



RAPID EVIDENCE ASSESSMENT ON THE IMPACTS OF CLIMATE CHANGE ON MIGRATION PATTERNS

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LIST OF ABBREVIATIONS

CAC	Central America and the Caribbean
FCDO	Foreign, Commonwealth and Development Office
IDMC	Internal Displacement Monitoring Centre
IPCC	Intergovernmental Panel on Climate Change
OECD	Organisation for Economic Cooperation and Development
RCP	Representative Concentration Pathway
REA	Rapid Evidence Assessment
SSP	Shared Socioeconomic Pathway
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

Human-induced climate change is a complex, long-term issue with wide-ranging implications for current and future migration patterns. This rapid evidence assessment (REA) assesses the extent and quality of existing evidence on the relationship between climate and migration, synthesising findings from 273 quantitative and qualitative studies published between 2005 and 2021, with particular attention to small island states, the Bay of Bengal, East Africa, and the Sahel. The overarching question guiding this analysis is: What are the current and likely future impacts of climate change on migration and displacement? We consider: 1) how climate change is affecting and likely to affect patterns of migration; 2) how different countries and regions are affected and likely to be affected; and 3) confidence in existing estimates and projections of climate change-related migration.

MAIN FINDINGS

HOW CLIMATE CHANGE IS AFFECTING PATTERNS OF MIGRATION

We hypothesise that climate change affects patterns of migration along five pathways: short-term shocks, long-term climatic and related changes, environmental pull factors, adaptation and mitigation measures, and perceptions and narratives. We have identified a very large body of evidence on shocks; large bodies of evidence on sea level rise, adaptation, and perceptions and narratives; and much smaller bodies of evidence on long-term warming and changes in precipitation patterns. We have not identified any evidence on the effects of environmental pull factors or mitigation.

The clearest evidence of existing relationships between climate change and migration relates to **climatic shock events** – floods, storms, droughts and short-term temperature and precipitation fluctuations. Evidence shows associations between shocks and increased internal and international migration along each of these sub-pathways. However, evidence simultaneously shows that climate-related shocks, especially short-term weather fluctuations, may reduce migration by depleting household resources and affecting capacities to migrate.

Among our pathways, **long-term climatic and related changes** potentially have the largest and most wide-ranging implications for migration. However, we have identified no studies of global climate change-induced sea level rise affecting present-day migration levels, though coastal hazards (e.g. flooding, erosion, storm surges, salinisation) do contribute to migration pressures. Only a small number of studies examine existing impacts of long-term temperature and precipitation changes on migration.

There is strong evidence that small-scale **adaptations** to climate-related shocks and hazards, especially adjustments to agricultural livelihoods and practices and improved infrastructures, can reduce migration pressures. However, there is also strong evidence of adaptation measures, or what may be called ‘maladaptation’, contributing to displacement and migration, including flood protection initiatives, coastal defence projects, dam building, agricultural development projects and land acquisitions.

There is strong evidence that **perceptions and narratives** of climate change, weather shocks and local environments affect migration. Local experiences of and attachments to place make migration less likely than it would otherwise be, and ‘climate crisis’ and ‘climate refugee’ narratives may contribute to people in vulnerable environments thinking that migration may be necessary, or even inevitable.

While most of the studies do not examine whether climate-related migration is, or is likely to be, mainly **temporary or permanent**, and mainly **internal or international**, those that do show that it is predominantly temporary and internal, although most of this evidence concerns the impacts of weather shocks.

With regard to **vulnerabilities**, youth and the dependence of countries and regions on agricultural production increase the likelihood of migration in response to climatic shocks. By contrast, limited evidence shows that women are more likely to face barriers to migration and to be ‘trapped’ in the face of climate-related changes. The poorest individuals and households are disproportionately affected by both migration pressures *and* barriers to movement.

HOW DIFFERENT COUNTRIES AND REGIONS ARE AFFECTED

In **small island states**, there is no evidence so far of global climate change-induced sea level rise contributing to migration, though there is some evidence of storms and droughts doing so. Attachments to place and narratives of climate change as unstoppable can influence migration decisions and intentions. Relocation in response to coastal hazards in small island states constitutes both an adaptation response *and* a form of migration.

In the **Bay of Bengal**, short-term temperature fluctuations and salinisation are associated with increased migration, whereas evidence on the impacts of flooding, storms and short-term precipitation fluctuations is mixed or inconsistent. Adaptations to climate-related changes through adjustments to agricultural practices can reduce migration, though maladaptation, notably through commercial aquaculture, may also contribute to migration.

In **East Africa**, short-term temperature fluctuations are associated with decreased migration, while evidence on the impacts of drought and short-term precipitation fluctuations is mixed. Adaptations to climate-related changes can both reduce migration pressures and generate resources needed to move. Moreover, maladaptation, especially land acquisitions for climate adaptation-related agricultural development, may contribute to displacement and migration.

The body of (English-language) evidence on the relationship between climate change and migration in **the Sahel** is much smaller than for the other regions, and what evidence exists is generally mixed or inconsistent.

ESTIMATES AND PROJECTIONS OF CLIMATE CHANGE-RELATED MIGRATION

There are no rigorous global **estimates** of the number of people displaced by or migrating in response to weather shocks or climate change, and there is no evidence of an upward trend in weather shock- or climate change-related migration.

There exist multiple **projections** of future migration relating to flooding, temperature and precipitation anomalies, sea level rise, and long-term warming, at both regional and global scales, but we have not identified specific projections relating to environmental pull factors, adaptation or mitigation, or perceptions and narratives. Projections vary hugely from one another (e.g. for sea level rise from the hundreds of million to the tens of thousand), depending primarily upon assumptions about potential in-place adaptations.

All **high-end projections** model future exposure to climate-related changes only, making no allowance for in-place adaptation, despite the extensive evidence of in-place adaptation provided by studies of present-day climate-related migration. For this reason in particular, high-end projections of climate-related migration are not considered credible.

EVIDENCE GAPS AND RECOMMENDATIONS

We identify **five main evidence gaps**:

- There exists little or no research on the migration implications of climate-related environmental pull factors and climate mitigation.
- There is a need for more integrated research on the migration implications of long-term climatic and related changes, with models incorporating technological and economic development, adaptation processes and social dimensions of migration.
- There exists little research on how other dimensions of environmental change and crisis, besides and in addition to climate change, affect migration.
- There is a surprising paucity of (English language) research on the Sahel; even research on the migration impacts of shock events in the Sahel is limited.
- There is a lack of clarity in the literature regarding the duration of shock-related migration, and there are very few studies of return migration.

The review of existing evidence informs **seven main recommendations**:

- Further research is particularly required on the duration of shock-related migration, and on the Sahel; plus there is a need for more integrated research on the migration implications of long-term climatic changes that incorporates potential adaptations.
- Policy and programming responses should explicitly consider the particular migration pressures and barriers to movement impacting poverty-affected individuals and households, and young people, as well as gendered vulnerabilities and barriers.
- We recommend that migration in response to climate vulnerabilities should be considered both as a form of adaptation and as involving social losses; greater attention should also be paid to the plight of 'trapped populations'.
- Greater attention should be paid to the risks of climate change maladaptation including those that contribute to displacement and migration.

- A narrow focus on climate change-related migration should be replaced with, or complemented by, broader consideration of environment-migration linkages.
- We recommend against the use of high-end projections of climate-related migration.
- The terms 'climate-related migration' or 'climate change-related migration' should be used instead of 'climate (or climate-induced) migration', to reflect the mediated, indirect ways in which climate change and climatic factors may influence migration.

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1.0 INTRODUCTION

1.1 CONTEXT AND BACKGROUND

Human-induced climate change (hereafter 'climate change') is a complex, long-term global problem with multiple and wide-ranging implications for future migration. Migration patterns may, most obviously, be affected by those climatic and environmental changes associated with climate change, from changes in the incidence and severity of extreme weather events, to long-term changes in temperatures, precipitation and sea-levels. But migration may also conceivably be affected by adaptation and mitigation responses to this unprecedented global challenge, and by policies and perceptions relating to both climate change adaptation and mitigation, and migration. In view of this, the question of how climate change may affect migration has received increasing attention from the United Nations and other international institutions, development agencies, and national governments in recent years, and will very likely be of increasing concern in the decades ahead (e.g. 1–3).¹ As the UK government prepares to assume the presidency of the United Nations Framework Convention on Climate Change (UNFCCC) for the 26th Climate Change Conference (COP 26) in November 2021, there is a need for an evidence-based understanding of the relationship between climate and migration to inform discussions with parties, and to inform broader Foreign, Commonwealth and Development Office (FCDO) policy and programming directions. This Rapid Evidence Assessment (REA) is intended to assess the extent and quality of existing evidence on this topic, presenting conclusions based on a rigorous analysis of reviewed literature.

1.2 RESEARCH QUESTIONS

The overarching question guiding this REA is: What are the existing and likely future impacts of climate change on migration and displacement? More specifically, this REA addresses the following sub-questions:

- 1) In what specific ways is climate change affecting and likely to affect patterns of migration?
- 2) How are different countries and regions affected and likely to be affected by climate change-related migration?
- 3) What estimates and projections of climate change-related migration exist, and how credible are these estimates and projections?

For each of these sub-questions, we seek to understand what evidence exists and the quality and consistency of this evidence base.

¹ Numbered references are used in this report, corresponding to the list of references that begins on page 66. The reference list includes the 273 studies forming the basis of the evidence review (listed in Appendix B) as well as additional supporting literature.

1.3 CONCEPTUAL FRAMEWORK

1.3.1 CLIMATE-MIGRATION PATHWAYS

In this REA, we understand climate change as potentially affecting patterns of migration along five hypothesised pathways:²

- 1) Through **short-term weather shock events** (both rapid-onset shocks such as floods and hurricanes, and slow-onset shocks such as droughts) and temperature and precipitation fluctuations linked and partially attributable to climate change;
- 2) Through **long-term global and local climatic and/or environmental changes** resulting from human greenhouse gas emissions (especially sea level rise, increased average temperatures, changes to precipitation and river flow patterns);
- 3) Through local environmental and associated economic changes which may act as **‘pull factors’ for in-migration** (e.g. to regions where there may be increased agricultural productivity and associated economic opportunities as a result of climate change);
- 4) Through **adaptation and mitigation policies, projects and investments** taken in response, or partly in response, to climate change (e.g. dam-building, land acquisitions, stranded assets); and
- 5) Through **perceptions and narratives** of the current and likely future impacts of anthropogenic climate change.

This framework is wider than usually employed in studies of climate change and migration. Most such studies focus exclusively on pathways 1 and 2 above without considering pathways 3 to 5. We include consideration of pathways 3 to 5 a) because these may have significant if under-acknowledged impacts on future climate-related migration patterns, and b) to help identify possible research gaps. We wish to emphasise, though, that the above are hypothesised pathways: we make no assumption that there will be evidence on each of them, or that they are of equivalent importance. Indeed, most of the studies examined in this REA focus on pathways 1 and 2, which are about environmental ‘push factors’ to migration.

1.3.2 GEOGRAPHIC FOCUS

This report focuses principally on evidence relating to low- and middle-income countries, with particular attention to four key regions: small island states, the Bay of Bengal, East Africa, and the Sahel. These regions were pre-selected given that islands, low-elevation coastal zones and drylands may be particularly vulnerable to climate change, and given FCDO’s specific interest

² The scoping report for this REA identified six, rather than five, pathways for analysis, with pathway 2 relating to long-term climatic shifts and pathway 3 to associated long-term environmental changes. To minimise repetition these two pathways have been merged.

in these contexts. The review does not, however, exclude other regions or countries (evidence on these is included in our analysis of climate-migration pathways, in Section 3). Moreover, because climate change has implications for migration which go well beyond low and low-middle income countries – to also include, for instance, migration from high-income states likely to experience dangerously high temperatures, or where there are high levels of economic dependency on oil and gas exports, or which are highly vulnerable to weather shocks - our analysis is not restricted to low- and middle-income contexts.

1.3.3 LINKING CLIMATE CHANGE AND MIGRATION

We understand migration as a complex, wide-ranging phenomenon, which can be either internal or cross-border; which is sometimes temporary or circular, and sometimes permanent; and which includes both voluntary migration and forced displacement and evacuation. This report considers the implications of climate change for each of these forms of migration. In addition, in line with the findings of the UK government's 2011 Foresight report on migration and global environmental change (4), we consider the impacts of climate change on 'trapped populations' who, whether through poverty or border policies, are unable to move despite exposure to severe environmental conditions. We also consider the potential impacts of climate change on the ability to return. And we consider evidence relating multiple 'waves' of climate change-related migration, for example evidence on how droughts may spark local out-migrations, which in turn generate social conflict in receiver areas, leading to secondary migration.

Across the above pathways and regions, the REA examines the full range of different types of evidence. It examines quantitative, qualitative and mixed methods research, and both primary and secondary review studies. It considers evidence on historical, present day and projected future climate change-migration linkages. It examines both global assessments and national, local and household-level case studies. It considers the evidence on both exposure to climate change-related changes and hazards, and specific vulnerabilities to them, and thus considers evidence of the socio-economic profile of migrants. It reviews the primary sources for the most widely used global estimates and projections of 'climate migrants' and 'climate migration'. To inform our analysis, it draws upon additional wider evidence which is not on climate-change related migration specifically, including, most notably, research on the drivers of migration (which may not be concerned with climate directly) and on projected climate change impacts (which may not consider migration). This additional evidence is not part of our dataset but is important in helping frame our analysis.

The study of climate change-migration linkages poses acute analytical challenges, as previous reviews emphasise (5–11). Climate change has a distinctive temporality, with significant lags between emissions and many of its existing and projected environmental and socio-economic, including migration, consequences. Future patterns of exposure to climate change-related hazards depend, in large part, on future greenhouse gas emissions, such that out-migration pressures are likely to vary significantly depending on what climate mitigation pathway the world ends up following. Climate change also sits alongside many other socio-ecological transformations and hazards, most of which, though commonly exacerbated by climate

change, typically also have other, and indeed far more fundamental, economic and political causes: deforestation, soil erosion, surface and groundwater over-abstraction, the loss of land to urbanisation, the collapse of fish stocks, reductions in agricultural employment as a result of mechanisation, and more, all fall into this category. Most of the impacts of climate change are thus indirect, in turn raising ‘climate attribution’ questions about the extent to which, say, individual rainfall anomalies or water supply shortages may be attributed to climate change (12). Moreover, given that human-induced climate change is a historically unprecedented global phenomenon, there are also limits on what can be learned from historical evidence.

Migration itself comprises many different phenomena, from temporary local relocations to routine circular movements, to permanent internal or cross-border changes in residence and associated livelihoods. Almost all forms of migration are multi-causal and affected by complex combinations of ‘push’ and ‘pull’ factors, as well as by migrant agency, aspirations and capabilities, as is well established in the literature (6,13–18). It is thus extremely difficult to disentangle factors associated with migration, considering the intersecting impacts of economic changes, processes of urbanisation, political instability and conflict, migration policies, long histories of mobility underpinning networks and remittance flows, and environmental and climate-related factors. There are also significant uncertainties over the likely future scale of local ‘in place adaptation’ to climate change, which may prevent or reduce migration pressures. Reflecting these complexities, existing research on climate change and migration includes studies from many different disciplinary and methodological perspectives, ranging from earth science projections of exposure to climate-related hazards to ethnographic analyses of migration discourses and behaviour, and is often inconsistent in its conclusions.

Given these complexities, we refer in this report to ‘climate-related migration’ (or ‘climate change-related migration’) rather than ‘climate migration’ or ‘climate-induced migration’. The latter formulations, which imply that climate change might be a sole or main cause of migration, are out of line with existing evidence on the multi-causal nature of migration, as well as with evidence of the frequently indirect and mediated character of climate change impacts. That said, we do not rule out the possibility that some climate change-related hazards may be so extreme, and so direct, as to render phrases like ‘climate migration’ appropriate in specific circumstances. We evaluate existing evidence on this issue in what follows and return to it in our conclusion.

1.4 STRUCTURE OF THE REPORT

The next section of the report describes the methods used within this REA; it details the selection and coding strategies employed, overviews the results of our search and assessment process, and discusses some of the limitations of this REA. Sections 3, 4, and 5 present findings. Section 3 addresses the first research question: In what specific ways is climate change affecting or likely to affect patterns of migration? This section considers evidence on the five pathways introduced above, analysing each of the main ways in which climate change might affect migration: through climatic shock events attributable to climate change (3.1), through long-term climatic and related changes (3.2), through environmental pull factors (3.3),

through adaptation and mitigation policies and projects (3.4), and through perceptions and narratives of current and future impacts of climate change (3.5). Section 4 presents findings on specific countries and regions, addressing the second research question: How are different countries and regions likely to be affected by climate change-related migration? This section examines the specific climatic and migration challenges of particular regional contexts: small island states (4.1), the Bay of Bengal (4.2), East Africa (4.3), and the Sahel (4.4). Section 5 examines estimates and projections of climate-related migration for each of the identified pathways and regions. Section 6, the conclusion, summarises the main findings on pathways, regions, and estimates and projections, and provides summary observations on the overall character and strength of the body of evidence reviewed. Key gaps in the existing evidence based are identified, along with recommendations for further research.

2.0 METHODS

2.1 SEARCH STRATEGY

In line with previous REAs (e.g. 19), this REA includes only academic journal articles, plus expert studies by climate change and migration research organisations and by development and non-governmental organisations. Student papers, dissertations, research briefs, books, book chapters, conference papers, unpublished papers and working papers have been excluded, to limit the number of publications to be reviewed. The report focuses only on studies from the last 15 years (since 2005) and those published in English.

To identify relevant literature, we conducted comprehensive searches of electronic academic and open-source databases relevant to the fields of climate change and migration. Searches were conducted between January and March 2021. Academic databases were selected that cover a range of disciplines relevant to the topic, including natural and social sciences. Other databases (e.g. 3ie, Climig, Eldis, Migrating Out of Poverty) were selected because they provide access to migration-focused as well as broader development-focused literature (potentially addressing elements of the five climate-migration pathways), as well as covering both academic literature and expert reports. To identify relevant grey literature, we conducted searches of publications by leading climate change, migration, and development organisations. These include organisations based in the 'Global South', especially the four priority regions: small island states, the Bay of Bengal, East Africa, and the Sahel. The selection of these organisations was intended to cover both research-focused organisations as well as international or regional organisations (e.g. development banks, UN agencies) in order to capture a wide range of relevant literature (e.g. expert reports, estimates and projections). See Appendix A (Table A1) for a list of databases and organisations covered in the search.

The first step in the search involved identifying studies with the keywords 'migration' and 'climate change' and synonyms thereof. A second step involved identifying studies using the keyword 'migration' (or synonyms thereof) and specific climate change-related environmental, economic, and political developments which also include some consideration of 'climate change'. The keywords used in database and organisational searches are presented in Appendix A (Table A2). We reviewed reference lists of existing systematic reviews to identify additional sources, using a 'snowballing' approach. Finally, we sought recommendations from the project's expert advisory group and around 20 additional experts and practitioners with expertise on climate change and migration. These experts were selected so that around (or a little over) half were academics and the others not; to ensure a spread of methodological and political perspectives; to include wide geographical representation, including expertise from the four priority regions; and to minimise gender imbalances.

We adopted four strategies to identify widely used global estimates and projections of climate-related migration. First, the searches of databases and organisational websites returned some studies of estimates or projections. Second, we scanned other relevant studies identified via database and website searches for references to estimates and projections, and

the primary sources for these figures were identified and reviewed. Third, we conducted Google searches to identify additional materials (see Appendix A for the keywords used). Fourth, the project expert advisory group plus additional experts and practitioners were asked for recommendations. Estimates and projections are often derived from grey material, including policy briefs and book chapters, which would otherwise have been excluded from our search. We therefore extended our search criteria on this issue so that all primary sources of estimates and projections were included, irrespective of publication type or quality.

