacuees	Journal of Health Care for the Poor and Underserved	USA	Evacuation	Hurricane Katrina	Hunger, environmental health risks, sleep disturbances,	Qual. *****	1, 1, 1, 1, 1

							access to health care		
45	Milan & Ruano (2014)	Rainfall variability, food insecurity and migration in Cabricán, Guatemala	Climate and Development	Guatemala	Seasonal & permanent migration	Rainfall variability	Food security (threat of local livelihoods)	Qual. ****	1, 1, 0, 1, 1
46	Molla, Mollah, Ali, Fungladda, Shipin, Wongwit & Tomomi (2014)	Quantifying disease burden among climate refugees using multidisciplinary approach: A case of Dhaka, Bangladesh	Urban Climate	Dhaka, Bangladesh	Migration, refugees	Flood/ river erosion, drought	DALYs los, diarrhea, asthma, morbidity	Quant. desc. *****	1, 1, 1, 1, 1
47	Molla, Mollah, Fungladda & Ramasoota (2014)	Multidisciplinary household environmental factors: Influence on DALYs lost in climate refugees community	Environmental Development	Dhaka, Bangladesh	Migration	Flood/ river erosion, drought	DALYs lost, diarrhea, asthma	Quant. desc. ***	1, 1, 1, 0, 0
48	Murali & Afifi (2014)	Rainfall variability, food security and human mobility in the Janjgir-	Climate and Development	Cchattisgarh state, India	Seasonal & permanent migration	Rainfall variability	Food insecurity, living quality in the city	MM ****	1, 1, 1, 0, 1; 1, 1, 1, 1, 1; 1, 1, 1, 1, 1

Champa district of
Chhattisgarh state, India

49	Nawrotzki, Schlak & Kugler (2016)	Climate, migration, and the local food security context: introducing Terra Populus	Population and Environment	Burkina Faso & Senegal	International migration	Adverse climate changes (heat waves, droughts, floods)	Food security, child (<5yrs) stunting & wasting	Quant. desc. *****	1, 1, 1, 1, 1
50	Oyekale, Oladele & Mukela (2013)	Impacts of flooding on coastal fishing folks and risk adaptation behaviours in Epe, Lagos State	African Journal of Agricultural Research	Nigeria	Migration	Flooding	Malaria, typhoid, cholera, diarrhea, dysentery, influenza, tuberculosis	Quant. desc. **	1, 1, 0, 0, 0
51	Pardi, Jungari, Kale, Bomble (2020)	Migrant motherhood: Maternal and child health care utilization of forced migrants in Mumbai, Maharashtra, India	Children & Youth Services Review	India	Forced Migration	Drought	Maternal Child Health care utilisation, immunisation	Qual. *	0, 0, 1, 0, 0

52	Penning-Rowsell, Sultana & Thompson (2013)	The 'last resort'? Population movement in response to climate-related hazards in Bangladesh	Environmental Science & Policy	Bangladesh	Temporary evacuation	Hazard events & disasters	Ill-health, lack of space & hygiene	Qual. ***	1, 1, 0, 1, 0
53	Perez-Saez, King, Rinaldo, Yunus, Faruque & Pascual (2017)	Climate-driven endemic cholera is modulated by human mobility in a megacity	Advances in Water Resources	Dhaka, Bangladesh	Urban migration	El Nino Southern Oscillation (ENSO)	Cholera	No cat.	
54	Philibert, Tourigny, Coulibaly & Fournier (2013)	Birth seasonality as a response to a changing rural environment (Kayes Region, Mali)	Journal of Biosocial Science	Mali	Seasonal migration	Climate & rainfall	Births registered in primary health care facilities	Quant. desc. ****	1, 1, 1, 0, 1
55	Rademacher-Schulz, Schraven & Mahama (2014)	Time matters: shifting seasonal migration in Northern Ghana in response to rainfall variability and food insecurity	Climate and Development	Northern Ghana	Seasonal & labour migration	Rainfall variability	Livelihood, food security	MM *	1, 0, 0, 1, 0; 1, 1, 0, 1, 0; 0, 1, 0, 0, 0

56	Rahaman, Rahman, Bahauddin, Khan & Hassan (2018)	Health Disorder of Climate Migrants in Khulna City: An Urban Slum Perspective	International Migration	Khulna City, Bangladesh	Slum migration	Climatic disasters (flooding, cyclone, storm surges, sea level rise, river erosion)	Waterborne diseases, undernutrition, micronutrient deficiencies, diarrhea, malaria	Qual. **	1, 1, 0, 0, 0
57	Rakib, Sasaki, Matsuda, Fukunaga (2019)	Severe salinity contamination in drinking water and associated human health hazards increase migration risk in the southwestern coastal part of Bangladesh	Journal of Environmental Management	Bangladesh	Migration	Sea level rise - Groundwater salinization	Hypertension, Cardiovascular disease, Renal disease, Diarrhoea, Respiratory disease, Skin disease, Access to healthcare and cost of healthcare	MM ***	1, 0, 1, 0, 1. 0, 0, 1, 1, 1. 1, 1, 0, 0, 1.
58	Roncoli, Ingram & Kirshen (2001)	The costs and risks of coping with drought: livelihood impacts and farmers' responses in Burkina Faso	Climate Research	Burkina Faso	Migration (sending of relatives)	Scarce and irregular rainfall, infertile and degraded soils, drought	Livelihood, food security	MM **	1, 1, 0, 0, 0; 1, 1, 1, 1, 1; 1, 1, 1, 1, 0

59	Shanthi, Mahalakshimi & Chandrasekar an (2017)	Assessment of challenges faced by the coastal women due to the impact of climatic change in selected coastal districts of Tamil Nadu, India	Indian Journal of Fisheries	Tamil Nadu, India	Urban migration	Unusual rainfall, floods, cyclones, change in water quality	Livelihood, health	Quant. desc. ***	1, 0, 1, 0, 1
60	Suckall, Fraser & Forster (2017)	Reduced migration under climate change: evidence from Malawi using an aspirations and capabilities framework	Climate and Development	Malawi	Internal migration	Climate stresses (droughts) and shocks (sudden flooding)	Food shortage	MM *	1, 0, 1, 0, 1; 1, 1, 1, 1, 1; 0, 0, 0, 0, 1
61	Taiban, Lin & Ko (2020)	Disaster, relocation, and resilience: recovery and adaptation of Karamemedesane in Lily Tribal Community after Typhoon Morakot, Taiwan	Environmental Hazards	Taiwan	Forced Relocation	Typhoon	Food security (food sovereignty), cultural preservation (social capital, mental health)	Qual. ***	1, 0, 1, 1, 0.
62	Tschakert, Tutu & Alcaro (2013)	Embodied experiences of environmental and climatic changes in landscapes of everyday life in Ghana	Emotion, Space and Society	Ghana	Rural - urban migration	Environmental and climatic change (unpredictable	Well-being, distress	Qual. *****	1, 1, 1, 1, 1

						and shifting rainfall)			
63	Van der Geest, Nguyen & Nguyen (2014)	Internal migration in the upper mekong delta, viet nam: what is the role of climate related stressors?	Asia-Pacific Population Journal	Vietnam	Internal migration	Climate-related stressors (floods, storms, rainfall)	Food insecurity	MM ***	1, 0, 1, 0, 1; 1, 1, 0, 0, 1; 1, 1, 1, 1, 1
64	Van der Geest, Burkett, Fitzpatrick, Stege & Wheeler (2020)	Climate change, ecosystem services and migration in the Marshall Islands: are they related?	Climatic Change	Marshall Islands	International migration	Sea-level rise, drought, extreme heat	Access to healthcare, Water security	MM ****	1, 0, 0, 0, 1. 1, 0, 1, 1, 1. 1, 1, 1, 0, 1.
65	Warner & Afifi (2014)	Where the rain falls: Evidence from 8 countries on how vulnerable households use migration to manage the risk of rainfall variability and food insecurity	Climate and Development	Guatemala, Peru, Ghana, Tanzania, Banglades h, India,	Migration	Rainfall variability	Food insecurity (food production & market food availability)	MM ****	1, 1, 1, 1, 1; 1, 1, 1, 1, 1; 1, 1, 1, 0, 1

				Thailand & Vietnam					
66	Wolsko & Marino (2016)	Disasters, migrations, and the unintended consequences of urbanization: What's the harm in getting out of harm's way?	Population and Environment	Shishmaref, Alaska	Planned relocation	Erosion, wind, ice melt, floods	Mental health status	Qual. **	1, 1, 0, 0, 0
67	Woodhall-Melnik & Grogan (2019)	Perceptions of mental health & wellbeing following residential displacement & damage from the 2018 St. John River Flood	International Journal of Environmental Research and Public Health	Canada	Residential displacement	Flood	Mental health, well being	Qual. *****	1, 1, 1, 1, 1
68	Zaman, Sammonds, Ahmed & Rahman (2020)	Disaster risk reduction in conflict contexts: Lessons learned from the lived experiences of Rohingya refugees in Cox's Bazar, Bangladesh	International Journal of Disaster Risk Reduction	Bangladesh	Forced displacement. Trapped populations.	Landslides, tropical cyclones, flash-flooding.	Infectious disease outbreaks. Access to healthcare. Food and water security.	MM ***	1, 0, 0, 0, 1. 1, 1, 0, 0, 1. 1, 0, 1, 1, 1.

2.6 Data analysis and synthesis of results

All eligible studies were included in the analysis. A meta-synthesis was undertaken which is considered advantageous when dealing with broader research questions with disparate outcomes (Buchenrieder et al, 2017). Meta-synthesis is a synthesis of qualitative evidence. We used a meta-aggregative approach to the synthesis that is sensitive to the practicality and usability of the original findings of selected articles and does not seek to re-interpret those findings, as some other methods of qualitative synthesis do (JBI 2020). Once policy recommendations were extracted from the selected papers they were analysed using N-VIVO and the six steps outlined by Braun and Clarke (2006), namely: familiarization with data; generating initial codes; searching for themes; reviewing themes; defining and naming themes; producing the report which included meaningful data presentation and visualization. The quality of the included studies was a component of the meta-synthesis. All authors were involved in and approved the thematic analysis that resulted in six themes.