We acknowledge the potential biases associated with our focus only on English-language academic articles and expert studies. These include:

- **Language bias:** Our focus on studies published in English excludes relevant studies covering low- and middle-income countries and the specific regions highlighted above which may be published in national languages or other ‘international’ languages. This limits not only the range of studies considered but may also be associated with particular Anglo/Euro-centric assessments of climate-related effects on migration. Furthermore, empirical research with statistically significant positive results may be more likely to be published in English (20,21).
- **Publication bias and discoverability bias:** Our focus on academic journal articles and expert studies leads to a disproportionate representation of studies published in international journals and by high-profile international organisations or available on well-indexed websites, potentially excluding those conducted by researchers in low- and middle-income countries. Moreover, particularly in the case of journal publications, research with statistically significant results and positive results may be more likely to be published than research with ‘non-significant’ or negative findings (22–24).

To mitigate these biases, we searched for literature published by organisations in low- and middle-income countries and regions. Searching the repositories of international migration, development and other research centres or networks also provided access to such studies.

2.2 INCLUSION AND EXCLUSION CRITERIA

The full text of each study was reviewed against a set of inclusion and exclusion criteria, which are presented in Appendix A (Table A3). The abstracts or executive summaries (and the full text where necessary) of initially retained results from database and organisation searches were subject to an initial review against the above inclusion criteria. All sources that met the inclusion criteria were coded and subject to quality assessment (Sections 2.3 and 2.4).

2.3 CODING FRAMEWORK

The studies included following this initial search and review process were coded in an Excel database using a framework covering research type and method, research scale and geographic context, pathways and sub-pathways, type of findings, and type of climate-migration relationship examined. See Appendix A (Table A4) for the detailed coding framework. The coding was based on a review of the full text of each study.

2.4 QUALITY APPRAISAL FRAMEWORK

Each individual study was first reviewed against a set of six assessment questions for ‘rigour’, which are detailed in Appendix A (Table A5). These questions are modified from FCDO’s standard research quality assessment framework and accompanying definitions (25), covering broad aspects of conceptual framing (questions 1 and 2), appropriateness (question 3), transparency (questions 3 and 4), validity (question 5) and cogency (question 6). Each individual study was designated as of either ‘high’, ‘moderate’, or ‘low’ quality based on these assessment questions. Studies evaluated as of low-quality in terms of rigour were excluded from the review. As an exception to this, however, where widely reproduced estimates of future climate migration were underpinned only by low quality research, the studies in question were not excluded. Within the main body of this report, the quality of individual studies is only reported where the studies in question are found to be of low quality. However, the full results of these ‘rigour’ assessments are summarised in Appendix B.

In a second step, the central findings of all studies providing estimates or projections of climate-related migration were reviewed against three ‘confidence’ assessment questions (see Table A5). The purpose of this element of the assessment was to evaluate estimates and projections only; hence it was not applied to studies that do not include estimates or projections, and was applied only to specific elements of each estimate and projection study rather than to the study in its entirety. Hence our confidence assessments do not provide a rounded evaluation of all studies included in this review and should not be taken to imply that those study findings which were not assessed in this way are beyond question. Reflecting this, we have opted not to grade estimates and projection findings in any way; instead, our evaluation of them is purely qualitative, though guided by our three confidence assessment questions. Our confidence in estimates and projections is reported in Section 5 of the report.

While this quality appraisal framework draws on FCDO’s standard framework as well as those adopted in previous REAs, the latter are modified for the purposes of report for three reasons: a) to cover the wide range of different types of study to be reviewed; b) to enable assessment of and provide information on the credibility of specific estimates and projections of climate change-related migration; and c) to ensure that the project team had sufficient time, within the context of a rapid assessment, to assess both the quality of all studies reviewed and our confidence in estimates and projections.

The overall strength of the body of evidence for each set of findings is assessed in terms of quality, size, and consistency (25), based on criteria detailed in Table 1, and is classified as ‘very strong’, ‘strong’, ‘medium’, or ‘limited’:

- Very strong: high overall quality (based on rigour assessments), large in size, and consistent findings
- Strong: high quality, large or medium size, and high or moderate (mixed) consistency
- Medium: moderate quality, large or medium size, and moderate consistency (mixed)

- Limited: moderate or high quality and small size; or moderate quality, medium or small size, and low consistency

Where evidence does not fall into these categories, quality, size and consistency are described in the text.

Component	High	Moderate	Low
Quality of the body of evidence	High overall quality of the studies reviewed, based on rigour scores	Moderate overall quality of the studies reviewed, based on rigour scores	Low overall quality of the studies reviewed, with rigour scores
Size of the body of evidence	Large in size (10 or more studies) ³	Medium in size (5 or more studies)	Small in size (less than 5 studies)
Consistency of the findings	Consistent: a range of studies point to similar conclusions	Mixed: studies involving different designs or methods, in a range of contexts, produce results contrasting with those of other studies	Inconsistent: one or more studies refute or contest findings of one or more other studies carried out in the same contexts or conditions

Table 1. Framework for assessing the strength of the body of evidence

2.5 SEARCH AND ASSESSMENT RESULTS

Approximately 650 potentially relevant journal articles and expert reports were identified through the database and organisation searches. These were then reviewed for retention based on the inclusion and exclusion criteria identified above. Approximately 380 studies were retained for closer analysis of the full study and coding. Roughly 120 of these were subsequently excluded, either because a closer reading revealed their limited relevance to this REA or because they were identified as ‘low quality’ following an assessment of rigour (see Figure 1). 15 additional studies were identified based on suggestions from experts and based on a scan of the reference lists of secondary reviews. In total, 273 studies were retained for the inclusion in the REA – examining pathways, estimates and projections – and form the basis of the analysis in Sections 3, 4 and 5.

2.6 LIMITATIONS

This study has several important limitations which deserve highlighting. This REA is, first of all, a ‘rapid evidence assessment’ produced under significant time constraints. Our database of studies will not be comprehensive: though undertaken in accordance with the methodology set out above, there are almost certainly a large number of studies which are relevant to the

³ Where 100 or more studies were identified for a given theme, we refer to a ‘very large’ body of evidence.

topic which were not identified via database or organisational searches, or other means (for instance because searches were conducted of the title and abstract of academic journal articles only, missing studies where implications for migration are discussed only within the main body of articles). It is also likely that the potential biases associated with our focus on English-language publications, and academic articles and expert studies, means that some important sources have been missed. The focus on four pre-selected regions represents another important limitation.

For analytical purposes, the five hypothesised pathways introduced above are coded and analysed separately. However, these pathways do not operate in isolation from one another, and we recognise the limitations of a framework that 'silos' them in this way. While many of the reviewed studies cover more than one pathway or sub-pathway, there is limited analysis of the linkages between them – both in the existing literature and, given the rapid nature of this REA, in the discussion of the findings below. The lack of detailed analysis of the interactions between different pathways and sub-pathways and their combined effects represents a gap in this REA.

3.0 EVIDENCE REVIEW FINDINGS: PATHWAYS

3.1 CLIMATIC SHOCK EVENTS ATTRIBUTABLE TO CLIMATE CHANGE

KEY FINDINGS

- Climate-related shocks can contribute to both increases *and* decreases in migration, increasing migration via impacts on agricultural production and income, and damage to or loss of property, but also constraining migration options by depleting household resources.
- Movement in response to climate-related shocks is mainly internal or local rather than long-distance or international; evidence on whether it is mainly temporary or permanent is mixed.
- Evidence on the social profile of shock-related migration is generally mixed, with different studies finding women, low incomes, limited formal education and agricultural occupations to be associated variously with higher or lower levels of migration; only youth and the dependence of countries and regions on agricultural production are consistently found to increase the likelihood of migration in response to climatic shocks.
- Adaptations to climate-related shocks through adjustments to livelihood (especially agricultural) practices and infrastructure adaptations can reduce migration pressures.

Evidence shows that climatic shocks can contribute to both increased *and* decreased internal and international migration. In the sub-sections below, we examine four types of climatic shock events, flooding, storms, drought, and short-term temperature and precipitation fluctuations, in each case considering their effects on migration and the mechanisms through which these effects occur. We then consider the types of migration associated with climate-related shocks, and vulnerabilities, barriers, and adaptations to shock-related migration. Consideration of estimates and projections is held over to Section 5.

Most of the reviewed studies analyse only the links between shock events and migration, and not the impact of human-induced climate change per se. While some studies assume that these shocks can be linked to or attributed to climate change, in light of the lack of clear evidence on whether the incidence of some shock types is increasing, and problems of attribution (26), this assumption is generally not warranted. Only a minority of studies include attribution analysis of the contribution of climate change to the shocks (and migration) under investigation. The migration impacts of shocks also pose methodological challenges. Except in the case of rapid onset shocks, where evacuation or displacement are often immediate (and often local and temporary) and can be directly linked to the shock in question, impacts on migration are often long-term and diffuse, and the precise contribution and significance of the shocks to migration may be unclear (e.g. in contexts where conflict and shocks overlap and may both contribute to displacement and migration pressures). Hence, we refer to ‘shock-

related migration’ (or e.g. ‘drought-related migration’) without assuming these shocks are caused by climate change or that they are the sole cause of migration.

3.1.1 FLOODING

There is a large body of high-quality evidence (31 studies) on the relationship between flooding and displacement or migration, although findings on the impacts of flooding on migration are mixed. Most of these studies focus on the Bay of Bengal region, with smaller numbers of studies focusing on Southeast and South Asia, Southern and East Africa, Central America, and global scales.

Eight studies (of Vietnam, Nigeria, Costa Rica, and globally) find that flood events are associated with increased levels of migration and displacement (27–34). In contrast, three studies (of Bangladesh and Tanzania) find that that flooding is associated with decreased internal (35,36) and international (37) migration, and a fourth (38) finds that migration declines immediately after flooding but soon (i.e. beyond the flood month) returns to normal levels. Five studies (of Bangladesh, Thailand, Indonesia, and Pakistan) find that flooding has weak or inconsistent effects on migration (39–43). For instance, Gray and Mueller (39) find that floods are associated with increased local migration but decreased long-distance migration, and only for women and the poor.

Several different processes seem to be at work. Flooding can contribute to displacement and migration pressures via damage to or loss of property (including homes), farmland, crops, and livestock, which in turn impact individual and household income (27,30,44–52), as well as through damage to or destruction of public infrastructure and services (44) and impacts on health (49). For instance, Dun (27) finds that repeated crop loss and unreliable crop yields and the cost of maintaining livelihoods due to repeated flooding contribute to migration decisions. At the same time, floods, especially severe floods, may deplete household resources and reduce migration options, leaving individuals ‘trapped’ (29,35–37,39). A recent secondary review (53) finds that shocks such as floods, drought and temperature extremes may impede migration capacities by depleting household resources. Floods may also be associated with lower migration when there are benefits to remaining in place, such as improved soil quality and crops due to flooding (35,37,54).

In addition, a range of context-specific factors affect whether floods increase or decrease migration. The intensity and frequency of flooding is one such factor: Robalino *et al.* (29) find that less severe floods are associated with increased internal migration while higher-intensity floods are associated with decreased internal migration, potentially due to impacts on household capacities for migration, while Chen *et al.* (35) find that, in areas frequently exposed to floods, households may have adapted to seasonal flooding and do not perceive these as shocks. Government policies and responses, such as existing flood protection and resilience measures, also affect whether flooding promotes or inhibits migration (30,31,36). Kakinuma *et al.* (31) report that flood-induced displacement is significantly higher in low-income countries, possibly because wealthier countries have greater protective infrastructure and flood management. At the same time, insufficient and inadequate government provision

of shelters and other crisis infrastructure, and a lack of planning for the movement of livestock, may serve as barriers to temporary evacuations (48).

3.1.2 STORMS

There is a large body of high-quality evidence (18 studies) on the relationship between storms and displacement or migration, although findings on the impacts of storms on migration are mixed, and in some cases inconsistent. Most of these studies focus on the Bay of Bengal and Central America, with smaller numbers of studies focusing on Southeast Asia, the Caribbean, and global scales.

Five studies (of Central America and the Caribbean, Costa Rica, Bangladesh, and the Philippines) show that storm events are associated with increased internal (29,55–57) and international (58) migration. Pajaron and Vasquez (59) find that migration may be a delayed response to storm shocks, with migration increasing the year following storm events. Similarly, Spencer and Urquhart (58) find that the effect of storms on migration is lagged, with no contemporaneous effect. In contrast, six studies (of Nicaragua, Mexico, Bangladesh, and globally) find that storms are not associated with large-scale internal (60–62) or international (33,34,63) migration.

As with flooding, storms may contribute to both migration pressures and constraints through impacts on property, livelihoods, and income (55,56,58,59,64–66). Recurrent storms may ‘wear down’ household coping and adaptation capacities, contributing to migration pressures (55). Insufficient and inadequate storm response provisions (e.g. emergency shelters, sanitation facilities, humanitarian relief) may amplify these effects (55). At the same time, storms may reduce migration options by depleting household resources (29,59). As with floods, contextual factors seem to be key. The intensity and frequency of storms may affect whether they promote or inhibit migration: two studies distinguish between the effects of lower- and higher-intensity storms, finding that less severe storms are associated with increased migration while higher-intensity storms are associated with decreased internal (29) and international (59) migration. Two studies find that the effects of storms on migration are stronger in subnational regions more reliant on agricultural production and incomes (56,59). Most studies of flooding and migration have similar geographical foci (Central America and Bangladesh) which, given their frequently contradictory findings, likely points to the influence of such contextual factors as the major determinants of migration behaviour.

3.1.3 DROUGHT

There is a large body of high-quality evidence (16 studies) on the relationship between drought and displacement or migration, although findings on the impacts of drought on migration are mixed. Most of these studies focus on East Africa and Southeast Asia, with smaller numbers of studies focusing on Central America and the Caribbean, Southern Asia, and global scales.

Droughts are slow-onset shocks, in contrast to rapid-onset shocks such as floods or storms (53,57). However, the conceptualisation and timescale of ‘drought’, and the specific

conditions under which this label should be applied, are contested. The reviewed studies do not follow a consistent definition, with some relying on specific indices (e.g. the Palmer Drought Severity Index or Standardized Precipitation and Evaporation Index) (57,67),⁴ others referring to numbers of months or years of low precipitation (42,68), others to self-reported assessments (69), and still others providing no specific definition. Particular caution is warranted in assessing the impacts of 'drought' on migration.

Reflecting this, findings on the impacts of drought on migration are particularly mixed. Six studies (of Central America and the Caribbean, Mexico, Ethiopia, India, and globally) find that longer, more intense or more frequent droughts are associated with increased internal and international migration (33,57,63,69–71). Migration pressures are linked to impacts on agricultural production and income (69–71) as well as household food shortages (71). Two studies suggest that droughts are more likely than rapid-onset shocks such as floods (53) and storms (57) to increase migration, possibly because rapid-shocks quickly deplete household resources and reduce the ability to move while slow-onset shocks (i.e. drought) allow households to gather resources needed for migration (53). By contrast, one study (of Tanzania) finds that drought is associated with decreased internal migration (36) and three studies (of East and Southern Africa, and Thailand) find that drought has weak or inconsistent effects on internal and international migration (42,67,68). Moreover, one study (of Syria) finds that one large-scale migration that has been widely attributed to drought actually had very different causes, most notably groundwater depletion, subsidy withdrawals and changes in government policy, and largely predated the drought in question (72).

Contextual factors may affect whether drought promotes or inhibits migration, with differences in the geographic foci of the two sets of studies potentially pointing to the influence of different economic or political conditions on the drought-migration relationship. For instance, Dallmann and Millock (70) find that the effects of drought on migration are stronger in subnational regions more reliant on agricultural production and incomes. Similarly, Abel *et al.* (73) find that drought is associated with increased international migration (asylum seeking) from the Middle East but only for a particular period (2011-2015) and in particular places (counties affected by the 'Arab Spring' and the wars in Syria and South Sudan).

3.1.4 SHORT-TERM WEATHER FLUCTUATIONS

In addition to evidence on the impacts of shock events on migration, there is a large body of high-quality evidence (73 studies) on the impacts of temperature and rainfall fluctuations (both increases and decreases, and variations in timing). Most of these studies focus on Central America or global scales, with South and Southeast Asia, East and Southern Africa, the Sahel, the Bay of Bengal, and South America also well represented.

There is strong evidence on the impacts of short-term **temperature** fluctuations on migration, although findings are strikingly mixed. 25 studies show associations with increased migration,

⁴ The Palmer Drought Severity Index considers monthly precipitation, temperature, and soil moisture levels, while the Standardized Precipitation and Evaporation Index considers monthly rainfall and temperature levels (57,67).

of which 18 find that short-term positive temperature fluctuations and high temperature extremes are associated with increased internal and international migration (32,38,40,41,56,74–86), one finds that negative temperature fluctuations have this effect (87), and six studies find that both positive and negative fluctuations are associated with increased migration (88–93). By contrast, nine studies find that short-term positive and negative temperature fluctuations and extremes are associated with lower migration (77,94–101), while one study finds no association between temperature shocks and migration (34).

There is a large body of high-quality evidence on the impacts of short-term **precipitation** fluctuations on migration, although findings are mixed and, in some cases, inconsistent. 19 studies show associations with increased migration, of which seven find that negative precipitation fluctuations are associated with increased migration (80,82,91,102–105), nine find positive precipitation fluctuations to have this effect (75,87,93,95,97,101,106–108), and three find that both positive and negative fluctuations are associated with increased migration (79,92,109). By contrast, nine studies find positive or negative precipitation fluctuations to be associated with decreased migration (28,38,54,70,77,84,91,110,111), and seven studies find that precipitation fluctuations have insignificant or inconsistent effects on migration (41,42,56,99,100,112,113).

Short-term temperature and precipitation fluctuations can contribute to migration pressures through negative impacts on agricultural productivity (e.g. crop yields), income, and food security (7,38,40,41,56,74,76,78,79,84,86,88,89,94,95,97,98,109,114–118,118–126) and health (101). Five studies identify thresholds for the effects of temperature fluctuations on migration. Three of these find increased migration to occur above average temperatures of about 22°C (127), 23°C (83), or 25°C (40). Nawrotzki *et al.* (105) find that while short-term temperature increases are initially associated with reduced migration, internal migration increases after roughly 34 warmer than average months – potentially because warmer temperatures may initially lead to higher crop yields but cumulative heat exposure may ultimately result in poorer yields, contributing to migration pressures. Similarly, Nawrotzki and DeWaard (80) find that migration is low immediately after hot spells but soon increases, peaking after about three years before declining, potentially pointing to gradual engagement with successful in-place adaptation measures.

At the same time, temperature and precipitations fluctuations can reduce migration via negative impacts on agricultural production and income that impede households' ability to finance migration (54,77,94–101). Conversely, warmer temperatures (98) and excess rainfall (41,77,84,91,95,100–102) may in some cases have positive effects on agricultural production and in turn local labour demands and employment opportunities and income, thus reducing migration pressures. For instance, Hunter *et al.* (106) report a lagged effect of rainfall deficits, associated with reduced migration from Mexico in the short term but increased international migration two years later, potentially after resources needed to migrate have been mobilised. Conversely, Thiede *et al.* (91) find that excess rainfall shocks have a lagged effect on migration in South America, potentially because positive impacts on agricultural conditions reduce migration pressures.

There is strong evidence that short-term weather fluctuations are most strongly associated with migration in regions more reliant on agricultural production and incomes or countries with larger agricultural sectors (7,28,32,56,75,78,87,88,92,97,109,118,124), and two secondary reviews (7,92) confirm this. Nawrotzki *et al.* (76) find that temperature fluctuations are associated with increased migration only in rural areas, potentially because impacts on employment are stronger, while access to in-place adaptation strategies may be higher in urban centres. Falco *et al.* (83) find that higher temperatures are more strongly associated with increased international migration from low-income than middle-income countries, as access to adaptations such as irrigation may be more limited. In contrast, two studies (92,96) show that the effects of weather fluctuations on migration are stronger in middle-income than low-income countries, where economic constraints limit migration options. Internally, Delazeri *et al.* (128) find that temperature and precipitation shocks are associated with decreased migration from more socioeconomically vulnerable rural areas but increased migration from less vulnerable regions. Riosmena *et al.* (129) find that temperature fluctuations are associated with international migration only from the most socioeconomically vulnerable regions while rainfall fluctuations are associated with increased migration from less vulnerable regions. Factors that may enable or constrain migration from these areas include availability of alternative livelihood options and resources for in-place adaptations (129). Finally, timing of weather fluctuations may influence effects on migration: two studies find that the impacts of precipitation shocks on migration are strongest when they occur prior to or during planting and growing seasons (97,103).

3.1.5 MIGRATION DESTINATIONS AND DURATION

There is very strong evidence that movement in response to climatic shocks is mainly internal, and that cross-border migration is generally to neighbouring countries. Studies show that flooding (27–29,39,44,47,49–51), storms (55,66), drought (53,57,71), and short-term weather fluctuations (92,112,118,121,122,124,130) is mainly internal or local, often toward urban areas seen as providing more income opportunities. However, most studies examining migration responses to flooding, storms, drought, and short-term weather fluctuations focus either on internal or international migration without examining their relative significance. A secondary review (53) reports that shocks such as floods, drought and temperature extremes tend to be associated more with long-distance internal migration than local or international moves. Another review (92) reports that the effects of weather fluctuations on migration are stronger for internal migration than for international migration. Similarly, Leyk *et al.* (109) find that rainfall fluctuations have stronger effects on internal than international migration. Shocks may be associated mainly with short-distance moves due to the social and financial costs of long-distance (including cross-border) migration (98,128,130). Beine and Parsons (96) find that while climatic shocks are associated with decreased international migration overall, they are associated with increased migration toward neighbouring countries (potentially due to lower migration costs and geographic and cultural proximity) or former colonising states (potentially due to the presence of diaspora networks). Similarly, Radel *et al.* (126) find that most cross-border migration linked to weather-related shocks is toward neighbouring countries in Central America. As an exception to this conclusion, Sedova and Kalkuhl (114) find that low rainfall is associated with higher internal and lower international migration whereas

high rainfall is associated with higher international migration, with positive weather shocks potentially facilitating the accumulation of resources needed for longer moves.

Internally, there is large body of high-quality evidence on the destinations of shock-related migration, although findings are mixed and, in some cases, inconsistent. Eight studies (of India, Pakistan, Bangladesh, Mexico, South America, sub-Saharan Africa, and globally) show that short-term weather fluctuations are associated with increased migration toward urban areas (38,82,90,91,104,105,114,131). Henderson *et al.* (104) find that precipitation fluctuations are associated with migration only towards industrialised urban centres (e.g. manufacturing centres), potentially because of employment opportunities. By contrast, three studies (of Bangladesh and Kenya) find that migration in response to climatic shocks tends to be between rural areas (51,116,132). One study (of Brazil) (93) finds that temperature fluctuations are associated with greater rural-to-urban migration while precipitation fluctuations are associated with greater rural-rural migration, potentially due to different impacts on agricultural production and opportunities. However, studies of internal migration often focus only on rural-to-urban movement, largely overlooking rural-to-rural, urban-to-rural, and urban-to-urban migration (92).

There is medium evidence on the duration of shock-related migration, and findings are mixed. 23 studies show that movement in response to flooding (27,30,44,47,48,50,51), storms (55,61,62,64,133), drought (71,134) and weather fluctuations (38,111,116,121,123,126,132,135,136) is mainly temporary or short-term, including in the form of cyclical movement (e.g. for labour) and evacuation or movement to shelters. One secondary review (92) reports that migration in response to climatic variations is often short-distance and temporary, and another (7) finds that while 'natural disasters' tend to increase short-term internal migration, findings regarding medium- and long-term migration are mixed. By contrast, six studies find weather fluctuations and extremes to be generally associated with long-term or permanent migration (40,41,54,75,84,127). Call and Gray (84) find that migration duration is affected by the duration of temperature fluctuations, with extended heatwaves associated with higher permanent migration and short hot spells associated with higher temporary migration. However, most studies on shock-related migration do not examine whether migration is temporary or permanent.

It seems likely that literature on the impacts of flooding and storms on migration mixes, and often conflates, two different phenomena: emergency displacement or evacuation, which is presumably mostly temporary and local, and subsequent migration in response to the economic impacts of flooding, which is more likely to be permanent and extra-local. The lack of explicit attention to evacuation as a specific category of displacement in responses to disasters has been highlighted elsewhere (e.g. 137). Furthermore, a recent report by the Internal Displacement Monitoring Centre (IDMC) (138) notes that short-term displacement often becomes protracted, but that insufficient data collection after the emergency phase of weather shocks impedes a clear understanding of these dynamics.

3.1.6 VULNERABILITIES AND BARRIERS

The reviewed studies identify differences in vulnerabilities to shock-related migration pressures and opportunities for migration based on gender, age, income, formal education, occupation type, and household size, although findings are mixed for most of these factors.

There is a large body of high-quality evidence on the **gendered** dimensions of shock-related migration, but findings are somewhat mixed and, in some cases, inconsistent. 20 studies show that men are more likely than women to move in response to flooding (30,47,48), storms (56), drought (53,69) and short-term weather fluctuations (38,41,56,74,82,98,100,118,121–125,139,140), a finding supported by secondary reviews (9,53). Moreover, men may be more likely to engage in long-distance migration (41) and to migrate internationally (102) in response to weather fluctuations. Women are more likely to face barriers to migration and to be ‘trapped’ in the face of climate-related shocks (38,55,74,141,142). Ayeb-Karlsson (141,142), for instance, finds that gendered social norms and power relations contribute to immobility in response to storms, with gendered distinctions between safe and unsafe spaces (e.g. shelters) and gendered knowledge of and influence over disaster preparedness and evacuation presenting barriers to women’s movement. By contrast, five studies find that the effects of flooding (39) and weather fluctuations (81,94,102,120) on migration are stronger for women, possibly due to more entrenched migration patterns among men, greater household reliance on men’s income and thus more flexibility in women’s migration responses, or more accessible urban employment opportunities for women (e.g. care or domestic work). A sixth study (133) finds that women-headed households are more likely to be displaced to shelters during storms. Hirvonen (94) finds that temperature shocks reduce migration among men while migration among women is largely unaffected (potentially because it is linked more to marriage and family than to income). The wide range of geographic foci of these two sets of studies and associated findings point to the likely influences of context-specific gendered norms and labour and mobility dynamics on shock-related migration.⁵

With respect to **age**, there is strong evidence that younger people are most likely to migrate in response to flooding (30,36,47), storms (56,57), drought (57) and weather fluctuations (56,79,85,102,107,113,115,122,123), a finding supported by a recent secondary review (9). Only one reviewed study finds a lower likelihood of migration among younger people than older people in response to weather fluctuations, potentially due to increased agricultural demands on younger household members (91). Xu *et al.* (115) find that younger people are more likely to migrate from rural to urban areas in response to rainfall changes, while older people are more likely to move between rural areas.

There is a large body of high-quality evidence on the impact of **income** on shock-related migration, although findings are mixed and, in some cases, inconsistent. 12 studies find that people from poorer (e.g. land-poor or landless, with low financial resources) households are more likely to be displaced or migrate in response to floods (30,39), storms (133), drought (69,144) and weather fluctuations (41,79,102,114,121,123,139). By contrast, six studies show

⁵ As wider migration research shows that women are as likely to migrate as men (143), these findings may point to the particular gendered dimensions of shock-related migration within different contexts.

that members of wealthier households are more likely to move in response to storms (60), drought (134) and weather fluctuations (37,38,99,114), while Kubik and Maurel (86) find that weather shocks are associated with increased migration only for middle-income households, as the poorest households cannot afford migration costs and the wealthiest can afford in-situ adaptation strategies. Insufficient resources are identified as key barriers to migration in response to climatic shocks (29,35–37,39,49,53,53,55,57,116,118,121–123,125,131,132,145), with the poorest households being least able to move. Two studies show that people from poorer communities may be more likely to migrate internally, while wealthier households may be more likely to migrate internationally (102,114). A recent secondary review (53) finds that poorer households are not necessarily more likely to migrate in response to climatic shocks – which increase both vulnerability to migration pressures and financial barriers to migration.

Similarly, there is strong evidence on the impact of formal **education** on shock-related migration, although findings are mixed. Eight studies find that people with no or low levels of formal education are more likely to migrate in response to flooding (30,36,146), storms (133), drought (36,63) and weather fluctuations (81,91,114). Nine studies, by contrast, find that people with more formal education (e.g. secondary school or higher) are more likely to migrate in response to flooding (33,47), storms (56,63), drought (33,56,134) and weather fluctuations (56,101,102,128). Drabo and Mbaye (33) find that floods and drought are associated with increased migration toward OECD destination countries only among highly educated people, potentially due to greater likelihood of employment and ability to afford migration costs, ability to obtain migration documents, and migration policies friendlier to 'skilled workers'. Xu *et al.* (115) find that people with higher formal education levels are more likely to migrate from rural to urban areas in response to rainfall changes, while people with less formal education are more likely to migrate between rural areas, potentially due to access to different work opportunities.

There is a medium body of high-quality evidence on the impacts of **occupation** type on the relationship between climate-related shocks (specifically weather fluctuations) and migration, although findings are mixed (representing strong evidence). Three studies (of Tanzania, India, and Bangladesh) find that the effects of weather fluctuations on migration are strongest for households involved in agricultural livelihoods (82,86,114). By contrast, three studies (of Bangladesh, Indonesia, and Vietnam) find that effects are stronger for members of non-farm households or those involved in non-agricultural work, potentially due to stronger ties to place of residence among farm households (47,98,101). Other studies also identify attachment to place and community as barriers to migration in response to climate-related shocks (not only for agricultural households) (49,55,139,147). The effects of education and occupation on shock-related migration are likely influenced by context-specific labour market dynamics and economic and employment opportunities in both source and destination areas.

A small body of high-quality evidence consistently shows that larger **household size** is associated with greater migration in response to flooding (30), storms (60), drought (69), and weather fluctuations (74). Additionally, there is strong evidence that **migrant or diaspora networks** can facilitate migration in response to climatic shocks by providing information and material support (e.g. financial resources) (9,55,60,70,82,90,99,102,106,129,134,148). One

study, however, finds that these networks can reduce migration pressures through the provision of knowledge and financial resources to support in-place adaptation (77).

These findings on the complex effects of age, income, education, occupation, diaspora networks, and others factors on shock-related migrations are broadly consistent with broader literature on migration (17,149–151). We should note that wider migration literature provides more comprehensive insights into migration-related vulnerabilities and barriers – at individual and household levels (e.g. gender, household dynamics) as well as systemic and structural influences (e.g. diaspora networks and visa regimes) – beyond the findings described here.

3.1.7 ADAPTATIONS

A large body of moderate-quality evidence consistently shows that adaptations to climate-related shocks, in the form of adjustments to livelihood practices and infrastructure adaptations, can reduce or otherwise affect migration pressures (there are also much larger bodies of literature on adaptations to flooding, storms and drought that do not address migration specifically, and are not considered here). Adaptations to flooding, drought and short-term weather fluctuations include adjustments to agricultural practices (e.g. planting and harvesting dates, crop varieties) (30,44,117,121,122,130,134,135,139,140,152–156) and engagement in non-agricultural livelihood activities (e.g. wage employment, daily labour, petty trade) (44,51,71,98,107,117,120–122,134–136,139,140,152–155). Responses to flooding also include shifting from farming to fishing occupations (45). Infrastructure adaptations to flooding include modification of housing structures (e.g. raising lower levels, building second stories) (49,50,121,147) and construction of embankments or dykes by governments or communities (48–50).

Resources necessary for adopting such strategies come from selling household assets, loans, non-governmental or community organisations, community collectives or savings schemes, and government support or compensation for losses (30,45,50,51,121,122,136,140,148,157). Migrant or diaspora networks can facilitate in-place adaptation through the provision of knowledge and financial support (e.g. remittances) (77,118,126,145,154,157,158). Wealthier (e.g. landowning) households are more likely to have alternative income sources and pursue in-place adaptation measures in response to shocks (116,117,132,134,136,139,159). For instance, wealthier farmers may be able to adapt to rainfall variability through irrigation, while poorer households cannot afford to do so and may thus face greater migration pressures (116,132). Call *et al.* (38) find that wealthier households are more likely to send migrants in response to negative rainfall fluctuations and less likely to send migrants during periods of high rainfall, pointing to greater adaptive flexibility.

With respect to flooding specifically, a small body of high-quality evidence shows that government-initiated relocation initiatives represent both an adaptation and a form of flood-related migration (27,160,161). Barriers to relocation, which might in turn contribute to migration pressures, include insufficient financial resources to access land in resettlement areas and lack of access to employment, infrastructure, services and social networks (27). Relocation projects may also be resisted by residents due to negative impacts on resource access and livelihoods and unequal impacts on particular ethnic groups and women (160,161).

3.2 LONG-TERM CLIMATIC AND RELATED CHANGES

KEY FINDINGS

- There is little evidence so far of global climate change-induced sea level rise affecting migration levels, although coastal hazards (e.g. flooding, erosion, storm surges, salinisation) may contribute to migration pressures.
- There is little evidence so far of long-term warming affecting migration.
- A limited body of evidence shows that long-term precipitation declines are associated with increased migration.
- Attachments to place and narratives of sea level rise as unstoppable can influence migration decisions and intentions – though immediate experiences, observations and attachments may be privileged over external narratives.

The projected long-term climatic and environmental consequences of climate change include increases in average global temperatures, global average sea level rise resulting from Arctic and Antarctic ice melt, and changes in precipitation and river flow patterns. Multiple studies suggest that each of these long-term trends has significant implications for migration. However, both the structure and likely future scale of this migration are uncertain, primarily because, unlike on short-term shocks, there is a paucity of evidence on whether and how such long-term changes are already affecting, or have historically affected, migration. In the subsections below, we examine three types of long-term climatic and related changes – sea level rise, long-term temperature changes and long-term changes in precipitation and river flow – in each case examining evidence relating to their existing migration impacts.

3.2.1 SEA LEVEL RISE

There is a large body of high-quality evidence (48 studies) on the relationship between sea level rise and displacement or migration. The vast majority of studies focus on small island states, with Southeast Asia also well represented and smaller numbers of studies focusing on the Bay of Bengal, West Africa and the Sahel, and Central and South America. However, we have identified no studies that specifically examine the impacts of existing sea level rise on migration levels. Global sea levels have risen by around 25 cm since 1850, too slight a change to detect any migration impact. Hence empirical studies of the migration implications of sea level rise utilise data proxies for global sea level rise, especially evidence relating to coastal flooding, erosion, subsidence, salinisation, storm surges and local sea level changes.

While such studies examine how coastal hazards contribute to migration pressures, the vast majority do not identify whether these hazards are leading to increased (or decreased) migration. As an exception, one study of Bangladesh (43) finds that while inundation alone has insignificant effects on migration, increasing soil salinity is associated with higher internal migration via impacts on crop production and revenues – though soil salinity may result from land changes, deforestation, and groundwater management, and not necessarily sea level rise

(37). Other studies, without identifying specific migration trends, find that coastal hazards may contribute to migration pressures via damage to or loss of household property, farmland and crops, negative effects on agricultural production and income, and the damage to or loss of coastal infrastructure (49,144,162–170). Local seawater intrusion and salinisation may contribute to migration pressures via negative effects on farmland, agricultural production and revenues, and groundwater (37,43,49,165,171) as well as health (49,171).

Regarding the **type of migration**, there is strong evidence that current migration patterns related to coastal hazards are mainly internal (e.g. between islands) (163,164,166,172) and that future migration intentions focus on international destinations (172–175). Chen and Mueller (43) find that a slight increase in soil salinity is associated with higher internal migration while extreme salinity is associated with reduced international migration, potentially due to adaptations via new internal livelihood opportunities (e.g. shifts to aquaculture) that deter international migration as well as resource constraints (associated with agricultural income loss) than limit moves to short distances.

There is strong evidence that **adaptations** to coastal hazards, in the form of infrastructure development and livelihood adaptations, may reduce or otherwise affect migration. Modifying and strengthening housing structures (e.g. raising houses, building second stories, building stilted houses) (49,147,166,170,176–179), raising public infrastructures (e.g. schools, churches, roads) (180), and constructing seawalls and planting mangroves or other vegetation along coastlines (170,177,179–182) are commonly identified as adaptations to coastal flooding. Government-led infrastructure projects such as road elevation, floodgate construction, dyke construction, and installation of pumping systems are also identified as adaptation responses (49,178). Hauer et al. (183), in a secondary review, identify these as common adaptations, alongside beach replenishment. Other strategies involve livelihood modifications in response to saltwater intrusion, such as adjustment of agricultural practices (e.g. changing cropping locations) and transition from agriculture to aquaculture (43,179,181). It is worth noting here that adaptation to sea levels is a widespread and long-established global phenomenon, with an estimated 100 million people currently living below the high-tide line (184).

There is a medium body of high-quality evidence on patterns of **vulnerability** to migration in response to coastal hazards, although this evidence does not allow for the identification of clear patterns. For instance, studies on migration in response to increasing soil salinisation find variously that higher-income households are less likely to migrate owing to their greater capacity to diversify livelihood practices (37), and more likely to migrate as they have the resources needed to move (43). Individual studies find that younger people (144) and people engaged in ‘skilled’ manual occupations (165) and with higher levels of formal education (175) are more likely to migrate, likely due to greater ability to pursue employment opportunities elsewhere. A recent secondary review (183) reports that those most likely to migrate in response to coastal hazards are healthy, skilled, working-age adults who can move to higher-wage labour.

There is strong evidence on **barriers** to migration in response to coastal hazards and sea level rise, showing that financial constraints, attachment to community and place, and migration policies hinder migration intentions or decisions. 10 studies report that financial constraints

are barriers to mobility (163,164,174,185), with the poorest individuals and households being the least able to migrate (125,144,163,165,166,186). (Although financial constraints also limit the adoption of adaptation measures (166,176,177)). Emotional, cultural, and ancestral attachments and obligations to community and place are frequently identified as barriers to migration (49,147,162,164,166,167,170,173,178,179,181,187–194). Religious beliefs (e.g. that God will determine fates or will prevent or protect against environmental changes) also represent barriers to migration (162,164,173,193).

There is strong evidence that migration or visa policies influence migration decisions or intentions: migration criteria or visa restrictions (e.g. income, language, accompanying dependents) can impede current and future international migration (164,174,185), and migration or visa policies in destination countries also influence migration destinations in response to coastal hazards (162,169,170).

There is strong evidence that planned **relocation** or resettlement in response to existing coastal hazards and projected sea level rise represent both an adaptation response and a form of migration (144,158,168,179,181,182,190,192,194–203). Some studies examine factors associated with successful relocation processes, including consultation and community-led decision-making, government provision of land and support for services and industries, and relocation within customary territories (158,181,182,192,194,195,198,200,203). However, a recent secondary review (183) reports that sea level rise-related relocation policies ‘are still too abstract and lack guidance on ensuring equity’. There is strong evidence that such relocation projects can themselves contribute to secondary migration pressures. This may result from tensions over land access and ownership, and conflicts between ‘settler’ and ‘host’ communities, as well as the reproduction of socio-economic inequalities through the distribution of relocation benefits (e.g. housing, resettlement supports) and negative effects on livelihoods, service access, and social relations (144,168,182,190,196,199,201,202,204).

3.2.2 LONG-TERM TEMPERATURE CHANGES

There is a small body of high-quality evidence (three studies) on the relationship between long-term temperature changes and migration. However, as with sea level rise few studies examine existing or historical migration impacts. (Additional projection studies focusing on long-term temperature changes are discussed in Section 5.)

There are a number of studies of the links between long-term temperature changes and migration (as well as conflict and instability) within pre-industrial societies (205–208). These studies consistently find that periods of below average temperatures are associated with increased migration (and conflict). However, these findings are of limited present-day utility, both because they relate to long-term cooling processes, as against global warming; and because of the much enhanced economic and adaptive capacities of modern societies, compared to pre-industrial ones (209).

In addition to these historical studies, one study examines twentieth century long-term temperature-migration linkages, Cattaneo and Peri (210) finding that long-term warming between 1960 and 2000 was associated with increasing international migration from middle-

income towards non-OECD countries (with no significant effects on migration to OECD countries) and towards nearby destinations, and with higher internal urban migration in middle-income countries but lower internal migration in low-income countries. Though plausible, it is also possible that the patterns identified in this study reflect the influence of factors other than long-term warming.