3. RESULTS

3.1. Included studies

The search strategy revealed 2,425 studies with 134 duplicates that were removed. We screened 2,291 studies by title and abstract and excluded 2,085 studies because they did not meet the inclusion criteria or met an exclusion criterion. The main reasons for exclusion at 'first pass' (title and abstract) were not empirical evidence (e.g. editorial); focus on a dyad (either climate change and health or climate change and migration) not the nexus (climate change - health - migration); animal or plant health/migration not human health/migration. The resultant 206 studies were screened in full-text and 138 were excluded (Figure 1). The systematic literature review yielded a total of 68 eligible studies. The main reasons for exclusion at 'second pass' (full-text) screening stage were not empirical evidence (e.g. editorial), focus on a dyad (two concepts) not the nexus (all three concepts); no health outcome. Less common reasons included; Mobility driver that was unrelated to climate change, or a population that was not engaged in, or affected by a mobility response. Publication of eligible studies increased significantly from 2012, with most included studies published between 2014 and 2020 (Figure 2).
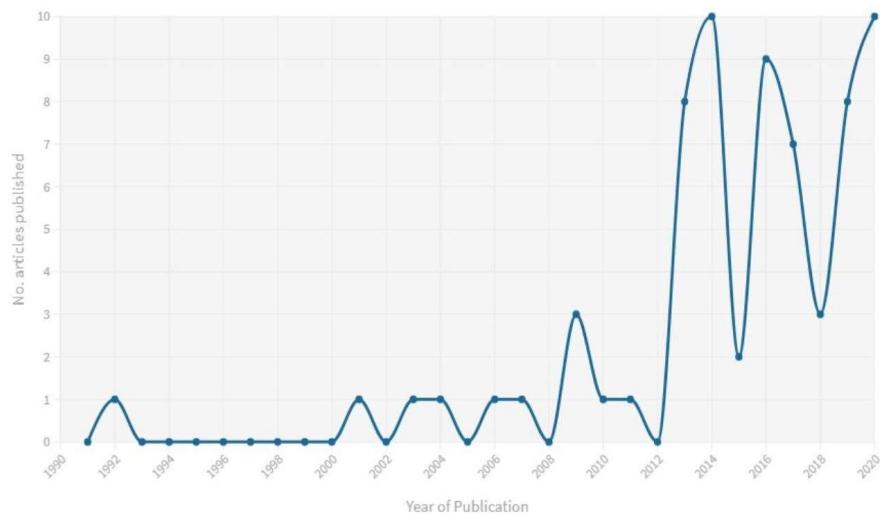
Figure 2: Publication year of included studies

3.2. Study settings

The 68 eligible studies were conducted in 36 countries. If one study included more than one country, it was duplicated in the analysis so that there were 81 study sites altogether (Figure 3). Most studies were conducted in the South East Asian region (36%) followed by the African region (26%), the Pan American region (22%) the Western Pacific region (9%), the Eastern Mediterranean region (3%) and Europe (4%). Notably, just under one-quarter of the eligible studies took place in Bangladesh (n = 18). Studies were conducted between 1991 and 2020 with the majority covering the period between 2012 and 2020 (n = 57). Details about the eligible studies can be found in Table 3.
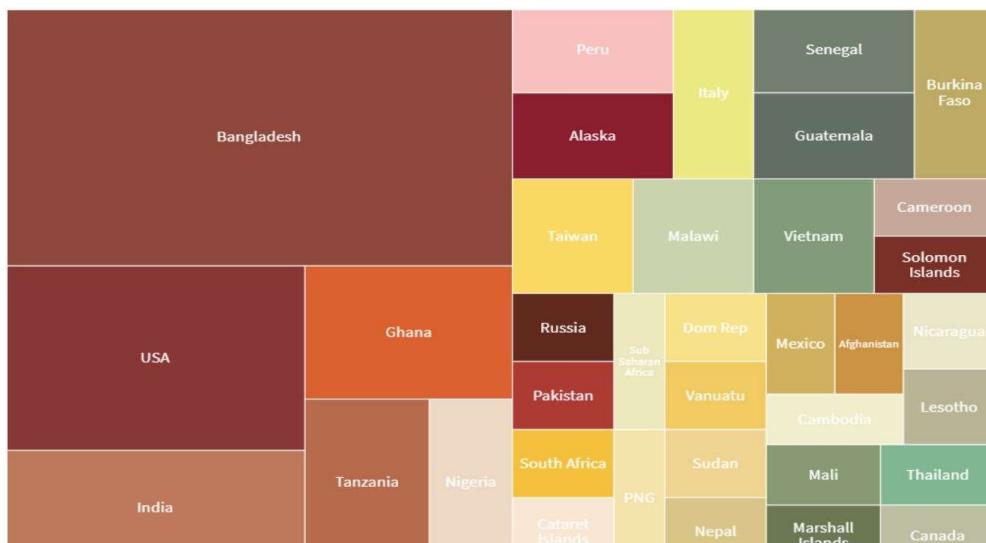
Figure 3: Study settings of included studies: A large proportion of the included studies were conducted in Bangladesh (24%), USA (12%) and India (7%). By WHO region 36% SEARO, 26% AFRO and 22% PAHO, 9% WPRO, 4% EURO, 3% EMRO

3.3. Study designs

The eligible studies (n = 68) were categorized, with reference to MMAT, into five types of study design: quantitative descriptive studies (17; 25%), quantitative non-randomized studies (12; 18%), qualitative case studies (17; 25%), mixed-methods studies (17; 25%); and modelling studies (5; 7%).

3.4. Quality appraisal

Each study was individually appraised for quality using the MMAT tool (see Figure 4) (Hong et al 2018). For individual studies, the quality score was attained by using the five custom questions for each study. We used a ranking system to summarize overall quality, based on the study's adherence to each of the quality criteria questions. Namely, how often (%) we could answer 'yes' to the quality appraisal question for a particular method according to MMAT (***** 100%, ****80%, *** 60%, ** 40% * = <20%).