A small body of moderate-quality evidence examines the impacts of warming-related **glacier retreat** on migration but reports no significant effect on migration (204,211).

3.2.3 LONG-TERM PRECIPITATION CHANGES

There is a small body of high-quality evidence (three studies) on the relationship between long-term precipitation changes and migration, showing that precipitation declines are associated with increased migration but identifying no clear trends in types of migration or associated vulnerabilities.

Changes in long-term precipitation patterns resulting from climate change may affect patterns of water availability and agricultural production, in turn contributing to out-migration. However, as with sea level rise and long-term warming, analysis of the links between long-term precipitation changes and migration poses acute analytical challenges. Long-term changes in precipitation are typically hard to identify, often being drowned out by the ‘noise’ of inter-annual and inter-decadal fluctuations. Moreover, declines in the availability of water resources are usually much more a consequence of local human activities (especially over-abstraction for human use, above all irrigation) than climate change.

A small body of high-quality evidence examines the impacts of long-term precipitation changes on migration, consistently showing that precipitation declines are associated with increased internal (85,212) and international (28) migration. Barrios *et al.* (212) find that declining precipitation is associated with increased internal migration toward urban areas only in sub-Saharan African countries and not in other low-income regions of the world, potentially due to the economic importance of rainfed agriculture. Beine and Parsons (28) find, similarly, that the effects of long-term precipitation changes on migration are stronger in countries more reliant on agricultural production (28).

Regarding **type of migration**, existing evidence focuses on either internal (85,212) or international migration (28), without considering their relative significance. Beine and Parsons (28) find that international migration associated with precipitation decline in the ‘global South’ mainly involves shorter-distance moves, e.g. to neighbouring countries. Two studies focus specifically on the association between precipitation changes and rural-to-urban migration (85,212). The reviewed studies do not explicitly discuss whether migration is temporary or permanent.

There is little evidence of patterns of **vulnerability** to current or future displacement or migration in response to long-term precipitation changes. One study finds that younger people are most likely to migrate in response to long-term precipitation changes (85). There is extensive literature on the impacts of changes in water availability on livelihoods and in turn

migration, but most of this relates to over-abstraction of water resources for irrigation and its consequences rather than climate change, so is not addressed in this review.

3.3 ENVIRONMENTAL PULL FACTORS

KEY FINDINGS

- While existing non-migration focused literature lends some support to the hypothesis that climate change may generate environmental incentives for in-migration, there is only a small body of evidence showing that people may migrate to areas with more favourable and stable climates.

In addition to causing or exacerbating out-migration pressures (pathways 1 and 2), climate change may also, we hypothesise, generate environmental incentives for in-migration to regions 'benefitting' (or projected to 'benefit') from it. Our reasons for considering this possible pathway are twofold. First, climate change is projected to have geographically highly uneven impacts, with some arid and semi-arid regions, for instance, being projected to experience significant increases in rainfall, and many northern latitudes and relatively cold regions being projected to see temperature rises that would increase agricultural productivity and other livelihood opportunities. Second, research on migration consistently emphasises the importance of both 'push' and 'pull' factors, such that it would be inappropriate, in our view, to only consider climate change as a push factor for migration.

Some literature, though not on migration directly, potentially lends support to this hypothesis. For instance, studies describe corporate and state land purchases motivated in part by concerns about climate change – often called 'land grabbing' or 'green grabbing' – concentrated in regions of relative resource abundance, often in areas projected to 'benefit' from climate change (213,214). Moreover, recent environmental security research identifies increasing interests and investments in the Arctic region, including its proto-militarisation, partly linked to, and in expectation of further, warming and ice retreat (215,216). These trends could, if continued, have significant migration implications. In addition, evidence points to the existence of 'lifestyle migration' from higher-income countries and associated labour demands (e.g. retirement migration and associated construction, care and hospitality), often motivated in part by climatic considerations (217–219).

That said, we have not identified any studies of climate change specifically generating or contributing to environmental incentives for in-migration. Only a small body of high-quality evidence (four studies) discusses environmental pull factors for migration, showing that people may migrate to areas with more favourable and stable climates. Bakaki (108), for example, finds both that high temperature shocks are associated with increased international migration, and that people experiencing such shocks are more likely to migrate toward countries with colder temperatures considered more 'environmentally safe'. Lewin *et al.* (54) find that temperature and precipitation fluctuations are associated with people moving to places where rainfall variability and drought probability are lower. Nguyen (101) finds that, in response to temperature fluctuations, there is increased migration toward destination regions with high precipitation, potentially because of favourable conditions for crop production and

farm employment. Similarly, van der Geest (220) finds that environmental ‘pull’ factors are more commonly identified than ‘push’ factors as reasons for migration in contexts of climatic changes, specifically areas perceived to have more attractive rainfall patterns and fertile land. These and other studies suggest that environmental variables may function as pull factors for migration, and that it may be mistaken to only consider environmental push factors. However, the evidence to this effect is limited and does not relate to climate change per se.

3.4 ADAPTATION AND MITIGATION POLICIES, PROJECTS AND INVESTMENTS

KEY FINDINGS

- Climate change adaptation measures relating to flood protection, coastal defence, dam building and agricultural development may involve displacement and contribute to broader migration pressures through the disruption to or loss of resource access and livelihoods.
- While existing literature not on climate change directly lends some support to the thesis that mitigation actions may contribute to migration, we have not identified any specific studies of this.

Climate change adaptation and mitigation measures may also, we suggest, cause or contribute to migration and displacement. Both adaptation and mitigation are likely to have wide-ranging economic and social consequences, some of which may serve as ‘push’ factors, and others as ‘pull’ factors for migration. Adaptation measures with potential migration implications include flood protection, coastal defence, land acquisition, irrigation, and dam-building programmes, as well as changes to agricultural and other rural livelihood practices. Mitigation developments with potential migration implications include reduced economic opportunities in fossil fuel producer regions and states (especially ‘rentier states’ with high levels of economic dependency on fossil fuel exports and revenues), increased economic opportunities in supplier regions of rare earth minerals required for ‘green technologies’, land purchases for renewable power generation, increased economic opportunities arising from green industrial development, and reforestation or afforestation initiatives.

Existing literature not focused directly on climate change suggests that adaptation and mitigation actions such as those above can have significant consequences for migration. For instance, studies highlight large-scale displacement as a result of mega-dam construction and the flooding of land behind them. The 2000 report of the World Commission on Dams (WCD 221) provides a great deal of such evidence, while McCully (222) estimates that 30-60 million people were displaced by dams between 1900 and 2000. Scudder (223) refers to those displaced by dams as ‘development refugees’. Studies also examine in-migration to and out-migration from oil and gas producer regions and states in response to both increases in production and prices, and negative price shocks (224,225). Such evidence provides reason to think, by analogy, that certain climate change adaptation and mitigation developments may have significant migration consequences.

There also exists a growing literature on ‘maladaptation’ which is relevant to this pathway, documenting how locally and internationally funded adaptation measures may have various

unintended negative environmental and social consequences, including reinforcing, redistributing, and creating new vulnerabilities (226–229). A recent review study (229) finds that climate change adaptation interventions such as hydroelectric dams, forest protection policies, flood protection initiatives, and agricultural development often reinforce existing vulnerabilities (e.g. exacerbating socioeconomic inequalities by benefiting elites while excluding marginalised groups) and introduce new risks and sources of vulnerability (e.g. undermining local adaptation strategies through impacts on land and resource access). Migration and/or displacement is one potential consequence of such ‘maladaptation’. Studies document, for instance, the impacts of large-scale land acquisitions, especially by the Gulf states, China and the US, which are undertaken partly for climate adaptation reasons and may have significant negative impacts on local land and water access, livelihoods, and food security (230–232). Recent studies also describe negative impacts (especially for Indigenous communities) of ‘green energy’ technologies such as wind and solar farms, including land access restrictions and dispossession, livelihoods disruption and violent responses to community opposition (233–238). While these studies do not examine implications for migration, the dynamics they describe might contribute to future migration pressures.

While the above is only indicative since these studies do not examine the migration impacts of climate change adaptation specifically, there already exists a large body of high-quality evidence (19 studies) that does. There is strong evidence that **relocations** associated with flood protection initiatives (160,161,199,239), coastal defence projects (240), and dam building (241–243) introduced as part of climate adaptation programmes may involve forced or coerced displacement and contribute to broader migration pressures through the disruption to or loss of resource access and livelihoods. For instance, Shinn *et al.* (161) report that relocation required for the development of a flood protection project in Botswana was enforced through threats by government authorities to withhold future flooding assistance. Narratives of ‘inevitable’ climate change impacts associated with coastal hazards and public safety may be used by government authorities to justify and encourage unpopular relocation initiatives (including long-standing resettlement plans) and forced removal (202,203,244). Similarly, the imposition of relocation policies as part of dam construction is rationalised through narrative representations, by government authorities and donors, of ‘resource scarcity’ (241) and of climate change impacts as ‘inevitable’ and relocation as necessary (242).

There is also strong evidence that **agricultural development projects** introduced as part of climate adaptation strategies can contribute to displacement and migration through pressures on land, water, and labour (227,245–251). Magnan *et al.* (227) find that the expansion of irrigated agriculture in dryland areas undermines local adaptive capacities by converting drought grazing land to private agricultural land, resulting in longer-distance seasonal migration. Adam *et al.* (246) find that climate adaptation projects involving irrigated cash crop production may contribute to overexploitation of water resources, exacerbate existing forms of inequality in land access, and contribute to migration pressures for marginalised communities (such as Indigenous communities). Paprocki (248–250) finds that in Bangladesh, commercial shrimp aquaculture promoted as an adaptation to climate change is directly contributing to out-migration through land encroachment, salinisation (due to intentional flooding of land) and loss of work opportunities (with shrimp aquaculture requiring 1 to 10%

the amount of labour as rice cultivation). Elsewhere, the implementation of smallholder adaptations (such as the introduction of drought-resistant crops or adoption of irrigation or water management technologies) may also provide access to resources necessary to engage in migration (247).

We have not identified any studies of the impacts of climate change **mitigation** on migration.

3.5 PERCEPTIONS AND NARRATIVES OF CURRENT AND FUTURE IMPACTS OF CLIMATE CHANGE

KEY FINDINGS

- Medium bodies of evidence show that perceptions of current and anticipated future climatic changes may independently contribute to migration, though these perceptions are influenced by livelihood dependence on the climate.
- Local experiences and attachments to place are often privileged over concerns about future climate change, suggesting that perceptions may, on balance, exert a downward impact on climate-related migration.
- A limited body of evidence shows that climate change narratives among authorities and elites may contribute to migration pressures.

A large body of high-quality evidence (83 studies) examines the effects of perceptions and narratives on the climate change-migration relationship, finding that these perceptions both contribute to migration pressures and decisions and present barriers to movement. Most of these studies focus on small island states and South and Southeast Asia, with others focusing the Bay of Bengal, East, West, and Southern Africa, Central and South America, East and West Asia, and global scales.

Perceptions and narratives may relate to either 'home' or migration destinations, they may influence or frame understandings of either threats or opportunities, and they may function as either 'push' or 'pull' factors (or both), either making migration more likely or deepening attachments to home. Research on these processes typically uses social science research methods (including surveys, interviews, and ethnographic research) to understand the views, meanings, assumptions and commitments of groups and individuals. Unlike scenario studies, this research does not provide a basis for making projections about levels of future climate change-related migration or displacement. It does, however, draw attention to key processes that shape migration, including climate- and environment-related migration.

There is medium evidence on the relationship between perceptions of **climatic shock events** and **short-term climatic variations** and migration, although findings are somewhat mixed. 51 studies (117–126,131,132,135,136,145,148,152–159,186,252–277) report that perceptions of current climate change impacts influence migration. While these studies do not examine impacts on migration levels (e.g. whether perceptions are associated with increased migration), respondents identify perceived (i.e. self-reported) climate-related and environmental changes – such as increased frequency of climatic shocks and short- or longer-term temperature or precipitation changes – as factors contributing to migration decisions or

intentions (although often secondary to socioeconomic motivations). Five studies find that perceptions of climatic shocks such as rainfall fluctuations (122,125,155,274) or increasing severity of floods (121) contribute to migration decisions even when they are *not* supported by existing data, suggesting that perceptions on their own can influence migration. In contrast, four studies report that perceptions of short- or long-term climatic changes do *not* significantly affect migration decisions (116,278–280). For instance, Shi *et al.* (278) find that perceived impacts of climate change on droughts, floods, and storms do not make migration more likely, as people are accustomed to the occurrence of climatic shocks.

A range of factors may influence perceptions of climate change impacts. These perceptions may be influenced by the degree to which livelihood are dependent on temperature and rainfall, with those involved in farming or herding more likely to perceive changes in precipitation and migrate in response (118,122,125,265). Perceptions of climate change impacts may also be influenced by access to water resources, with people with more limited access to irrigation and water-saving technologies being more likely to perceive adverse climate impacts and engage in migration or express migration intentions (148,273). Jha *et al.* (267) focus on sources of information, finding that perceptions of climate-related changes are shaped by information obtained via agricultural extension services (including meteorological information obtained from government sources, field officers, radio, television, and mobile sources), with migrating households more likely to have made use of these information services.

There is medium evidence on the effects of perceptions or narratives of **future sea level rise**, although findings are mixed. Seven studies show that perceptions of the potential impacts and threats of future sea level rise – such as coastal erosion, saltwater intrusion, and flooding – may inform future intentions to migrate, with respondents reporting that they would consider migrating in the future if coastal hazards – and impacts on property and livelihoods – intensify (162–164,174,175,177,193). Concerns about the potential impacts of sea level rise also influence future decisions regarding return migration (169). In contrast, two studies find that concerns about future sea level changes (167,188) are not significantly associated with migration decisions or intentions.

There is very strong evidence that **local experiences and attachments** to place are often privileged over concerns about future climate change, suggesting that perceptions may, on balance, exert a downward impact on climate-related migration. Emotional, cultural, and ancestral attachment to place and community and concerns about loss of culture and identity may be privileged over perceived climate-related changes, including short-term climatic fluctuations and sea level rise (139,164,167,170,172,173,175,186–189,191–193,259,261,277,279,281,282). For instance, Khanian *et al.* (282) find that perceived impacts of drought are shaped by people’s attachment to their surrounding environment (and associated aspects of identity), which inform subjective adaptive capacities and discourage migration. Attachments to place may be shaped by historical experiences of forced displacement, such as conflict-related displacement (283,284). Negative perceptions of potential destination areas (both urban and rural) based on perceived danger and socio-cultural differences also present barriers to climate-related migration (186,279). These

attachments and fears may be less significant for young people than for older people (186,266,279). Moreover, immediate experiences and observations may be privileged over external (e.g. policy or media) information about climate change effects or external narratives about 'crisis' (e.g. of sea level rise) may be downplayed, with people prioritising in-place adaptation and viewing movement as a last resort (167,192,285,286). Kelman *et al.* (167) find that local perceptions of climate change effects on sea level rise are determined by immediate experiences and locations rather than external information, with migration not considered a priority due to attachment to home, irrespective of observed or potential climate change impacts.

A small body of high-quality evidence consistently shows that broader 'climate migration' **narratives** may contribute to migration pressures. In studies of Bangladesh, Paprocki (248–250) describes policy narratives that present 'rural decline' and 'uninhabitable rural spaces' as the inevitable consequences of climate change, by contrast with desirable 'urban futures'. Urban visions of climate adaptation and resilience (framed as opportunities for economic growth) are tied to the devaluation of rural agrarian livelihoods to encourage relocation, and in turn contribute to out-migration toward urban and peri-urban areas. Hermann and Kempf (287) find that government adaptation initiatives, such as large-scale land purchases for future relocation in response to sea level rise, can influence public perceptions of future migration options by 'making migration imaginable'.

4.0 EVIDENCE REVIEW FINDINGS: COUNTRIES AND REGIONS

The following sections synthesise existing evidence on four regions: small island states, the Bay of Bengal, arid and semi-arid regions in East Africa, and the Sahel. For each of these regions, we examine the main pathways and sub-pathways covered in the reviewed studies and associated types of migration, as well as the vulnerabilities and barriers to displacement and migration, and potential adaptations. Small island states and the Bay of Bengal are the focus on the largest number of studies, while East Africa and in particular the Sahel have received less attention. As discussed in Section 1.3, the focus on these regions does not mean they will be the ones most affected by climate-related migration.

4.1 SMALL ISLAND STATES

KEY FINDINGS

- There is no evidence so far of global climate change-induced sea level contributing to migration, though there is limited evidence of storms and droughts doing so.
- Perceptions and narratives of climate change can influence migration decisions and intentions – though immediate experiences and observations may be privileged over external narratives.
- Adaptation measures, primarily infrastructure developments responding to coastal hazards and sea level rise, may reduce migration.
- Relocation in response to coastal hazards in small island states can represent both an adaptation response *and* a form of migration.

A large body of high-quality evidence (37 studies) examines the relationship between climate change and migration in small island states. Most of these studies focus on Pacific states, including Fiji, the Solomon Islands, Vanuatu, Kiribati, the Marshall Islands, Nauru, and Tuvalu, with one study focusing broadly on Pacific island states. Smaller numbers of studies focus on the Maldives and Caribbean island states. The main pathways addressed in these studies concern sea level rise, with a smaller number of studies examining the contributions of climatic shocks.

4.1.1 CLIMATE-MIGRATION PATHWAYS

There is a large body of high-quality evidence on the relationship between **sea level rise** and migration in small island states (accounting for most studies on the region). However, while these studies discuss past and ongoing relocation initiatives in response to coastal erosion and flooding in Fiji (181,194,195,198) and Papua New Guinea (190,200), or how coastal hazards might contribute to migration pressures (162–164,169,170), they do not provide evidence of sea level rise per se contributing to increased migration. Moreover, while these studies are often framed as examining the impacts of sea level rise on migration, coastal flooding, storm

surges, erosion, and saltwater intrusion are not necessarily attributable to human-induced climate change.

Only one reviewed study specifically examines the impacts of **storms** on migration in small island states. Spencer and Urquhart (58) find a positive association between hurricanes and international migration in Caribbean island states, with more damaging storms having a greater impact on migration through impacts on agricultural livelihoods and income and household property. They report the highest rates of migration for the average hurricane as occurring in Barbados and Dominica, potentially due to lower GDP per capita impeding coping in place (58).

A small body of moderate-quality evidence consistently shows that **drought** contributes to migration pressures in small island states via negative effects on agricultural and fishing production and income (163,169,288). In Kiribati, drought is associated with increased short-distance migration between more central islands but decreased migration between more geographically isolated islands and central islands, likely by depleting resources needed to support longer-distance moves (288). While the above studies identify relationships between climate-related factors and migration pressures in small island states, these and other studies consistently show that climate-related factors are not frequently identified as reasons for migration, and that existing migration decisions are instead tied primarily to employment opportunities, education and better access to services (162–164,169,172–175,188,191).

There is strong evidence that **perceptions** influence relationships between climate change and migration in small island states, although in contrasting ways. Studies of Kiribati (164,193), Tuvalu (162,163,193), Nauru (174,193), Tonga and Samoa (177), and the Maldives (175) find that perceptions of future sea level rise may generate intentions to migrate in future. One study of Kiribati finds that most respondents feel migration will be necessary if sea level rise, saltwater intrusion and flooding become more serious and affect agricultural yields (164). Similarly, in Tuvalu, Milan *et al.* (163) find that most respondents feel that migration will be necessary if sea level rise, saltwater intrusion and flooding worsen. A study of migration from the Marshall Islands (169) reports that concerns about the impacts of sea level rise also influence future decisions regarding permanent *return* migration from the US.