Overall, the quality of the included studies was high with the quantitative non-randomised studies (n: 12) achieving the highest quality assessment result, with 67% scoring between 'good' and 'excellent' and no studies being appraised as poor (See Figure 4). The quality of quantitative descriptive studies (n: 17) was also high overall, with 71% of studies scoring between 'good' and 'excellent'. Qualitative methods (n: #) were predominant are were analysed in pure qualitative studies as well as mixed methods studies with a qualitative component. Overall, the quality of qualitative studies was high with 65% of studies scoring between 'good' and 'excellent' although these studies often incorporated small sample groups with limited ability to generalise. The quality of mixed methods studies (n: 17) was also high overall with 65% attaining a 'good' or 'very good' rating yet no studies achieved excellence according to MMAT and this seemed largely due to either the quantitative or qualitative component scoring higher and less transparent integration of results and interpretation of both methods.

Areas for improvement in methodological design included matching temporal-spatial scales of the hazard, mobility response, and health outcomes when compared and strengthening demographic matching of comparison groups. More meaningful and transparent integration of climate data would have more clearly linked the mobility responses and health outcomes to the climate scenario.
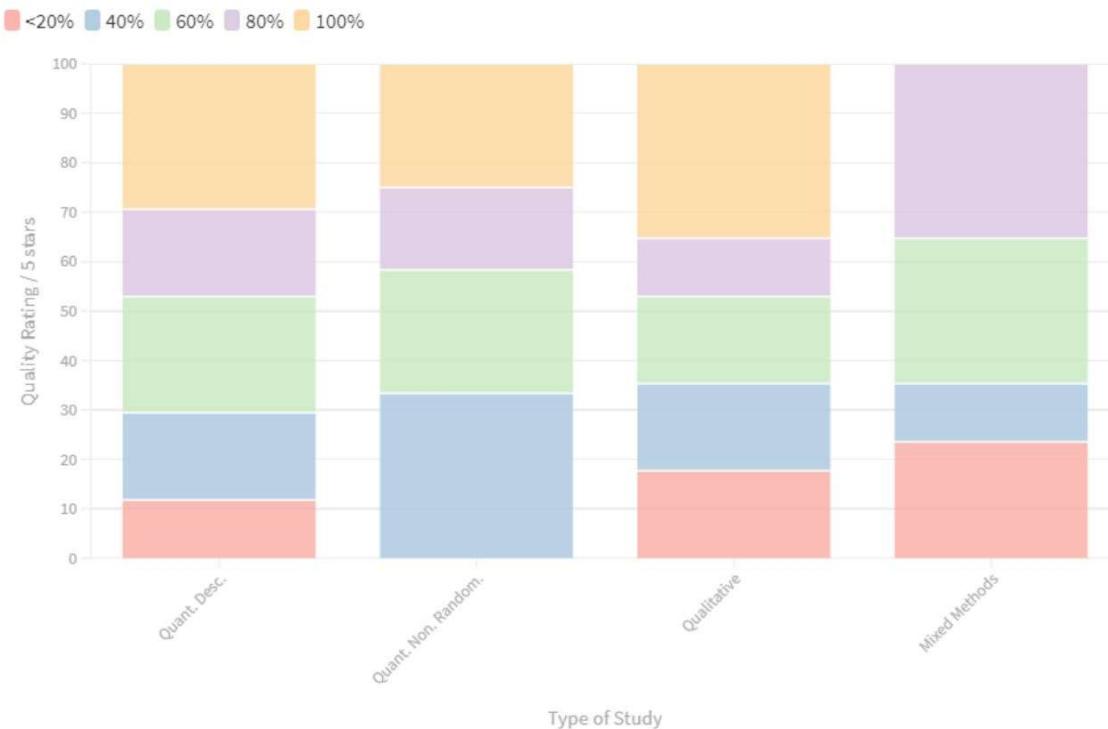
Figure 4: Quality Appraisal of included studies with MMAT: The majority of studies (approx. 70%) were of moderate - high quality according to the quality appraisal tool.

Individual Quality Appraisal. The ranking system is according to the articles adherence to each of the MMAT 5 question criteria i.e—frequency (%) we could answer 'yes' to the quality appraisal question and not 'no' or 'cannot tell' (*****100%, ****80%, *** 60%, ** 40%, *<20%).

3.5. The relationships between climate hazards, mobility responses, and health

There were three key concepts in this review as defined by the PEO approach (Populations participating in, or affected by mobility responses; the Exposure of climate hazards; and health Outcomes). A range of climate hazards (n: 24) were associated with diverse mobility responses and health outcomes studied, without clear trends or patterns emerging. The climate hazards in the studies were half sudden-onset (n: 12) such as storms, floods and cyclones, and half slow-onset (n: 12) such as drought, sea-level rise and glacial retreat. The most studied hazards included floods (n: 19; 16%), rainfall variability (n: 18; 15%), drought (n: 17; 14%) and multiple climate hazards or general climate change (n: 14; 12%). Other common climate hazards included extreme heat, sea-level rise and hurricane (n: 6; 5%). The predominant mobility responses were forced displacement, relocation (planned and forced), seasonal migration and rural-urban migration. A range of health issues were studied in the context of these climate hazards and the most commonly studied were food insecurity, access to healthcare, infectious disease and mental health issues (Figure 5 Sankey) (Nayna Schwerdtle et al, 2020).