However, there is also strong evidence that attachment to place and community, as well as religious beliefs and historical experiences, exert a downward impact on climate-related migration in small island states. Studies of Kiribati (164), Tuvalu (162,173,187,189,193), Fiji (179,181,194), Vanuatu (170,192), the Solomon Islands (188), the Maldives (167,191), Papua New Guinea (190), and Mauritius (277) show that emotional, cultural and ancestral attachments to community and place (including sacred areas and burial grounds), community obligations, and concerns about loss of culture and identity are barriers to migration in response to projected sea level rise. Studies of Kiribati (164) and Tuvalu (162,173,193) also identify religious beliefs (e.g. that God will determine fates or will prevent or protect against environmental changes) as barriers to migration. Bordner *et al.* (283) suggests that historical experiences of displacement may also inform resistance to migration in response to climate-related changes, with migration perceptions in the Marshall Islands informed by histories of

forced displacement to the nuclear testing by the US in the 1940s-50s and a commitment to maintaining national sovereignty and identity.

There is strong evidence on the effects of **narratives** on the relationships between climate change and migration in small island states, showing that external narratives about climate change effects can influence migration decisions or intentions or legitimise relocation initiatives – but that immediate experiences and observations may be privileged over these narratives. A study of north-western Tuvalu (289) finds that narratives about impeding climate risks and potential relocation have undermined government investments in infrastructure (e.g. water systems) in the region, in turn contributing to migration pressures and decisions. Hermann and Kempf (287) report that the Kiribati government’s land purchase in Fiji has influenced public perceptions of future migration by ‘making migration imaginable’ due to perceived possibilities for maintaining community solidarity and cultural identities through relocation to culturally significant land.

Immediate experiences and observations, however, may be privileged over external information or narratives about climate change effects. Arnall and Kothari (286) describe differences in perceptions of the timescale and urgency of climate change-related migration between elites (e.g. officials, policy-makers) and non-elites in the Maldives, finding that non-elites often downplay the ‘crisis’ of sea-level rise, *reducing* the likelihood of climate-related migration. A study of ‘climate refugee’ narratives in Tuvalu (285) shows that in contrast to government narratives centred on vulnerability and displacement due to climate risks, civil society narratives emphasise the need for support for adaptation (e.g. public services and facilities), prioritising in-place adaptation and viewing migration or relocation as a last resort. A study of the Maldives (167) shows that local perceptions of climate change effects on sea level rise are determined by immediate experiences and locations rather than by external (e.g. government, media) information. And Perumal (192) describes a widespread refusal to accept the language of ‘climate refugee’ in Vanuatu, with people prioritising in-place adaptation, emphasising community control over movement, and viewing resettlement as a last resort.

4.1.2 MIGRATION DESTINATIONS AND DURATION

There is medium evidence that current climate-related migration patterns in small island states are mainly internal, primarily in the form of migration between islands or atolls while future migration intentions focus on international destinations. For instance, in Tuvalu, climate-related factors (e.g. drought, sea level rise) are more commonly identified as reasons for internal migration than for international migration, and that most current migration associated with climate-related factors is toward the capital island (163). Similarly, in Kiribati the capital island is the main destination for current climate-related migration (164). In contrast, four studies show that *future* migration intentions associated with climate change (e.g. sea level rise), on the other hand, focus mainly on international destinations (172–175). For instance, studies of Nauru (174) and the Maldives (172,175) find that future migration intentions associated with climate change focus on international migration, mainly toward larger countries in the region (e.g. Australia). Three studies focus specifically on international migration, reporting that migration destinations in response to climate-related pressures are

informed by migration or visa policies in destination countries such as New Zealand, Australia, or the US (162,169,170).

4.1.3 VULNERABILITIES AND BARRIERS

While few studies examine **vulnerabilities** to climate-related migration in small island states, a small body of moderate-quality evidence consistently shows that in atoll states outer islands are most exposed to climate-related risks (163,164,288). For instance, in Tuvalu the impacts of saltwater intrusion, flooding and storm surges, and associated migration pressures, are strongest on the outer islands (163). At the same time, these outer islands may face greater barriers to migration. In Kiribati, drought is associated with decreased migration between more geographically isolated islands and central islands, likely by depleting resources needed to support longer-distance moves from more isolated islands (288).

There is strong evidence that financial constraints are key **barriers** to migration in response to climate-related hazards in small island states. Studies of Tuvalu (163) and Kiribati (164) find that financial constraints impede current mobility in the face of climate-related pressures, while a study of the Solomon islands identifies high transport costs as a barrier (188). A study of Kiribati (164) finds that the poorest and wealthiest are more likely than other income groups to move for reasons associated with climatic changes. Studies of Vanuatu (170) and Fiji (179) identify concerns about livelihoods as barriers to relocation or migration in response to climate change. And studies of Tuvalu (163), Kiribati (164), Nauru (174), and Tuvalu and the Marshall Islands (185) find that a lack of financial resources and visa restrictions present barriers to anticipated *future* migration in response to climate-related changes.

4.1.4 ADAPTATIONS

There is strong evidence that adaptations, primarily infrastructure developments responding to the effects of sea level rise, can reduce or otherwise affect migration in small island states. Adaptation measures identified in studies of Fiji, Tuvalu, Vanuatu, Samoa and Tonga include constructing seawalls, planting coral gardens, and planting mangroves or other vegetation along coastlines to manage erosion (170,177,179,181,182), modifications to housing structures (such as elevating houses), materials, and locations (163,164,170,177,179), and livelihood modifications such as adjustment of agricultural practices (e.g. changing cropping locations or crop types) and diversification of fishing practices (e.g. types of catches) (179,181). In Tuvalu, adaptations to drought include water management strategies such as expanding water storage capacity by building new water tanks and cisterns, digging wells, water budgeting, and resorting to bottled water (177). The adoption of such measures may be impeded by financial limitations (177) (although this challenge is likely more widespread in low-income countries) and may be financed by migrant remittances (e.g. from labour or seasonal migration) (164,170).

There is very strong evidence that past, ongoing, and planned **relocation** initiatives in response to coastal erosion and flooding in small island states represent both an adaptation response and form of migration, as described in studies of Fiji (179,181,194,195,198,201,203), Vanuatu (192), and Papua New Guinea (190,200). These studies examine factors associated

with successful relocation processes, discussed in Section 3.2.1 There is also evidence of maladaptation: studies of Fiji (203) and the Maldives (244) show that narratives of ‘inevitable’ climate change impacts and public safety are used by government authorities to justify and promote unpopular relocation initiatives (including long-standing resettlement plans).

4.2 BAY OF BENGAL

KEY FINDINGS

- A limited body of evidence shows that short-term temperature fluctuations and salinisation are associated with increased migration in the Bay of Bengal, whereas evidence on the impacts of flooding, storms and short-term precipitation fluctuations on migration is unclear or inconsistent.
- Evidence on the impacts of gender, income and agricultural livelihoods on climate-related migration is inconsistent.
- A limited body of evidence shows that insufficient or inadequate government support may present barriers to migration and return.
- Adaptations to climate-related changes through changes in agricultural practices can reduce migration pressures in the Bay of Bengal, though there is limited evidence that maladaptation, most notably through commercial aquaculture, may also contribute to migration.

A large body of high-quality evidence (40 studies) examines the relationship between climate change and migration in the Bay of Bengal. Most of these studies focus on Bangladesh, with a smaller number of studies focusing on southern India. None of the identified studies examine relationships between climate change and migration in Burma. The main pathways addressed in these studies are climatic shocks, especially flooding, storms and short-term climatic fluctuations, and long-term changes, specifically sea level rise, with smaller numbers of studies focusing on maladaptation and perceptions and narratives.

4.2.1 CLIMATE-MIGRATION PATHWAYS

A large body of high-quality evidence examines the relationship between **flooding** and migration in the Bay of Bengal, although findings are inconsistent: three studies find that floods are associated with decreased internal (35,38) and international (37) migration, and two report weak or inconsistent effects on migration decisions and intentions (39,43). For instance, a study of south-central Bangladesh (38) finds that migration declines immediately after flooding but soon (i.e. beyond the month of occurrence) returns to normal levels, while a study of rural Bangladesh (39) finds that flooding is associated with increased local migration but decreased long-distance internal or cross-border movement, and only for women and the poor. Mechanisms linking floods and migration in the Bay of Bengal echo those described in Section 3.1.1: flooding contributing to migration pressures via damage to or loss of property and livelihoods (45–48,50) while potentially reducing migration by depleting household resources (35,37,39) or via benefits to remaining in place (e.g. improved soil quality and yields) (35,37). In areas more exposed to flooding, households may already have adapted to flood

patterns: a country-level study of Bangladesh (35) finds no significant correlation between flooding and migration in high river density areas, potentially because households have adapted to seasonal flooding patterns and may not perceive these events as shocks.

A medium body of moderate-quality evidence examines the impacts of **storms** (e.g. cyclones, typhoons) on migration in the Bay of Bengal, showing that storms can contribute to migration pressures but providing no evidence of associations with increased migration. Storms may contribute to migration pressures via damage to or destruction of household property, land, crops and income (55,65,66). Kartiki (55) finds that recurrent storms may contribute to migration pressures by 'wearing down' household coping and adaptation capacities, and that a lack of sufficient and adequate local storm response provisions for temporary relocation (e.g. insufficient and inadequate emergency shelters, sanitation facilities, and humanitarian relief) may further contribute to migration pressures. Additionally, studies of 'climate induced' or 'disaster induced' migrants in Dhaka, Bangladesh (46,290) find that most report being displaced by storms, floods and erosion (based on self-reports rather than an analysis of displacement data) and resulting damage to or loss of property, land, crops, and livelihoods.

A small body of high-quality evidence consistently shows that short-term **temperature** fluctuations are associated with increased migration in the Bay of Bengal. Hot seasons and hot years (38,89) and shorter warm spells (82) are associated with increased migration in Bangladesh, due to negative impacts on agricultural yields, producer revenues, household income, and workers' wages (38,89).

A medium body of high-quality evidence examines the impacts of **precipitation shocks** on migration in the Bay of Bengal. Findings are inconsistent, however, potentially due to regional socio-economic factors. One study finds that low rainfall is associated with increased migration in south-western Bangladesh (82). In contrast, a study of south-central Bangladesh (38) finds that precipitation shocks are associated with reduced migration due to impacts on income both when crops are stunted by insufficient rainfall and when drowned by excess rainfall. The impacts of precipitation shocks on both migration pressures and constraints in the Bay of Bengal echo those discussed in Section 3.1.4 (38,89,116,132). Broader socio-economic factors may also influence the effects of precipitation variability on migration: a study of north-west Bangladesh (116) finds that economic differences between regions, including higher social inequality and food insecurity in regions of origin and structural economic differences between remote rural areas, wealthier agricultural regions, and urban centres, affect migration decisions in response to precipitation variability.

A small body of high-quality evidence consistently shows that **salinisation** contributes to increased migration in the Bay of Bengal, via negative effects on farmland, agricultural production and revenues, and groundwater. A study of south-western coastal Bangladesh (171) finds that drinking water salinisation is associated with increased migration, and two other studies (37,43) find that while inundation alone has insignificant or negative effects on migration in coastal areas of Bangladesh, increasing soil salinity is associated with higher internal migration via impacts on crop production and revenues. It should be noted that salinisation may be caused by storms, local subsidence, irrigation practices and intentional flooding (e.g. for shrimp farming), as well as sea level rise resulting from climate change.

A small body of high-quality evidence consistently shows that **maladaptation** contributes to migration pressures in Bangladesh. Paprocki (248–250) finds that in southern coastal Bangladesh, commercial shrimp aquaculture promoted as an adaptation to climate change is directly contributing to out-migration through land encroachment, salinisation (the intentional flooding of land) and loss of work opportunities (shrimp aquaculture requires 1 to 10% the amount of labour as rice cultivation).

There is strong evidence that **perceptions and narratives** of climate change can contribute to both migration pressures and barriers in the Bay of Bengal. A study of coastal areas in Bangladesh and India (272) shows that perceived increases in drought severity are associated with reduced future migration intentions, while perceived changes in rainfall predictability are associated with increased migration intentions in Bangladesh but reduced migration intentions in India. Climate narratives also contribute to migration pressures, as described by Paprocki's (248–250) studies of climate adaptation in Bangladesh, discussed in Section 3.5. Two studies find that attachment to place and emotional ties to community are important barriers to migration in response to climatic shocks such as flooding (48) and short-term weather fluctuations (139) in Bangladesh.

4.2.2 MIGRATION DESTINATIONS AND DURATION

A large body of high-quality evidence examines destinations of climate-related migration in the Bay of Bengal, although findings are somewhat inconsistent. Five studies find that migration in response to flooding and storms (39,47,50,55,66) and short-term precipitation variability (116,132) is mainly internal rather than international (although most reviewed studies on the region focus only on internal migration). In a study of coastal areas in Bangladesh, Chen and Mueller (43) find that a slight increase in soil salinity is associated with higher internal migration while extreme salinity is associated with reduced international migration, as discussed in Section 3.2.1. However, their later study (37) find that increasing soil salinity is associated with increased *international* migration from coastal Bangladesh. A study of Bangladesh (257) finds that migration destinations (internal or international) in response to temperature and rainfall fluctuations, riverbank erosion, and flooding vary widely across districts and villages, although they do not examine the reasons for this. Rahman *et al.* (66) report that international migration from Bangladesh in response to climatic shocks may be impeded by challenging terrain and presence of security forces along borders with India and Myanmar.

A medium body of high-quality evidence examines internal migration destinations in the Bay of Bengal, although findings on whether climate-related migration is primarily toward rural or urban areas are inconsistent. Four studies suggest that migration in response to flooding (39,47) and short-term climatic fluctuations (38,82) is mainly toward urban areas. In contrast, four studies find rural-to-rural migration to be more significant. Chen and Mueller (43) find that migration associated with increasing soil salinity in coastal Bangladesh is mainly to other rural areas. Similarly, studies of north-west Bangladesh (116,132) find that migration associated with precipitation variability occurs mainly between rural areas, particularly among members of lower-income groups seeking work as agricultural wage labourers in other

regions. And a study of riverine islands in three districts in northern Bangladesh (291) finds that most migration takes places between neighbouring islands.

There is strong evidence that movement in response to climatic shocks in the Bay of Bengal primarily takes the form of temporary evacuation or short-term internal migration (38,47,48,50,55,64,116,132,135,136,292,293). Studies of coastal Bangladesh (61,62) find that a 2013 cyclone did not result in large-scale permanent changes in population distribution; instead movement mainly entailed evacuation ahead of the storm, on the basis of storm forecasts, and temporary movement (likely to shelters) during the storm. A district-level study of north-eastern Bangladesh (292) finds that the loss of crops and livestock due to riverbank erosion and flooding is associated with increased temporary migration, while the loss of assets (e.g. home, property) is associated with permanent migration – that is, more temporary losses are associated with temporary moves and more permanent losses with permanent moves. Two studies of long-term, enduring changes such as salinisation (37,43) focus on permanent migration, but without considering whether migration is more likely to be temporary.

There is strong evidence (from Bangladesh) that family, community, and migrant networks inform migration decisions and facilitate migration processes in response to climatic shock events, by providing access to information and resources needed to move (47,55,66,82,257,292,293).

4.2.3 VULNERABILITIES AND BARRIERS

There is a large body of high-quality evidence on **gendered vulnerabilities** to displacement and migration associated with climate-related pressures in the Bay of Bengal, although findings are inconsistent. 10 studies of Bangladesh show that men are more likely to move due to climatic shock events (38,47,48,64,82,132,139) while women are most likely to be ‘trapped’ (38,55,141,142). For instance, men may migrate to seek economic opportunities due to loss of agricultural and other income while women may for the same reasons lose the opportunity to migrate for education or marriage (38). Gendered social norms and fear of harassment also constrain women’s migration (132). Studies of coastal Bangladesh (141,142) find that gendered distinctions between safe and unsafe spaces (e.g. shelters) and gendered knowledge of and influence over disaster preparedness and response are barriers to women’s movement in response to storms. In contrast, three studies of Bangladesh find that women are more likely to move in response to climate-related shocks (39,292,294). A study of north-eastern Bangladesh (292) finds that women are more likely to migrate temporarily in response to riverbank erosion and flooding, with women’s migration viewed as a temporary household survival strategy. Other reasons identified for women’s migration include less secure access to land and thus more limited ability to adapt to the effects climatic shocks on agricultural income (39) and gendered segregation of urban labour markets that allow for more stable incomes for women (e.g. garment work) (294). A small body of high-quality evidence consistently shows that **younger** people are more likely to migrate in response to climatic shock events in the Bay of Bengal (47,292).

There is strong evidence that **financial constraints** represent both migration pressures and barriers in the Bay of Bengal. Five studies show that poorer households are more likely to

migrate in response to climate-related shocks (39,116,132,139,295). In contrast, five studies find that wealthier individuals or households are most likely to move in response to climatic shocks (37,38,47) while the poorest households are the least able to move (116,132). Call *et al.* (38) find that wealthier households are more likely to send migrants in response to negative rainfall shocks in south-central Bangladesh and less likely to send migrants during periods of high rainfall, pointing to greater adaptive flexibility associated with greater financial resources and lower likelihood of involuntary migration. Studies on migration in response to increasing soil salinisation in coastal Bangladesh find that higher-income households are less likely to migrate, potentially due to their increased capacity to diversify livelihood practices (37), but that they may also be more likely to migrate as they have the resources needed to move (43). A study of north-western Bangladesh (296) finds that landless households and those facing seasonal income poverty are more likely to engage short-term (rather than long-term) migration, with migration serving as a (seasonal) livelihood diversification strategy. Similarly, a study of south-western Bangladesh (293) finds that migration in response to climate-related shocks among poor and extremely poor groups is most likely to be unplanned and in search of subsistence, while lower-middle class groups are more likely to migrate for income generation, and wealthier groups have the greatest choice over migration decisions.

There is medium body of high-quality evidence on the impacts of **occupation** on climate-related migration in the Bay of Bengal, although findings are inconsistent: four studies find that the effects of temperature and precipitation fluctuations on migration are strongest for households involved in agricultural livelihoods (82,116,132,292), while one study finds that effects are stronger for members of non-farm households or individuals working outside the agricultural sector (e.g. in small shops, construction, or manufacturing), potentially due to greater economic flexibility (47).

A small body of high-quality evidence consistently shows that insufficient or inadequate government support and responses are **barriers** to migration and return. A study of riverine islands in northern Bangladesh (291) reports that exclusion from government and NGO training services on environmental awareness, disaster preparedness, income generation, etc. (potentially due to geographic isolation) contributes to vulnerability to climatic shock events and limits possibilities for in-place adaptation, in turn contributing to migration decisions. Another study of Bangladesh (48) finds that barriers to migration include a lack of information and assistance from authorities, including specific government provisions (e.g. compensation) for displacement by 'natural disasters'. Studies of temporary evacuation in response to flooding and storms identify shortfalls in government provision of shelters and other crisis infrastructure (48,64). For instance, Ingham *et al.* (48) identify a lack of planning for mobility of livestock, central to local livelihoods, as a barrier to temporary evacuation in Bangladesh, noting that evacuation plans are made at the central government level with a lack of knowledge of local circumstances and needs. Barriers to return migration include lack of government support for rebuilding infrastructure and difficulties in establishing land rights, and that systemic gendered inequalities in land tenure and land claim processes present a particular barrier to return for women following displacement (48).

4.2.4 ADAPTATIONS

A large body of high-quality evidence examines **adaptations** to climatic shocks and salinisation – notably modifications of agricultural livelihoods – in the Bay of Bengal, although findings are inconsistent, with adaptations both reducing and contributing to migration pressures. Adaptation measures include modification of agricultural practices (e.g. adjusting cropping patterns and planting dates, adopting new rice varieties, increasing dependency on livestock) (45,135,136,139,154,159,295), and shifts from farming to fishing or aquaculture (43,45,257) or to non-agricultural livelihood activities or income sources (45,135,136,139,154,159,295). Wealthier households are more likely to have alternative income sources and are better able to pursue in-place adaptation measures, and thus may be less likely to move, while a lack of financial resources can limit the adoption of such measures (116,132,135,136,139,159). Other adaptation strategies include the construction of embankments or dykes intended to prevent the inundation of farmland or grazing land (48,50) and modification of housing structures (50). Some of these adaptation strategies may be maladaptive, and themselves contribute to migration, such as commercial aquaculture projects (248–250) discussed in Section 3.4.

4.3 EAST AFRICA

KEY FINDINGS

- A limited body of evidence shows that short-term temperature fluctuations are associated with decreased migration in East Africa, while evidence on the impacts of drought and short-term precipitation fluctuations is mixed.
- While a limited body of evidence shows that younger people are more likely to migrate in response to climatic shocks, evidence on the impacts of gender, income and education on the climate-migration relationship are mixed or inconsistent.
- Adaptations to climate-related changes can both reduce migration pressures and generate resources needed to move, and there is limited evidence that maladaptation, especially land acquisitions for climate adaptation-related agricultural development, may contribute to displacement and migration.

A large body of high-quality evidence (20 studies) examines the relationship between climate change and migration in East Africa. These studies focus on Ethiopia, Kenya, and Tanzania (studies identified for this review did not cover other countries in the region), or on multiple countries in the region (though not only arid and semi-arid areas). The main pathways addressed in these studies concern climatic shocks, mainly drought and short-term climatic changes, while a smaller number of studies focus on maladaptation.

4.3.1 CLIMATE-MIGRATION PATHWAYS

A small body of high-quality evidence examines the relationship between **drought** and migration in East Africa, although findings are mixed. Two studies find that longer, more intense and more frequent droughts are associated with increased internal and international

migration in Ethiopia (69,71). In contrast, Ocello *et al.* (36) find that drought is associated with decreased internal migration in Tanzania. A study of the East Africa region (including Eritrea, Ethiopia, Somalia, South Sudan, and Kenya) (67) finds that drought has weak or inconsistent effects on internal and international migration. Mechanisms linking drought and migration pressures and constraints in East Africa echo those described in Section 3.1.3 (36,69,71). Only two reviewed studies (36,51) examine the impacts of **flooding** on migration in East Africa. While floods may contribute to migration pressures through damage to land property (51), Ocello *et al.* (36) find that flooding is associated with decreased internal migration in Tanzania.

A small body of moderate-quality evidence consistently shows that short-term positive **temperature** fluctuations and extremes are associated with decreased migration in East Africa. Studies of Kenya (112), Tanzania (94) and the wider East Africa region (100) show that temperature fluctuations are associated with reduced migration, likely because negative impacts on agricultural income impede the ability to finance migration. A small body of moderate-quality evidence examines the impacts of short-term **precipitation** fluctuations on migration, although findings are mixed. Three studies find that precipitation fluctuations are associated with increased migration: studies of Tanzania (86,256) find that low rainfall is associated with increased migration, while a study of northern Ethiopia (107) reports that longer rainfall seasons are associated with increased migration, with favourable weather conditions facilitating agricultural production and thus increasing household resources and in turn migration ability (but only in combination with family migration networks, which reduce migration costs and risks). In contrast, two studies find that precipitation fluctuations are associated with *decreased* migration: a study of multiple East African countries (111) finds that negative rainfall fluctuations are associated with decreased internal migration, while a study of Kenya (100) finds that precipitation increases are associated with reduced internal migration as a result of increased local employment opportunities.

A small body of high-quality evidence consistently shows the season- and location-related effects of rainfall and temperature variations on migration. A study of central Ethiopia (297) finds that high rainfall during the long rainy season is associated with increased migration the following year, while high rainfall during the short rainy season is associated with reduced migration the following year, potentially due to differential impacts on agricultural production. The impacts of short-term weather fluctuations on migration may also be related to particular combinations of temperature and precipitation changes: a study of Kenya (112) finds that cool temperatures combined with high precipitation, conditions beneficial for agriculture, are associated with internal labour-related migration among men.

4.3.2 MIGRATION DESTINATIONS AND DURATION

There is medium evidence that climatic shocks are associated with internal migration in East Africa, although evidence on internal destinations is mixed. Five studies of Ethiopia (71,252), Kenya (51,112) and Tanzania (122) find that climatic shocks are associated more with internal than international migration (although most studies examining the relationships between climatic factors and migration in East Africa focus only on internal migration). While two studies of Kenya and Tanzania (51,122) find that most migration in response to flooding and

rainfall variability occurs between rural areas, Mueller *et al.* (111) find that climatic anomalies in the region are associated with decreased migration from urban areas but do not significantly affect rural out-migration.

A small body of moderate-quality evidence consistently shows that climatic shocks are associated mainly with temporary migration in East Africa, as reported in studies of Ethiopia (71), Kenya (51), Tanzania (122), and the wider region (111,252) (although most studies do not directly examine whether migration in the region is temporary or permanent). Afifi *et al.* (252), in a study of displaced communities in Ethiopia and Uganda, find that while permanent relocation in response to climatic variability was rare, the poorest people were more likely to relocate permanently (though internally).

4.3.3 VULNERABILITY AND BARRIERS

A small body of moderate-quality evidence examines the **gendered** dimensions of vulnerability to climate-related migration in East Africa, although findings are mixed. Four studies find that men are more likely than women to move in response to drought (69) and short-term temperature and precipitation fluctuations (100,112,122) in East African contexts. For instance, in Ethiopia drought is associated with increased labour migration among men but decreased marriage-related migration among women, potentially due to limited ability to finance wedding expenses and new household formation (69). In contrast, a study in Tanzania (94) finds that temperature shocks reduce migration among men while migration among women is largely unaffected, potentially because women's migration is more likely to be linked to marriage and family than to income-seeking. A small body of moderate-quality evidence consistently shows that **younger** people are more likely to migrate in response to flooding (36) and short-term climatic fluctuations (100,107,122) in East Africa.

A medium body of moderate-quality evidence examines the impacts of **income** or **wealth** on climate-related migration in East Africa, although findings are inconsistent. Two studies of Ethiopia find that people from poorer (e.g. land-poor or landless, low financial resources) households are more likely to migrate in response to drought and rainfall fluctuations (69,254). In contrast, two studies of Ethiopia (297) and Tanzania (256) find that wealthier households are more likely to have migrant members. For instance, a study of north-eastern Tanzania (256) finds that large farmers and landless households have higher numbers of migrants than small or medium farmers, with wealthier households having the means to move in response to rainfall variability and the poorest households facing the greatest pressures to move. In another study of Tanzania, however, Liwenga *et al.* (122) find that medium and large farmers are most likely to migrate and landless households the least likely to move, possibly due to an inability to afford the costs of migration. Kubik and Maurel (86), in another study of Tanzania, find that weather shocks are associated with increased migration only for middle-income households, and for those whose income is dependent on agriculture.

A small body of moderate-quality evidence examines the impacts of **education** on climate-related migration in East Africa, although findings are mixed. While a study in Tanzania (36) finds that people with no or low levels of formal education are more likely to migrate in response to flooding and drought, a study in Kenya (100) finds that having at least primary

education doubles the odds of migration in response to climatic fluctuations relative to those without formal education. Individual studies point to certain other factors as being associated with greater vulnerability to migration in response to climatic shocks in East African contexts, including larger household size (69,297) and unmarried status (100).

4.3.4 ADAPTATIONS

A medium body of high-quality evidence examines the impacts of **adaptations** to climate-related pressures, especially drought, on migration in East Africa, although findings are inconsistent, showing that adaptation measures can both reduce migration pressures *and* generate resources needed to move. Adaptation strategies in Ethiopia, Kenya, and Tanzania echo those described in Section 3.1.7, including modifications to agricultural or herding livelihoods (122,252,297,298) and involvement in non-agricultural work (51,71,107,122,252,256,297). Other studies suggest that some adaptation mechanisms may function to generate the resources needed to move. For instance, a study of central Ethiopia (297) finds that while adoption of crop diversification is associated with lower incidence of migration in the following year, involvement in non-farm livelihood activities is associated with a higher incidence of migration. Similarly, a study of northern Ethiopia (107) finds that non-farm in-place income activities are associated with increased migration by increasing household resources and thus migration ability – but only in combination with family migration networks, which reduce costs and risks of migration.

A small body of high-quality evidence consistently shows that **maladaptation** – specifically in terms of land acquisitions for agricultural development – may contribute to displacement and migration in East Africa. Magnan *et al.* (227) find that the expansion of irrigated agriculture north-eastern Ethiopia, associated with climate change adaptation efforts, undermines local adaptive capacities by converting drought grazing land to private agricultural land, resulting in longer-distance seasonal migration. In Tanzania, large-scale land acquisitions for adaptation-related agricultural development have been found to contribute to migration pressures due to loss of farmland (251).

Migration and local adaptations may function as complementary rather than substitutive protection mechanisms: a county-level study of northern Kenya (298) finds that remittances from migrant household members enable the adoption of new adaptation measures – especially high-cost adaptations such as the purchase of drought-tolerant livestock – in response to climatic shocks. Similarly, a study of north-eastern Tanzania (122) finds that migrant remittances support diversification of livelihood strategies in response to rainfall fluctuations. A study of multiple countries in East Africa (281) finds that provision of cash transfers can reduce the need to migrate in response to climate-related changes such as drought, including by supporting diversification of livelihoods.

4.4 THE SAHEL

KEY FINDINGS

- The body of (English-language) evidence on the relationship between climate change and migration in the Sahel is much smaller than for the other regions.
- Evidence on the impacts of short-term temperature and precipitation fluctuations on migration, on destination and duration, and on the social profile of migrants is generally mixed or inconsistent.

A large body of high-quality evidence (10 studies) examines the relationship between climate change and migration in the Sahel, focusing on Burkina Faso, Mali, and Senegal, with smaller number of studies focusing on northern Nigeria (the studies identified for this review did not cover other countries in the Sahel region). The main pathways addressed concern the impacts of short-term weather changes. Overall, the body of evidence on the relationship between climate change and migration in the Sahel is much smaller than for the other regions (although this may be in part due to the exclusion of French-language studies on the region).

4.4.1 CLIMATE-MIGRATION PATHWAYS

A small body of moderate-quality evidence examines the relationship between short-term **temperature** fluctuations and migration in the Sahel. Findings, however, are mixed. A study of northern Nigeria (74) finds that extended heat shocks are associated with increased internal migration, while three studies of Burkina Faso (95,97,112) find that temperature anomalies and heatwaves are associated with reduced internal and international migration. Gray and Wise (112) find that while temperature anomalies are associated with reduced migration in Burkina Faso, they have no consistent relationship with migration in Senegal or Nigeria (potentially due to the location of the study samples).

Similarly, a small body of high-quality evidence examines the impacts of short-term **precipitation** fluctuations on migration in the Sahel. Findings, however, are inconsistent. Two studies of Senegal (95,97) find that excess rainfall is associated with increased international migration, especially in areas more reliant on agricultural production and incomes. In contrast, two studies find that precipitation fluctuations have insignificant or inconsistent effects on migration in Burkina Faso and Senegal (112) and south-eastern Mali (113). Other studies report mixed findings: a country-level study of Burkina Faso (130) reports that poor rainfall conditions are associated with higher short-term internal migration but lower long-term and international migration. Echoing findings from Section 3.1.4, studies show that weather fluctuations in the Sahel contribute to migration pressures *and* constraints through impacts on agricultural productivity and income (74,95,97,112,299).

4.4.2 MIGRATION DESTINATIONS AND DURATION

A small body of high-quality evidence shows that migration in response to climatic shocks in the Sahel is mainly internal and temporary. Studies of Senegal and Mali (299) and Burkina Faso (130) find that precipitation changes are associated primarily with internal and temporary or short-term, rather than cross-border or permanent, migration, building on long-standing histories of seasonal migration in the region (299). However, most studies on the region do not directly consider whether climate-related migration is internal or international, or temporary or permanent. One study examines the impacts of migrant networks on migration decisions and destinations in the Sahel region: Hummel (299) finds that destination kinship and peer networks influence migration choices in Senegal and Mali, and provide information and practical and emotional support.

4.4.3 VULNERABILITY AND BARRIERS

A small body of high-quality evidence examined **gendered** dimensions of vulnerability to climate-related migration in the Sahel, although findings are inconsistent. A study of northern Nigeria (74) finds that men are more likely to move in response to short-term temperature fluctuations, while women are more likely to be ‘trapped’. A study of western Senegal and eastern Mali (299) finds that men are more likely to migrate in response to precipitation changes only in Mali, and not Senegal, potentially due to stronger sociocultural restrictions on women’s migration. In contrast, a study of south-eastern Mali (113) finds that heat shocks are associated with increased internal migration among women but not among men, suggesting that this may be due to more entrenched patterns of migration among men or greater household reliance on men’s income and thus more flexibility in movement among women.

A small body of high-quality evidence (only two studies) examines the impacts of **age** on climate-related migration in the Sahel, although findings are mixed. While a study of Mali (113) finds that younger people are most likely to migrate in response to temperature shocks, a country-level study of Burkina Faso (130) finds that older people are more likely to engage in long-term migration to rural areas and less likely to engage in long-term migration to urban areas or internationally in response to poor rainfall conditions.

A small body of high-quality evidence examines the impacts of **education** on climate-related migration in the Sahel but again, findings are mixed. A study of Burkina Faso (130) finds that people with higher formal education levels are more likely to engage in long-term international migration, and that education affects duration of migration toward rural and urban areas. In contrast, a study of Senegal and Mali (300) reports that formal education level has no significant effects on migration in response to environmental changes. However, this study does show that education level influence migration *motivations*, as individuals with no or primary education only are more likely to depend on climate sensitive work and are thus more likely to migrate for work, while those with at least secondary education are more likely to migrate for further education or vocational training (300).

4.4.4 ADAPTATIONS

A small body of high-quality evidence shows that **adaptations** to climate-related shocks – notably modification of agricultural practices – can reduce or otherwise affect migration in

the Sahel region, as reported in studies of Burkina Faso (130,274). In Mali, Senegal, and Mauritania, migrant remittances are sources of financing for climate adaptation measures, notably water development projects such as wells and pumps (301).

5.0 EVIDENCE REVIEW FINDINGS: ESTIMATES AND PROJECTIONS

KEY FINDINGS

- There are no rigorous global estimates of the number of people displaced by or migrating in response to weather shocks or climate change, and there is no evidence of an upward trend in weather shock- or climate change-related migration.
- There exist multiple projections of future migration relating to flooding, temperature and precipitation anomalies, sea level rise, and long-term warming, at both regional and global scales, but we have not identified specific projections relating to environmental pull factors, adaptation or mitigation, or perceptions and narratives.
- Projections vary hugely from one another (e.g. for sea level rise from the hundreds of million to the tens of thousand), depending primarily upon assumptions about potential in-place adaptations.
- All high-end projections model future exposure to climate-related changes only, making no allowance for in-place adaptation, despite the extensive evidence of in-place adaptation provided by studies of present-day climate-related migration. For this reason in particular, we do not consider these high-end projections credible.

Having examined evidence on both global and geographically specific processes, we turn now to quantitative estimates and projections of current and future climate change-related migration. In what follows we both summarise the range of existing estimates and projections and indicate our confidence in them, in line with the approach outlined in Section 2.4.

The business of estimating and projecting the impacts of climate change on migration is beset by methodological difficulties. There are many different potential pathways and sub-pathways through which climate change may affect migration, as discussed at length above. In addition, the fact that migration is almost always multi-causal for the most part makes it impossible to categorise individuals as 'climate migrants' (or even e.g. 'drought migrants'); hence rigorous estimation of climate-related migration has to involve quantitative estimation strategies (e.g. by testing for correlations between weather shocks and short-term changes in migration numbers). Reflecting this, there exist only a small number of rigorous estimates of climate-related migration (and no rigorous *global* estimates). Most estimates do not use such estimation strategies or even datasets, relying instead on broad guesses and/or journalistic sources.

As for projections, these are necessarily assumption laden. They must rely, first, on assumptions about future greenhouse gas emissions, and on climate scenarios of how these may affect future temperatures, precipitation patterns, sea level rise, and so on. Some of these scenarios are more plausible than others: for instance, the Representative Concentration Pathway (RCP) 8.5, which is often described as a 'business as usual' scenario and is the one most extensively used within high-end climate impact studies, is nonetheless widely considered implausible even with no further action to reduce global greenhouse gas

emissions (302,303).⁶ Projections of future climate-related migration rely second on models of population exposure to these projected climate-related changes, and assumptions about how this exposure might translate into migration pressures. This includes, crucially, assumptions about the causes of and reasons for migration, and about the potential for in-place adaptation. Moreover, projection studies have to rely on simplified models in which all future changes except for those associated with climate change (plus sometimes population growth) are held constant; following Hulme (304), such studies ‘reduce the future to climate’. For example, projections of future climate-related migration typically do not allow for or incorporate any future technological or economic change, or any increase in adaptive capacities, let alone adaptation measures taken in response to climate change specifically.

Reflecting these problems, estimates and projections of both ‘climate’ and ‘environmental migration’ have been extensively critiqued within expert studies and reviews (4,305–309). The IPCC’s 2014 assessment report notes that while climate change over the 21st century is projected to increase displacement, ‘[t]here is low confidence in quantitative projections of changes in mobility, due to its complex, multi-causal nature’ (1). Concurring with this assessment, we wish to stress that all estimates and projections are highly uncertain and that all should be approached with caution. However, it is also the case that some estimates and projections are less credible than others. In particular, high-end projections of ‘climate migration’ numbers typically achieve their results by relying on especially unrealistic climate and socio-economic assumptions, as will be detailed below.

In what follows, we summarise and comment on estimates and projections relating to climatic shocks, long-term climate and related changes, including for our four geographical regions. We do not consider environmental ‘pull factors’, adaptation and mitigation measures, or perceptions and narratives, as we have not identified any rigorous estimates or projections relating to these pathways.

5.1 CLIMATIC SHOCK EVENTS ATTRIBUTABLE TO CLIMATE CHANGE

While there exists a large body of evidence on the links between climatic shocks and migration (as discussed in Section 3), the number of studies providing estimates and/or projections thereof is relatively small. The small number of estimates reflects multi-causal character of shock-related migration, and the difficulties inherent in identifying the contribution of shocks per se. Added to this, the small number of projections reflects the extent of the uncertainties over future climatic trends, since while climatic shocks are widely anticipated to increase in both incidence and severity, by how much remains unclear (310,311).

⁶ RCPs are idealised greenhouse gas concentration pathways used for climate models in the Intergovernmental Panel on Climate Change’s most recent published assessment reports (2014). In RCP8.5, emissions rise throughout the 21st century at an accelerating rate, whereas, of other scenarios considered in this report, in RCP6.0 emissions peak around 2080 and then decline, and in RCP2.6 emissions are reduced rapidly. In what follows we sometimes also refer to SSPs (Shared Socioeconomic Pathways), which are the new pathway system being used for the IPCC’s 2021 assessment report.

5.1.1 FLOODING

Nine reports provide **estimates** of flood-related displacement and migration. At the regional level, the IDMC (312) estimates that 858,000 people were internally displaced by flooding in the Middle East and North Africa between 2010 and 2019, while globally they report that 14 million people were internally displaced by floods in 2020, primarily in East Asia, the Pacific and South Asia (138). The IDMC (313) estimates that 10 million people were internally displaced by floods in 2019, primarily in East Asia and the Pacific, South Asia, and Sub-Saharan Africa; they note, however, that most of this displacement was pre-emptive state-led evacuations. Over the past decade, IDMC reports estimate flood-related internal displacement to have been 10.2 million in 2011 (314), 6.2 million in 2013 (315), 8.3 million in 2014 (316), 8.3 million in 2015 (317), 8.6 million in 2017 (318), and 5.4 million in 2018 (319). While this is plausible in our assessment, three points should be noted. First, these estimates are based on compilations of governmental, international organisation, NGO and media sources which may not be accurate or consistent (either overstating or understating displacement), and the studies themselves are assessed as low quality in terms of rigour (as defined for this REA). Second, as IDMC themselves acknowledge, much and perhaps most of this displacement is in the form of pre-emptive state-led evacuations, and thus may have been predominantly temporary (no data is provided on this). Third, despite some claims to the contrary, this IDMC data provides no evidence of a clear upward trend in flooding-related displacement.