Figure 5: Sankey diagram showing the relationship between mobility responses and health outcomes studied in the context of climate change according to the included literature

3.6. Thematic analysis of policy recommendations

Six themes were identified in the thematic analysis of policy recommendations extracted from 68 studies. A synopsis of the themes with illustrative quotes are outlined in Table 4 (Note: Additional illustrative quotes, codes and study details available as supplementary material)

Table 4: Synopsis of themes and illustrative quotes

Theme	Illustrative Quote
1. Avoid the universal promotion of migration as an adaptive response to climate risks. Prevent forced migration by investing in climate change adaptation at origin. Consider planned relocation as a last resort. Responses should aim to cope with, avoid and prevent the impacts of climate change.	*'The policy implication is that governments should not make assumptions a priori about whether a location is undesirable and promote migration as a blanket solution to the negative impacts of climate change' (Adams, 2016, Quantitative descriptive, Peru).*
2. Preserve cultural and social ties of mobile populations. Strengthen governance of socio-ecological systems**.**	*"Developing government frameworks that can draw on the strengths of the community-led approaches to relocation whilst also providing a mechanism for communities to stay intact will be an important step forwards for Small Island Developing States (SIDs) facing these climate pressures" (Albert et al, 2018, Qualitative case studies, Alaska and Solomon Islands).*
3. Enable participation of migrants in their sites of relocation and resettlement. Support the self-sufficiency of both incoming and host communities by supporting new livelihoods, developing social networks, and integrating cultural considerations.	*"As to the migrants, their value added to the areas of destination should be maximized by involving them in activities that match their skills (e.g. farming and construction), so that they actively contribute to the overall welfare of the new areas on one hand and to the well-being of themselves and their families on the other" (Afifi et al, 2014, Mixed methods, Tanzania).*
4. Strengthen health systems and reduce barriers for migrants to access health care.	*"Relocation of local health facilities with basic and emergency care provisions to areas in which the displaced have resettled, reinforcement of Family Planning services, and extension of coverage of the Maternity Allowance benefits in the displacement prone mainland riverine areas are recommended policy responses" (Haque et al, 2019, Quantitative non-randomised study, Bangladesh).*
5. Provide migrants with the requirements and the determinants for good health.	*"The rights of these displaced people, including the right to health, are often poorly protected in practice. More vigorous application of existing human instruments is needed, as well as clarification and possibly re-definition of the rights of those displaced" (Rahaman et al, 2018, Qualitative, Bangladesh).*
6. Integrate health into loss and damage assessments. Including for people at higher risk, such as those that are immobile or trapped.	*"The findings outlined a long line of climate-induced non-economic losses and damages that people faced through the rural-urban move from the island, and through the displacement in the slum. These included the loss of identity, honor, sense of belonging, physical and mental health or wellbeing" (Ayeb Karllson et al, 2020, Mixed methods, Bangladesh).*

4. DISCUSSION

This review highlighted a paucity of research on the nexus between climate change, migration and health. The geographical settings where this nexus research has taken place to date, the predominant study designs, their quality, and the relationships between climate hazards, mobility responses and health outcomes are discussed below. Finally, a narrative synthesis of the policy recommendations extracted from the included studies is placed in the context of the current policy environment on this topic.

4.1 Study settings

The predominant geographical foci of the studies in this review; Sub-Saharan Africa, South Asia and Latin America. Bangladesh is of particular interest to climate change, migration and health studies possibly, because it is highly exposed and vulnerable to climate hazards, densely populated.

These regions identified in the research align with existing evidence that indicates that currently, most climate-related migration is internal and takes place in developing countries (Foresight 2011; Riguad et al 2018). Three regions in the world are projected to see more than 140 million internal climate-related migrants by 2050, without urgent global and national climate action and economic development (Riguad et al, 2018).

4.2 Study designs and quality appraisal

The included quantitative descriptive studies (n=17) mainly consisted of surveys and case reports. Some of these studies looked at the association between climate hazards, migratory behaviours and health outcomes and sought to determine the extent to which migration was adaptive or maladaptive. Overall, the quality of quantitative descriptive studies was high with 71% of studies scoring between 'good' and 'excellent' (See Figure 4). Analysis ranged from simple descriptive statistics to regression analyses.

The included quantitative non-randomized studies (n: 12) mainly consisted of cross-sectional analytic studies that were used to study climate exposures without using randomization to allocate units to comparison groups. These studies tended to compare migrating and non-migrating households and resultant health outcomes, or climate-vulnerable and less climate-vulnerable households. Overall, the quality of quantitative non-randomized studies was high with 67% of studies scoring between 'good' and 'excellent'. This was the only category of studies without any scoring 'poor' quality. Quality issues included mismatching of temporal-spatial scales of the hazard, mobility response, and health outcomes and inadequate demographic matching of comparison groups.

Included qualitative studies (n=17) mainly consisted of case studies and narrative research. Qualitative methods were used to explore and explain in-depth the issues intrinsic to a particular case of climate-related migration and health. Overall, the quality was high with 65% of studies scoring between 'good' and 'excellent'. Qualitative studies with higher MMAT scores described data collection in detail and derived findings clearly from the data (e.g. using quotes to substantiate themes). Improvements could be made by clearly demonstrating coherence between data sources, collection, analysis, and interpretation.

The included mixed methods studies (n=17) combined quantitative descriptive studies (mostly using surveys) with qualitative methods (mostly using focus groups or interviews). Mixed methods seem to be well suited to the topic due as methods can complement each other and provide further details and explanations. The quality was high overall with 65% attaining a 'good' or 'very good' rating with no studies achieving excellence according to MMAT criteria. Stronger studies balanced the emphasis on different methods, adhered to the quality standards for both qualitative and quantitative components, and integrated findings arising from different methods.

4.3 Relationships between climate hazards, mobility responses, health outcomes

The relationships between mobility and health are complex and the extent to which they are examined in the literature in the context of climate change is depicted in the Sankey figure (Figure 5). Connections are population-specific and vary over space and time (Nayna Schwerdtle, 2020). Nevertheless, there is particular research focus on infectious diseases, access to healthcare, mental health, and food insecurity. While the global burden of disease has shifted to non-communicable diseases, NCDs are an under-researched theme with greater focus on infectious disease in climate-migrant populations. The review also reinforces the recognition that migration does not capture the diverse ways in which people do and do not move in response to a changing climate. Highlighting the need for researchers to challenge the 'climate change causes mass human migration' narrative and to shift attention from climate migration to more diverse forms of climate mobility and indeed immobility (Boas et al, 2019).
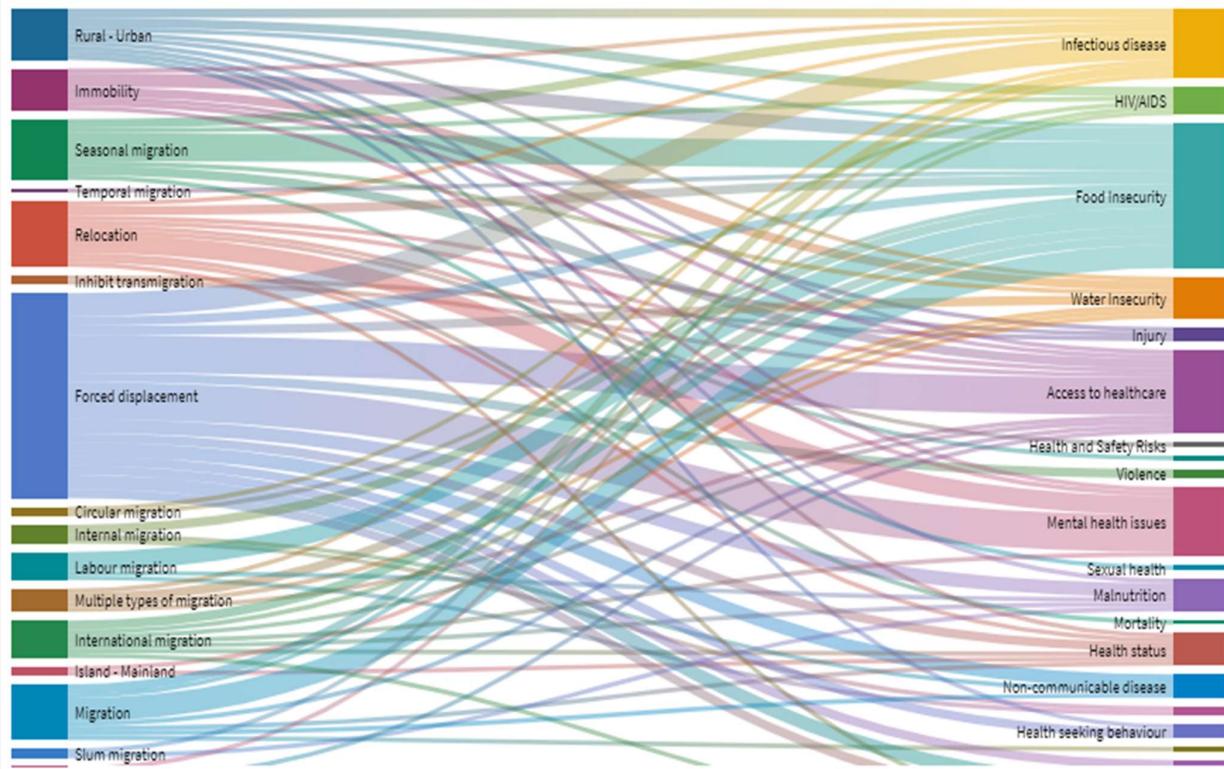
Figure 5: Relationships between mobility responses and health outcomes studied in the selected articles

4.4 Thematic analysis of policy recommendations

The effect of climate-related mobility on health depends on the policy decisions made by host, home and transit states and involved organisations, rather than on the mobility itself (Boas et al, 2019) highlighting the value of evidence-based policy in migration and health governance. In light of this, we extracted and analysed the policy recommendations from all 68 included studies. Six themes were identified that are presented graphically in Figure 6. The themes range from overarching recommendations such as avoiding universal promotion of migration or supporting community participation in migrant health initiatives, to targeted recommendations such as specific climate-change adaptation activities or the importance of preserving social and cultural ties in contexts of climate mobility.

Figure 6: Policy recommendations synthesis

Firstly, there were consistent recommendations to avoid universal promotion of migration as an adaptive response to climate risk, to prevent forced migration by investing in climate change adaptation at origin, and to consider relocation only as a last resort [2, 8, 21, 25, 37, 43, 52, 64, 65, 66]. These recommendations echo the broader calls by, for example, the International Organization of Migration (IOM) to minimize forced climate-related migration (IOM, 2020) and also the need to avoid assumptions that mobility is inherently positive or

negative (Boas et al, 2019). Given widespread preferences to remain in sites of belonging, many studies reviewed here called for policy initiatives that enable people to cope with, avoid and prevent the impacts of climate change at origin in order to prevent forced migration (Farbotko et al, 2020).

The included studies made recommendations to support investment in climate change adaptation and supporting sustainable development of agriculture generally. Specific suggestions included providing credit facilities and building agricultural extension services - also known as agricultural advisory services - that build knowledge of agronomic techniques and skills to improve productivity, food security and livelihoods. The focus was clearly on rural farming communities and adaptation with no studies exploring mitigation and few urban settings. This raises some questions about the extent to which the research is focussing on adaptation in a critical period when the mitigation window is closing. Alternatively, this gap may simply reflect that when migration is triggered, there is an urgent adaptation situation in play. In some contexts, existing migration flows and networks may provide opportunity for investment in the economies of sending communities (via remittances) that can increase opportunities for in situ adaptation and resilience among those who remain.