Three reports provide **projections** of future displacement and migration associated with flooding. An IDMC report (312) projects that, in the future, 392,000 people per year could be internally displaced by flooding in the Middle East and North Africa, primarily from urban and peri-urban areas. Another IDMC report (320) projects that the risk of internal displacement due to flooding will double by 2090 under RCP2.6/SSP1 and increase fivefold under RCP6.0/SSP4, especially in low-income countries in sub-Saharan Africa, South and Southeast Asia, Oceania, and Latin America. Though far from implausible we wish to note four points: that even if correct, such displacement may, judging by the current pattern, mostly take the form of temporary evacuations; that the increases in displacement projected in these studies stand in contrast to the absence of any equivalent present-day trend; that roughly half of the increase in displacement projected is a result of assumed population growth, not climate change; and that no consideration is given to possible future adaptations. Kam *et al.* (321) find that displacement due to river flooding will increase by between 110% (under RCP2.6/SSP1) and 350% (RCP6.0/SSP4) by 2090, especially in Central and Eastern Africa, Polynesia, and the Indus river basin. While plausible (and while the study is assessed as moderate quality in terms of rigour), we note that population growth accounts for the majority of these projected increases in flood risk, and that these projections take no account of the local causes of flood-related displacement (e.g. changes in land use).

5.1.2 STORMS

10 reports provide **estimates** of storm-related displacement and migration. The IDMC (138) reports that, globally, 14.6 million people were internally displaced by storms in 2020, including 5.5 million in East Asia and the Pacific and 2.7 million in the Caribbean. The IDMC (313) estimates that 13 million people were internally displaced by storms in 2019, primarily in East Asia and the Pacific, South Asia, and Sub-Saharan Africa; again, most of this involved pre-emptive state-led evacuations. Previous IDMC reports estimate storm-related internal displacement to be 3.1 million in 2011 (314), 14.2 million in 2013 (315), 9.1 million in 2014 (316), 6.3 million in 2015 (317), 12.9 million in 2016 (322), 7.5 million in 2017 (318), and 9.3 million in 2018 (319). At the regional level, a further IDMC report (312) estimates that 175,000 people were internally displaced by storms in the Middle East and North Africa between 2010 and 2019. As above, we wish to note that though plausible, these numbers are based on journalistic sources and likely mainly refer to pre-emptive evacuations, and that IDMC's data also provides no evidence of a clear upward trend in storm-related displacement.

Spencer and Urquhart (58) estimate that between 1989 and 2005 the average hurricane increased international migration from Central America and the Caribbean (CAC) to the US by 6%, and by 34% for more damaging storms. The relationship identified is lagged, meaning that it likely captures the impact of storms on long-term livelihoods, rather than immediate shock-related displacement. We consider this finding plausible (and the study is assessed as high quality in terms of rigour). We note, however, that the findings relate only to those regions directly affected by storms, not international migration from the CAC as a whole; and thus that the numbers in question are quite low (6% translates to around 4,000 people per year, a small fraction of total CAC migration to the US).

We have not identified any **projections** of future migration associated with storms specifically.

5.1.3 DROUGHT

Seven studies provide **estimates** of drought-related displacement and migration. The IDMC (312) reports that 20,000 people were internally displaced by drought in the Middle East and North Africa between 2010 and 2019, and reports that, globally, 32,000 people were internally displaced by drought in 2020 (138). The IDMC estimates that 277,000 people were internally displaced by drought in 2019 (313), compared to 1.3 million in 2017 (318) and 764,000 in 2018 (319). As above, we note that these numbers are based on journalistic sources, and that IDMC's data provides no evidence of a clear upward trend in drought-related displacement. We also note that these drought displacement numbers are far lower than for floods and storms - which, though plausible, may primarily reflect the fact that droughts are slow-onset shocks the immediate impacts of which are harder to detect, and which do not involve temporary evacuations.

Kelley *et al.* (323) claim that around 1.5 million people were displaced during 2008-09 in Syria, as a result of a severe multi-year drought. We note, however, that although this paper draws on climate datasets to analyse the causes of this drought, the 1.5 million claim specifically is based on an inaccurate journalistic source and has been shown to be false (324). Using quantitative methods, Dallmann and Millock (70) estimate that between 1991 and 2001 drought contributed to the inter-state migration of 2 million people per year in India. This

study is assessed as high quality in terms of rigour, and we consider the finding plausible. We note, however, that the study analyses the 'marginal effect' of drought and does not mean that 2 million people per year migrated 'because of drought'.

We have not identified any **projections** of future drought-related migration.

5.1.4 SHORT-TERM WEATHER FLUCTUATIONS

Nine studies identify **estimates** of migration and displacement associated with short-term weather fluctuations. The IDMC (312) reports that 11,000 people were internally displaced by extreme temperatures in the Middle East and North Africa between 2010 and 2019, and reports that, globally, 46,000 people were internally displaced by extreme temperatures in 2020 (138). The IDMC (313) estimates that 24,500 people were displaced due to extreme temperatures in 2019. Previous IDMC reports estimate internal displacement related to extreme temperatures to be 87,800 in 2011 (314), 2,000 in 2015 (317), 4,500 in 2017 (318), and 24,000 in 2018 (319). As above, we note that these numbers are based on compilations of sources, and that IDMC's data provides no evidence of a clear upward trend in extreme temperature-related displacement. Using quantitative methods, Marchiori *et al.* (88) estimate that at least 5 million people were displaced in sub-Saharan Africa between 1960 and 2000 due to temperature and rainfall anomalies, while Sedova and Kalkuhl (114) estimate that 8% of internal moves in India between 2005 and 2012, about 1.5 million people, were due to temperature and precipitation changes. While these statistical findings are plausible (and while these studies are assessed as high quality in terms of rigour), we note that the quantitative methods used offer no means of knowing whether the weather anomalies in question were primary causes of migration or proverbial 'straws which broke the camel's back', or whether they affected the occurrence or just the timing of migration (209).

Three studies identify **projections** of future weather fluctuation-related displacement and migration. Feng *et al.* (325) suggest that 1.4 to 6.7 million adults could migrate internationally from Mexico by 2080 due to the effects of temperature on agricultural productivity (the study is assessed as moderate quality in terms of rigour). Similarly, Marchiori *et al.* (88) project that, by 2099, an additional 11.8 million people may be displaced annually in sub-Saharan Africa as a result of temperature anomalies, ranging from 4 million to 18.5 million under 'best' and 'worst' IPCC scenarios. However, we have concerns about these findings, since they are driven by projections of long-term warming and assume that the causal processes through which long-term warming affects migration are identical to those through which short-term temperature anomalies do so, an assumption which is misplaced, especially because of the many means of adaptation to long-term warming (209). Iqbal and Roy (89) find that precipitation fluctuations may result in a 20% increase in net internal migration in Bangladesh by 2030 compared to 1990, equivalent to 21 million people, due to impacts on agricultural productivity. However, we have parallel concerns about this finding (although the study is assessed as high quality in terms of rigour), as it too is based on short-term associations which are not necessarily translatable to long-term trends; as the authors themselves observe, because they do not allow for long-term adaptations their projections 'likely exaggerate the effects of future weather changes' on migration.

5.2 LONG-TERM CLIMATIC AND RELATED CHANGES

5.2.1 SEA LEVEL RISE

Reflecting the fact that there has so far been only a small rise in global sea levels (with the large majority still to come, regardless of future emissions pathways), we have not identified any **estimates** of existing migration or displacement associated with it.

Sea levels are projected, under RCP8.5, to rise by up to 0.32 m by 2050 and up to 0.84 m by 2100 (326), possibly more in the event of Antarctic instability. There is consensus that, if correct, this would potentially expose hundreds of millions of people to the effects of sea level rise, though exact projections vary. For example, Kulp and Strauss (184) project that by 2100 sea level rise will bring land with current population of between 150 million (under RCP4.5) and 300 million (under RCP8.5 plus Antarctic instability) below the high-tide line, compared to 100 million today. Hinkel *et al.* (327) project that by 2100 an average 168 million people per year will be exposed to flooding as a result of sea level rise (assuming 63 cm global mean sea level rise). Dasgupta *et al.* (328) project that 56 million people would be exposed under a 1-metre sea level rise scenario, 89 million people with 2-metres sea level rise, and 245 million with 5-metres sea level rise. And Neumann *et al.* (329) project that 268 to 286 million people will be at risk from coastal flooding from storm surge events by 2030, rising to 411 million by 2060, with the greatest exposure in China, India, Bangladesh, Indonesia, and Vietnam.

While exposure on such scales would evidently have serious implications for migration, it is unclear how much migration would follow. Recall that there are already many millions living below the high-tide line (184); it is at least conceivable that many more could do so. Yet few existing projections take such complexities into account. Most provide projections of exposure only. As a recent review study (330) observes, existing research is characterised by limited understanding of the links between sea level rise and various other factors, including specific local hazards, social and political contexts, adaptation processes, migration decisions, and immobility. We concur with this finding and wish to stress that exposure to sea level rise is not a reliable indicator for migration.

One exception – which considers the potential effects of adaptation measures alongside exposure – is a study by Nicholls *et al.* (331), which projects that 72 to 187 million people may be displaced from small island regions in the Caribbean, Indian Ocean, and Pacific as a result of sea level rise by 2099 (under AB1 scenario), but also reports that these displacement numbers drop to between 41,000 and 305,000 people when protections via dyke construction and beach replenishment are integrated into their model (the study is assessed as moderate quality in terms of rigour). With just these two adaptations, they conclude, 'the problem of environmental refugees almost disappears', even under the most pessimistic climate scenario. We note, though, that adaptation on this scale would require significant investment, governance capacities and political commitment.

As further exceptions, two studies present projections of sea level rise-related migration in small island states, using an agent-based model that includes data about vulnerabilities and migration behaviours. Milan *et al.* (163) find that internal migration in Tuvalu could increase by 62% (representing an estimated 215 people) per year by 2055 under RCP6 and 138% (879 people) per year under RCP8.5, while international migration could increase by between 133% (380 people) and 242% (557 people), mainly due to sea level rise. Using the same approach, Oakes *et al.* (164) report that international migration from Kiribati could increase by 60% (an estimated 181 people) per year by 2055 under RCP6 and by 59% (180 people) per year under RCP8.5, while internal migration could increase by 226% (1,615 people) and 449% (2,724 people) per year, respectively. Though this approach has merit, insufficient information is provided about the model or data used to assess the plausibility of these findings (the studies are assessed as moderate quality in terms of rigour). We also wish to note that the numbers suggested are quite small: Milan *et al.* (163), for example, find that even under the most pessimistic climate scenario, RCP8.5, Tuvalu's total population is projected to increase by 10%, as a result of population growth being higher than out-migration.

Five studies discuss projections of future climate change-related displacement and migration in the Bay of Bengal region. Rajan (332) projects that 75 million people could be displaced in Bangladesh and 43 million in India by 2100 due to climate change impacts, including sea level rise and drought (under a scenario similar to A1), mainly within and to India (assessed as low quality in terms of rigour). Rigaud *et al.* (2) project that 13 million people could be displaced in Bangladesh by 2050 out of a combination of sea level rise, warming and changes in water availability (assessed as moderate quality in terms of rigour). Hassani-Mahmoei and Parris (333) project that sea level rise (alongside drought, floods, and storms) will contribute to the internal migration of 3 to 10 million people in Bangladesh by 2050, mainly toward the country's east and north. By contrast, Davis *et al.* (334) project that 0.9 million people will be displaced in Bangladesh by 2050 due to inundation associated with sea level rise (under RCP8.5), rising to 2.1 million by 2100 under a global mean sea level rise for four RCP pathways (2.6, 4.5, 6.0, and 8.5); they suggest that almost all of this movement will occur internally and will mainly involve rural-to-urban migration (assessed as moderate quality in terms of rigour). Bell *et al.* (335) find that no sea level rise scenarios (under RCP2.6, 4.5, or 8.5) predict flooding impacts great enough to drive populations away from coastlines in Bangladesh by 2100; instead they find that flooding will accelerate a transition from agricultural to non-agricultural income opportunities, which will be most abundant in coastal cities, and point to the potential for some populations to be 'trapped' due to cumulative flood losses and reduced livelihood alternatives (assessed as high quality in terms of rigour). The significant differences between these projections are mainly related to differences in climate scenarios and modelling assumptions, suggesting that they should all be treated with caution.

5.2.2 LONG-TERM TEMPERATURE CHANGES

Average global temperatures are currently around 1°C above pre-industrial levels and 1.5°C over land (336). However, the relatively slow pace of this warming (until recently), combined with the methodological difficulties inherent in identifying socio-economic consequences of

this long-term trend, means that there are unlikely to be any **estimates** of existing migration or displacement associated with it (and no such estimates were found in this REA).

Global temperatures are projected, under RCP8.5, to rise to around 4.3°C above pre-industrial levels by 2100. Five studies offer **projections** of future migration and displacement associated with such long-term warming. However, given the paucity of empirical evidence of warming-migration linkages, these studies use data proxies or assumptions which are of questionable merit. Missirian and Schlenker (337) analyse the links between temperature and asylum applications to the European Union for the period 2000-2014, and on this basis estimate that long-term warming will increase EU asylum applications by 28% (98,000 applications annually) by 2099 under RCP4.5, and by 188% (660,000 applications annually) under RCP8.5. However, we have major concerns about this finding (although the study is assessed as moderate quality in terms of rigour). Missirian and Schlenker's method is to test for an association between countries with an 'optimal temperature range for agriculture' (which they define as around 20°C), and asylum applications to the EU during 2000-2014, and to use this evidence as the basis for making projections about long-term impacts of warming. The problem is that this (cross-sectional) method and ensuing findings are fundamentally flawed: their statistical finding is essentially that most migration to the EU is from relatively hot countries – a fact which, though no doubt true, tells us nothing about the causes of this migration, or about whether and to what extent future temperature increases will lead migration to the EU to increase. In addition, the idea that there is an 'optimal temperature' for agriculture is flawed, reflecting 'anti-tropics' value assumptions. This study has also been extensively critiqued (e.g. 338,339).

Using a very different method, Xu *et al.* (340) suggest that between 1.5 billion and 3.5 billion people (under RCP2.6 and 8.5, respectively) will lie outside of the 'human climate niche' by 2070 due to warming, with the implication that this will result in large-scale warming-driven permanent out-migration. The study is explicitly framed as a 'thought experiment' framed around the idea that there exists a 'human climate niche' within which the large majority of humankind has always lived (defined by average temperature of 29°C). However, we have major concerns about these findings, for various reasons (and the study is assessed as low quality in terms of rigour): the existence of a 'human climate niche' is extremely questionable given the range of environments that humans now inhabit; no justification is provided for the assumed threshold of this niche, 29°C; the modelling involves untenable assumptions about future warming (assuming that under RCP8.5, by 2070 the mean experienced average temperature will be 7.5°C above pre-industrial levels, 2.3 times the projected global average temperature rise); no back-casting of the projection is undertaken (important as, if it were valid, there would already be substantial evidence of people being displaced as a result of long-term warming); and no allowance is made for long-term adaptation to higher temperatures. Indeed, the authors themselves 'acknowledge that realized migration numbers will likely be much lower than suggested'.

Chen and Caldeira (341) project that under RCP8.5, 0.6 to 1.9 billion people will face climate change-induced migration pressures by 2050, and between 3.3 and 4.9 billion by 2100, as a result of long-term temperature, and to a lesser extent precipitation, changes. At the national

level, they project that by 2100 90 million people in Bangladesh, 890 million in India, 110 million people in Sudan, 90 million in Tanzania, 140 million people in Niger and 460 million in Nigeria will face warming-induced migration pressures. However, we have major concerns about these findings, for reasons similar to those identified for Xu *et al.* (although this study is assessed as moderate quality in terms of rigour): in particular it is assumed without basis that the relationship between average temperature and global population distribution will remain stable.

Two studies of Brazil provide more fine-grained projections, considering not the direct impacts of long-term warming but its impacts on agricultural yields and in turn migration. Barbieri *et al.* (342) suggest that under the A2 scenario (equivalent to RCP8.5), around 500,000 people may migrate internally within Brazil's northeast region between 2025 and 2050 due to the impacts of warming on agricultural yields and employment. Oliveira and Pereda (343) suggest that 1 million people might migrate internally in Brazil between 2040 and 2070 under the A2 scenario and 0.9 million under the B1 scenario, due to the effects of warming on agricultural productivity and wages. However, although these studies are assessed as high and moderate quality, respectively, in terms of rigour, we have concerns about these findings as they assume no change in crops or agricultural practices.

It is conceivable that the warming-induced decline of mountain glaciers may have significant impacts on both the volume and timing of river flow, and in turn agricultural production and migration. Melting glaciers and snow associated with warming are projected to have profound impacts on river flows, seasonal surface runoff, and water availability in major river basins such as the Indus, Brahmaputra and Euphrates-Tigris (344,345). Huss and Hock (346) find that, under RCP8.5, total glacier volume across 56 glacierised drainage basins may decrease by about 74% by 2100, resulting – after an initial increase – in a decline of basin runoff of 10% or more, with the largest reductions in central Asian basins. Immerzeel *et al.* (344) suggest that reduced river flows associated with glacier melting could threaten the food security of an estimated 60 million people in the Brahmaputra and Indus Basins over 2046-2065 under the A1B scenario. While it seems likely that such scenarios would have major implications for migration, we have not identified any projection studies that explore them specifically.

Overall, we consider that while long-term warming may contribute to significant levels of out-migration, none of the above projections provide a sound basis for understanding either its dynamics or its likely scale.

5.2.3 LONG-TERM PRECIPITATION CHANGES

Projections of future precipitation under different climate scenarios are often highly uncertain – much more so than temperature projections – often varying not just in the degree of change projected, but in its sign (i.e. whether precipitation will increase or decrease). Reflecting this, we have not identified any global **estimates** or **projections** of the effects of long-term precipitation changes specifically on migration.

We have identified just one regional projection study: Defrance *et al.* (347) find that, under RCP8.5 plus with extensive Greenland ice melt and sea level rise of up to 3 m, there would be

a significant decrease in West African monsoon rainfall with resulting impacts on cultivable areas and agricultural production, which could bring 360 million in the Sahel below the water threshold for sorghum cultivation by 2100 and result in tens to hundreds of millions of people being forced to leave the Sahel. However, we have concerns about these findings (although the study is assessed as moderate quality in terms of rigour), partly because they are based on an extreme climate scenario, but above all because they explicitly include no allowance for adaptation.

The World Bank's *Groundswell* report (2) offers projections of internal migration arising from three combined slow-onset climate impacts: water stress, declining crop yields, and sea level rise. It projects that by 2050 internal migration resulting from these long-term changes within Sub-Saharan Africa, South Asia and Latin America will total between 31 million (under RCP2.6) and 143 million people (RCP8.5), accelerating after then. At the regional level (under RCP8.5), this would include 86 million people in sub-Saharan Africa, 40 million in South Asia and 17 million in Latin America. At the national level, the report projects, inter alia, that internal migration in Bangladesh will be between 3.6 million (RCP2.6) and 13.3 million people (RCP8.5) by 2050, mainly in the eastern coast and rice-growing areas of the northeast; and that internal migration in Ethiopia will be between 1.3 and 1.5 million people, mainly from northern highland regions, again accelerating after 2050. While these findings are difficult to evaluate based on the data and methodological notes provided in the report, we have major concerns about them. The report lacks clarity on whether the projected impacts are mainly the result of sea level rise, water stress, or warming impacts on crop yields, and how long-term changes in precipitation and yields are modelled to affect changes in population distribution. The report is explicit that its model of future population distribution changes does not allow for possible 'technological advances' and 'adaptation responses' (which would include changes in crops, agricultural practices, irrigation supplies, etc.). It includes some curious findings (e.g. in for some regions 'climate migration' is found to be higher under the report's 'climate friendly' scenario than under its pessimistic reference scenario). Finally, the report uses a baseline of 1970-2010 to model, for instance, the impacts of climate change on water availability – though water availability is in many regions in long-term decline for reasons which often have little or nothing to do with climate change. Put differently, this report 'reduces the future to climate' (plus population growth) (304).