The second theme highlighted the importance of the preservation of cultural and social ties for the health of mobile populations through preserving and revitalizing traditional solidarity measures [21, 29, 41, 42, 43, 61]. Selected articles recommended strengthening governance or socio-ecological systems, favouring community-led approaches, and in doing so, recognizing the agency and inherent resilience of communities and to promote collaborative, adaptive migration governance structures. This agency and resilience focus is predominant in research recommendations yet somewhat lacking in research questions whereby disease and risk factors are the focus, rather than positive health outcomes and protective factors.

The third theme pertained to policy recommendations that sought to enable migrants to participate socially and economically in destination sites. The focus was on employment and income that have clear advantages for health and well-being of both migrant and host populations as well as sending communities if remittances are mobilized [3, 20 – 23, 26, 32 – 34, 55, 56, 58, 63, 63]. These studies tended to focus on subsistence farmers in rural settings, although many other types of populations will have migration decisions influenced by climate change, and the causal pathways can appear over-simplified. This theme incorporated studies about relocation and resettlement and was the theme with the most focus on host and sending communities rather than purely mobile communities. A well-defined example of promoting self-sufficiency was planned relocation in the Carteret Islands, where there was recognition that the resettled Carteret families may not have the skills necessary to cultivate kitchen gardens. New arrivals received training in appropriate

agricultural techniques, enabling self-sufficiency through income generated from selling cash crops (Edwards, 2013).

The fourth theme brought out the recommendations around the need to strengthen health systems generally where migrants are (in both sending communities and destination areas) in terms of both primary health care and more specialized vertical programs such as for HIV and Maternal Child Health (MCH) services. The findings in the selected articles revealed financial, geographic and cultural barriers for migrants accessing healthcare in the context of climate change and led to recommendations to reduce or remove these barriers to improve migrant health for example by including migrants in health insurance schemes [7, 11, 12, 17, 26 – 29, 31, 37, 40, 41, 46, 55 – 57, 62, 67]. There are clear benefits to broader population health from investing in a health systems strengthening approach, so the recommendations within this theme would have substantial flow-on benefits to the community at large.

The fifth theme went upstream from quality accessible health services, to identify the importance of ensuring basic requirements for health such as food, water, and shelter, which are basic human rights and necessary to protect life, reduce suffering and preserve human dignity. These studies highlighted the need to focus on health equity in a range of settings including climate-vulnerable regions and sites of relocation and resettlement. This includes the need to integrate migrants into labour markets (see Theme 3) to support livelihoods and food security and to enable access to education [9, 10, 19, 23, 31, 34, 36, 39, 57, 58, 61].

This theme corroborates the demand for establishing migrant-inclusive health systems, as suggested by the Lancet Commission on Migration and Health (Abubakar et al. 2018). They constitute the basis for supply and utilization of patient-centred access to health and social protection. This theme reiterates WHO's Global Action Plan for promoting the health of refugees and migrants under Priority 4. Enhance capacity to tackle the social determinants of health and to accelerate progress towards achieving the Sustainable Development Goals, including universal health coverage (WHO, 2019).

Finally, the sixth theme focussed on the need for policy to integrate health into the full range of loss and damage calculations [11, 21, 30, 32, 33, 67]. Loss and damage refers to negative effects of climate variability and change that people are not able to cope with or adapt to. Research and policy discussions of loss and damage recognize that climate change impacts are differential, with greater losses accruing to vulnerable populations and regions, thereby exacerbating inequities (Ebi, 2020). And it is important to note that vulnerability to climate change is fundamentally a matter of political economy, with those least responsible for climate change most at risk from adverse climate impacts. For example, immobile populations in sites of climate risk may be trapped and experience loss and damage including because they lack resources, assets and networks to enable migration away from sites of risk (Ayeb-Karlsson et al, 2020).

There is critical need and value in initiatives that address 'vulnerability' and improve 'adaptive capacity' by investing in adaptation and human development in local sites of climate risk, thereby potentially limiting the need for out-migration. However, policy initiatives that focus on 'the vulnerable' and proximate social and environmental contexts are at risk of obscuring complex power relations and global inequities that create these vulnerabilities, or limit adaptive capacity (Barnett 2020).

Policy recommendations referred to both economic and non-economic losses and damages and suggested widening our understanding of the linkages between mobility responses (including immobility) and wellbeing by looking at non-economic loss and damage and its links to mental health. It was argued that a lack of focus on this aspect might constitute a potentially costly public health inaction. The need identified was to provide culturally appropriate compensation for displaced and host populations with a range of populations at heightened risk requiring careful consideration including women and girls, elderly people, trapped populations, people living with disabilities, and people living with HIV/AIDS.

Immobile populations living in such contexts may experience adverse health impacts that emerge from changes in water and food security, disease ecology, flooding and saltwater intrusion, and the psychosocial impacts of disrupted livelihoods (McMichael, 2020). These represent important aspects of loss and damage that emerge from climate change impacts (Warner & Van der Geest, 2013). Despite widespread focus on livelihood security and damage to physical assets as key aspects of loss and damage, adverse health impacts among climate-affected populations - such as food and water insecurity – also represent aspects of loss and damage. These health costs and consequences, including among (im)mobile populations in contexts of climate risk, cause significant harm and impede sustainable development.

The studies we review here all discuss the policy and practice significance of their findings. Most note that the scale of climate-related migration is projected to increase in the coming decades (while also noting that climatic factors rarely act alone in shaping human mobility) and that there are health risks and opportunities of climate-related mobility. Climate change is likely to act as an amplifier of health risks among mobile populations, rather than creating new vulnerabilities that require distinct policy and practice responses. Nevertheless, it is still an important and increasingly significant consideration in both migration and health policy. Therefore, it will remain of importance and value to strengthen the migrant sensitivity of health systems, ensure universal health coverage, and continue efforts to address the social determinants of health inequities for all including for mobile populations. Yet there may also be a need to respond to the increasing vulnerability of some migrants. There will likely be climate-related mobility across and within borders of countries in the Global South where health systems are generally weaker and have a lower capacity to deal with increased demand. And many people migrating in the context of climate change may move into areas

of increased risk, such as in Bangladesh where informal settlements form in flood zones (Hutton & Haque, 2004; Molla et al 2014). So, rather than creating new categories of vulnerable mobile populations, there will be an amplified need to address the health of mobile populations in often under-resourced and climate-vulnerable sites.

4.5 Limitations and opportunities

To limit bias, this study used a priori protocol and a double-blinded approach for study selection and quality appraisal. The inclusion of only English and German papers published in academic journals may have contributed to selection bias and there is always a risk despite a thorough search strategy that articles were missed however, this risk was mitigated by searching reference lists of relevant articles. Studies were not omitted due to quality as per the MMAT tool recommendations, which may have led to findings of studies with weaker designs being included in the meta-synthesis. The decision to exclude grey literature may have led to the omission of some important findings yet peer-reviewed studies aligned better with the research aim and specific objectives to synthesize empirical research. Primary studies within grey literature reports should have been captured by the search strategy.

Health research is context and population-specific and climate-related migration is variable over space and time. Therefore, while some key concepts are clear and widely agreed there is also a need to understand the risks, exposures, vulnerabilities and capacities of unique populations and settings to inform policy and practice decisions. The decision to exclude grey literature may have led to the omission of some important findings yet peer-reviewed studies aligned better with the research aim and specific objectives to synthesize empirical research. Primary studies within grey literature reports should have been captured by the search strategy.

Reporting ambiguity within included studies may have led to over or underestimation of methodological quality. Caution is needed in interpreting these studies because secondary data were often used with other objectives and because some studies used small sample groups (especially qualitative case studies) with findings that could not be generalized to larger groups. Five studies did not fit within the MMAT categorisation (modelling studies) and were therefore not assessed for quality, which remains a limitation of this review. This study attempted to introduce systems thinking in fields of research that are still siloed. The inclusion of all three elements of the climate- migration-health nexus was required for inclusion, some studies still focused on a 'dyad' within the nexus, with an element at times underexplored requiring interpretation in the extraction phase. Some eligible studies suggested potential links to climate change rather than demonstrate the link with climate data. This may have led to an overestimation of the relationship between the mobility response and health outcomes and climate change and also capture climate variability and

other forms of environmental change, which would be challenging if not impossible to set apart as an exposure in this SLR.

4.6 Future research directions

The recommendations extracted, analysed and synthesized in this review pertained mainly to rural livelihoods revealing a potential gap in researching this nexus in urban settings. The research focussed on mobile populations and less so on the entire migration ecosystem including sending and host communities echoing a call for research on climate mobilities to shift part of its focus from climate-sensitive sending areas to destination areas (Boas et al, 2019). Further, there was a focus on adaptation with less attention paid to mitigation activities. It may be worthwhile looking at these concepts together, or on a spectrum whereby adaptation activities can play a role in mitigation and vice versa. There was very little to no reference to conflict in these studies although we know that conflict and migration are both related socially mediated, tertiary impacts of climate change and likely to be playing a role in some of these settings, and influencing health and health resources. Finally, the included studies focused on agricultural climate change adaptation with less attention paid to infrastructure and health.

5. CONCLUSION

As climate change continues to shape patterns and scales of human migration, policy makers are challenged to make evidence-based decisions that enable competent governance of orderly, safe, regular and humane migration, that safeguards human health and wellbeing. This review identified, analysed and synthesized what is known to date from research investigating the climate change, migration and health nexus. The findings largely confirm principles of good migration governance; that the universal promotion of migration should be avoided because it is not always adaptive, that forced migration should be prevented and that mobile populations should be supported in their decision-making. Some elements of our current understanding are reinforced in terms of the need to favour community-led approaches, provide durable solutions, preserve cultural ties and to enable migrant participation because it has the potential to maximise benefit for all those affected by mobility responses. This review also draws attention to more novel discussions such as non-economic loss and damages arising from climate change that include health impacts. The included studies focussed on adaptation without mention of the role of mitigation, or adaptive responses that also mitigate climate change. Revealing an area where the climate, migration and health community may want to take a stand, in the spirit of true prevention. The research also focussed on rural rather than urban settings and agriculture and less so health. Yet the policy recommendations synthesized by this review still call for the provision of basic prerequisites for health, a focus on health equity, and access to health care,

reiterating that these fundamental requirements for health are not a reality for all. In sum, the results call for transformative policies that support the health and wellbeing of people engaging in, and affected by mobility responses, including those whose migration decisions and experiences are influenced by climate change, and to establish and develop inclusive migrant healthcare.

Supplementary Materials: Extraction documents and collated additional illustrative quotes and coding framework is available as supplementary material.

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