A study published by ProPublica and the *New York Times Magazine* (348), using the same model, projects that over 30 million people will migrate from Central America to the US due to climate change effects by 2050 'in the most extreme climate scenarios' (under RCP8.5), with 5% of migration to the US being 'driven primarily by climate'. Though supported by a separate methods paper (349), the results of this study are presented only in a newspaper report (348) and are impossible to evaluate. The study overall is assessed as low quality in terms of rigour, and we have concerns about its findings both for the reasons already discussed in relation to the *Groundswell* report (since the same model is used, and most of the same model assumptions therefore apply), and because of the lack of clarity on the modelling of international migration (the *Groundswell* report's methodology was developed to consider internal migration only).

6.0 CONCLUSION

6.1 MAIN FINDINGS

6.1.1 PATHWAYS AND PROCESSES

This report identifies and summarises wide-ranging evidence on the implications of climate change for migration. Our starting point and hypothesis was that there are five distinct pathways through which climate change might conceivably affect migration: through short-term shocks, long-term climatic and related changes, environmental pull factors, adaptation and mitigation measures, and perceptions and narratives. Of these, we have identified a very large body of evidence relating to shocks, large bodies of evidence relating to sea level rise, adaptation, and perceptions and narratives, and much smaller bodies of evidence relating to long-term warming and precipitation changes. We have not identified any evidence on the contributions of either environmental pull factors or mitigation to migration.

We wish to stress that the volume and strength of evidence per pathway (or sub-pathway) is not necessarily an accurate reflection of its current or future significance. The volume of research on any subject also reflects the feasibility of conducting research on it, methodological challenges involved, and donor and other research funding priorities (in terms of both pathways and countries or regions). In this case, the volume of research on short-term shocks partly reflects the fact that there exists an abundance of data on them, which can be easily analysed for associations with migration. Conversely, the relative paucity of research on the migration implications of long-term warming and precipitation changes is primarily a function of the fact that there are no obvious frameworks, methods, or ‘data analogues’ for studying them, given that these are changes without clear historical precedent. It may be that the same applies to environmental pull factors and/or mitigation as well. Stated differently, while the analysis above would not support a conclusion that there are five pathways (each with their sub-pathways) through which climate change might affect migration, it does not falsify our hypothesised framework either. As indicated repeatedly above, there exist huge uncertainties over both how, and how much, climate change will cause or contribute to migration.

The strongest evidence of existing climate-related migration relates to **shocks** – floods, storms, droughts, and short-term temperature and precipitation fluctuations, although evidence is mixed (and as noted in Section 3.1, most of the reviewed studies analyse only the links between shock events and migration, and not the impact of human-induced climate change per se). Multiple studies identify associations between shocks and increased internal and international migration. Moreover, according to the IDMC (138), 30 million people were displaced by weather-related disasters in 2020, compared to 9.8 million displaced by conflict. Complicating matters, however, much and perhaps most of this weather-related displacement comprises pre-emptive evacuations, and evidence suggests that most of it is temporary, though firm evidence on this question is lacking. Evidence also suggests that

weather-related shocks, while contributing to migration pressures, may simultaneously or in different contexts reduce capacities to migrate. Perhaps most significantly, there is no evidence of an upward trend in weather shock-related migration. And while climate change is projected to increase the incidence and severity of shock events, there are no convincing global projections of weather shock-related displacement (see below).

Among our pathways, **long-term climatic and related changes** potentially have the biggest implications for migration, although we identified few studies of their existing impacts. Modelling projections of these changes suggest that by 2100, and possibly earlier, many hundreds of millions of people globally may be living below the high-tide level, or in regions beyond the usual limits of human habitability, or suffering from long-term declines in precipitation and resulting water availability (especially but not exclusively under the more pessimistic climate scenarios). However, projected exposure to such long-term changes is not a good indicator of migration numbers. Adaptations are not only possible, but already widespread. Adaptation to climatic, weather, and environmental changes and variations, along with migration, is not exceptional, but a constant feature of human societies and human development (fire, clothes, shelter, agriculture, pastoralism, and so on can all be understood as human adaptations to environmental changes, variations, and hazards). Around 100 million people, for instance, already live below the high-tide level. And given the long-term timeframe of projected changes, technological innovations, infrastructure investments, and economic growth – which are typically not allowed for in climate impact projections – may make new forms and degrees of adaptation possible and affordable. It seems likely that migration associated with this pathway will be considerably less than projected by exposure models – but how much less is impossible to say.

There is strong evidence that small-scale **adaptations** to climate-related shocks and hazards, especially adjustments to agricultural livelihoods and practices and improved infrastructures, can reduce migration pressures. There is strong evidence that migrant or diaspora networks can facilitate in-place adaptation through the provision of knowledge and financial support (e.g. remittances), suggesting that migration and local adaptations may function as complementary rather than substitutive protection mechanisms. However, there is also strong evidence of climate change-related adaptation measures, or what may be called ‘maladaptation’, contributing to displacement and migration, especially flood protection initiatives, coastal defence projects, dam building, agricultural development projects and land acquisitions. We have not identified any estimates or projections of the current or future scale of adaptation-related migration.

There is strong evidence of how **perceptions and narratives** of climate change, weather shocks and local environments affect migration practices and decisions. Two themes stand out. First, there is very strong evidence that local experiences of and attachments to place are often privileged over concerns about vulnerability to weather shocks or future climate change, and make migration less likely than it would otherwise be (with much of this evidence emerging from studies of small island states, discussed in Sections 3.5 and 4.1.1). Second, ‘climate crisis’ and ‘climate refugee’ narratives may contribute to people in vulnerable environments thinking that migration may be necessary, or even inevitable (as illustrated by

examples from small island states and the Bay of Bengal region, discussed in Sections 3.5, 4.1.1, and 4.2.1).

While most of the reviewed studies do not examine whether climate-related migration is, or is likely to be, mainly **temporary or permanent**, there is medium evidence that migration associated with climatic shock events is mainly temporary or short-term, including in the form of cyclical movement (e.g. for labour) and evacuation or movement to shelters. However, most studies of this issue are on weather shocks, making it at least possible that other pathways will be characterised by a higher degree of permanent migration.

It is possible that climate change may contribute to multiple '**waves**' of migration, for example with drought contributing to local out-migrations, and this in turn generating social conflict in receiver areas, leading to secondary migration. However, we have not identified any evidence of this in which we have confidence. While Syria is often identified as an example of this, the pre-civil war drought being identified as a contributor to the country's civil war and the subsequent mass displacement (323), the supporting evidence to this effect is weak (324). More broadly, the diffuse and multi-causal character of most climate-related migration poses acute analytical challenges to studying such processes.

While most of the reviewed studies do not examine whether climate-related migration is, or is likely to be, mainly **internal or international**, there is strong evidence that migration associated with climatic shock events and coastal hazards is predominantly internal. However, most studies of this issue are on weather shocks, making it at least possible that other pathways will be characterised by a higher degree of international migration. It seems likely, for instance, that in the event of long-term warming contributing to migration, much of this would be cross-border (though how much would depend on multiple factors: for instance, there is strong evidence that migration and visa policies influence migration decisions and intentions, by restricting international movement and affecting destinations preferences).

Regarding existing **vulnerabilities** to climate-related displacement and migration across different pathways and sub-pathways, gendered, age-related, income-related, education-related, and occupational dimensions of vulnerability and barriers to migration have received the most attention in the reviewed studies, and emerges primarily from studies on climatic shock events. Regarding **gendered** vulnerabilities, a limited body of evidence shows that women are more likely to face barriers to migration and to be 'trapped' in the face of climate-related shocks and changes. However, existing evidence (discussed in Section 3.1.6 in particular) points to the influences of context-specific gendered norms and labour and mobility dynamics on shock-related migration, and other literature highlights the fundamentally gendered dynamics of climate-related migration vulnerabilities and barriers (350–352). Regarding **age-related** vulnerabilities, there is strong evidence that young people are more likely to move in response to flooding, storms, short-term weather fluctuations, and long-term precipitation changes.

Evidence on **income** effects on climate-related migration is mixed across all pathways. While the poorest individuals and households face the greatest climate-related migration pressures and may be more likely to move in some contexts, they are also more likely to be trapped,

with lack of financial resources identified as key barriers to mobility in response to flooding, storms, and sea level rise – showing that they are disproportionately affected by both migration pressures *and* barriers to movement. Findings that wealthier households are more likely to migrate in response to flooding, drought, and short-term weather fluctuations may indicate greater choice over when to migrate and may be more or less likely to move depending on contextual pressures and opportunities. Similarly, **education** effects on climate-related migration are mixed across most pathways. Individuals with both lower *and* higher levels of formal education are more likely to migrate in response to flooding, drought, and short-term weather fluctuations in different contexts. As with income level, this may indicate that individuals with higher levels of formal education may have greater choice over when to migrate and may be more or less likely to move depending on contextual pressures and opportunities. Regarding **occupation** effects on climate migration, there is strong evidence that short-term temperature and precipitation fluctuations are most strongly associated with migration in regions more reliant on agricultural production and incomes. Evidence is mixed as to whether individuals involved in agricultural or non-agricultural employment are more likely to migrate in response to short-term weather fluctuations.

There is little attention, in the reviewed literature, on other dimensions of vulnerability associated with existing (context-specific) structures of marginalisation or discrimination that shape both experiences of climate-related changes and migration pathways (including vulnerabilities and barriers). Only three reviewed studies address such issues. Mastrorillo *et al.* (79) find that short-term weather fluctuations have stronger effects on migration among Black and low-income populations than for white and high-income populations in South Africa. Adam *et al.* (246) find that entrenched discrimination, harassment, and exclusion are barriers to climate-related migration among Indigenous populations in India. Gautam (276) finds that migration in response to perceived climatic changes in Nepal is influenced by caste, with the most marginalised being significantly more likely to migrate. Such dynamics, however, have received relatively little attention in studies of climate-related migration.

In line with the findings of the UK government's 2011 Foresight report on Migration and Global Environmental Change (4), many studies suggest that migration should be considered **a form of adaptation**. Studies often distinguish between 'in place adaptation' and 'migration as adaptation', the latter recognising that 'migration may be the most effective way to allow people to diversify income and build resilience where environmental change threatens livelihoods' (353). However, this is potentially misleading. Migration in response to climate vulnerabilities does and will involve losses or costs. Many of studies reviewed above emphasise the losses associated with climatic hazards and climate change, whether these be losses of property and livelihoods, or of ties to community, culture and place. Moreover, the distinction between 'in place adaptation' and 'migration as adaptation' misses out on the fact that there are, stated schematically, three types of migration-related response to climate change and climatic hazards: migration, adaptation and – though often ignored – suffering. The substantial evidence reviewed in this report of climatic shocks being associated with decreased migration, combined with the evidence of this effect applying disproportionately to women and poor households, substantiates this, suggesting that in certain circumstances people and communities are being trapped in situations of extreme vulnerability.

6.1.2 COUNTRIES AND REGIONS

While studies of climate-related migration in **small island states** focus predominantly on the implications of sea level rise, these do not provide evidence of it already contributing to migration. By contrast, there is some (limited) evidence that coastal hazards, notably storms and drought, contribute to migration pressures. There is also evidence that perceptions and narratives relating to climate change have important effects in small island states, with attachments to place being a barrier to movement, and perceptions of anticipated future climate-related changes, especially sea level rise, and narratives of climate change as unstoppable being associated with intentions to migrate. There is evidence that adaptation measures, primarily infrastructure developments responding to coastal hazards and anticipated sea level rise, may reduce migration pressures. There is very strong evidence on planned relocations in small island states, as both a form of adaptation and a form of migration. There is medium evidence that current migration is often internal, but that future migration intentions focus on international destinations.

On the **Bay of Bengal**, small bodies of evidence show that short-term temperature fluctuations and salinisation contribute to increased migration. By contrast, evidence on the impacts of flooding and short-term precipitation shocks, flooding and storms is mixed, variously identifying associations with both increased *and* decreased migration. Moreover, while there is strong evidence that migration in response to climatic shocks is primarily temporary, rather than permanent, the evidence on migration destinations is much less clear. Evidence on the impacts of gender, income and agricultural livelihoods on climate-related migration is inconsistent. A small body of evidence shows that insufficient or inadequate government support may present barriers to migration and return. While adaptations to climate-related changes through changes in agricultural practices can reduce migration, some of these adaptations, most notably through commercial aquaculture, are maladaptive and themselves contribute to migration.

Studies of climate-related migration in arid and semi-arid regions of **East Africa** focus largely on drought and short-term precipitation fluctuations, with smaller numbers of studies examining the impacts of flooding and short-term temperature fluctuations. A small body of evidence shows that temperature fluctuations are associated with *decreased* migration in the region, whereas evidence on the impacts of drought, flooding and precipitation fluctuations is mixed, pointing sometimes to increased and sometimes to decreased migration. Adaptations to climate-related changes can both reduce migration pressures and generate resources needed to move, and maladaptation, especially land acquisitions for climate-related agricultural development, may contribute to displacement and migration. Evidence on the impacts of gender, income and education on climate-related migration is mixed or inconsistent.

Of the four focus regions, **the Sahel** is the focus of the smallest number of reviewed studies (though our omission of French-language research on the region may partly account for this). These studies focus principally on the impacts of short-term temperature and precipitation

fluctuations, but findings are mixed or inconsistent, sometimes pointing to associations with increased, and sometimes with decreased, migration. A small body of evidence shows that climate-related migration in the region is often internal and temporary, although there is little comparative analysis of internal versus international movement. Evidence on migration destinations and duration, on the social profile of migrants, and on adaptations to climate-related pressures is also either mixed or inconsistent.

6.1.3 ESTIMATES AND PROJECTIONS

There are very few rigorous **estimates** of the number of people displaced by or migrating in response to weather shocks and/or climate change. We have identified only one set of global estimates of shock-related migration, that produced annually by the IDMC (138,313–319,322), according to whom, as already mentioned, 30 million people were displaced by weather-related disasters in 2020. However, these IDMC estimates are potentially misleading given that they are compilations of sources, and given that they mainly refer to pre-emptive, and likely mostly temporary, evacuations. There exist a small number of regional estimates using more rigorous estimation strategies, which each point to weather anomalies as having significant impacts on migration; however, even with these studies there are problems, as it is impossible to know whether the weather anomalies studied were primary causes of migration or proverbial ‘straws which broke the camel’s back’, affecting the timing rather than the occurrence of migration. We have not identified any estimates of the number of people to have migrated owing to sea level rise, long-term temperature or precipitation changes, environmental pull factors, adaptation or mitigation measures, or perceptions and narratives. There is no evidence of which we are aware of an upward trend in weather shock- or climate change-related migration.

We have not identified any specific **projections** of future migration relating to environmental pull factors, adaptation or mitigation measures, or perceptions and narratives. However, we have identified a moderate number of projections relating to sea level rise, plus small numbers relating to flooding, temperature and precipitation fluctuations, and long-term warming. Here we summarise upper and, where appropriate, lower end projections. Studies reviewed on sea level rise project that, at the upper end, 300 million people globally may be exposed by 2100 (184), and at the lower end that displacement may be less than 100,000 (331). Two studies of long-term temperature increase suggest, even more strikingly, that several billion people globally may face warming-related migration pressures by the late twenty-first century (340,341). One study of flooding suggests that flooding risk in the Middle East and North Africa may increase by a factor of 4 by 2100 (312). One study of short-term weather anomalies suggests that by 2099 up to 18.5 million people may be being displaced annually within sub-Saharan Africa (88).

In addition to these studies of specific pathways, there exist a small number of projections of ‘climate migration’ in general. The World Bank’s *Groundswell* report (2) projects that by 2050 internal migration resulting from combined slow-onset climate impacts (water stress, declining crop yields, sea level rise) within Sub-Saharan Africa, South Asia, and Latin America may be as high as 143 million people. A follow-up study published by the *New York Times*

Magazine (348) projects that over 30 million people may migrate from Central America to the US due to slow onset plus shock-related climate change effects by 2050. Separately, and not so far discussed in this report, Myers (354) suggests that as many as 200 million people could be displaced by combined climate change effects, a figure that was influentially reproduced in the Stern Review (355). Christian Aid (356) suggests that 250 million people will be permanently displaced by climate change-related floods, droughts, and storms by 2050, and the Institute for Economics and Peace (357) projects that 1.2 billion people will be at risk of displacement by 2050 due to floods, droughts, and storms as well as sea level rise and rising temperatures.

We have examined each of the projections summarised above and have concerns about the large majority of them, especially the more high-end projections. Some of the projections (most notably 354,356,357) are little more than back of the envelope calculations, which are not based on any dataset and have repeatedly been critiqued within expert studies (4,305,306). Others, by contrast, are based on datasets and formal models, but are typically premised on various untenable assumptions. Some use invalid data proxies, for example using contrasting out-migration rates between relatively hot and relatively cold countries as a basis for projecting warming impacts (337). Others make the erroneous assumption that evidence of short-term shock-migration relationships can be projected onto long-term trends – when this is likely invalid given the far more wide-ranging means of adaptation to long-term trends. Virtually all climate migration projection studies ‘reduce the future to climate’ (304), not allowing for economic growth or technological change. All high-end projections operate with the assumption of no in-place adaptation, which is at odds with the extensive evidence of this within studies of present-day climate-related migration. Most high-end projections are premised on a particular climate scenario/pathway, RCP8.5, which is widely considered highly unlikely or implausible. Multiple expert studies and reviews have been highly critical of projections of ‘climate migration’, and ‘environmental migration’ more broadly (4,305–309). We concur with these judgements and conclude that such high-end projections are not credible.

6.2 EVIDENCE GAPS AND RECOMMENDATIONS

6.2.1 EVIDENCE GAPS

Being a ‘rapid evidence assessment’, there are almost certainly a large number of studies of relevance to understanding climate-related migration which were not identified via database or organisational searches. That said, the analysis above suggests several major evidence gaps within the existing literature on climate change and migration.

First, some pathways and sub-pathways are weakly represented in the evidence base. There exists very little research on the migration implications of climate-related environmental pull factors, and no specific research on the migration implications of climate mitigation. It may be that there are good reasons for this, relating either to the difficulties inherent in researching uncertain future developments for which there are no obvious precedents, or to such linkages simply being unlikely. However, we suggest that further consideration of this issue is required.

Second, further and more integrated research is required on the migration implications of long-term climatic and related changes. As noted above, these potentially have the greatest implications for migration. Yet the volume of research on them is dwarfed by that on short-term shocks. Moreover, existing research on the migration implications of long-term climatic and related changes is dominated by climate science and earth systems models and projections which, because of their climate-centrism and failure to incorporate technological and economic developments, adaptation processes, and the more sociological dimensions of migration into their models, do not provide a sound basis for understanding either the likely mechanisms or the likely scale of future climate-related migration.

Third and related, further research is needed on how other dimensions of environmental change and crisis, besides and in addition to climate change, are affecting or are likely to affect migration patterns. As mentioned in the introduction, most contemporary socio-ecological transformations and hazards, though exacerbated by climate change, typically have other far more fundamental causes. Moreover, some hazards, industrial and agricultural pollution for instance, fall into the category of barely being caused by climate change at all. Unfortunately, a narrow focus on 'climate-related migration' is likely to obscure the importance of these other hazards and changes, as well as their interactions with climate change. This matters first because some of these hazards and changes may themselves have impacts on migration independent of climate change: for instance, the 'global groundwater crisis' caused principally by over-abstraction for irrigation is already having, and is likely increasingly to have, significant impacts on agricultural production, rural livelihoods and potentially migration, especially in key agricultural production zones in Asia (72,358). But it also matters for understanding 'climate migration' itself: for instance, projections of how climate change may affect precipitation and in turn migration are likely to be highly inaccurate if they do not incorporate agriculture-induced water resource degradation into their models (and none of the projection studies examined in this report do this). To this extent, the framing of the UK government's 2011 Foresight report (4) – 'migration and global environmental change' – provides a richer and more coherent framework for analysis than that offered by a focus on 'climate change and migration' only.

Fourth, there is a surprising paucity of research on the Sahel region. Most research on climate-migration linkages in the Sahel focuses on the impact of shock events and short-term weather fluctuations, and even this body of research is limited – although our focus on English-language publications likely resulted in the omission of French-language research on the region. Further research is needed on the impacts of long-term climate and environmental changes in the region and their implications for migration, especially given the region's vulnerability and high levels of poverty.

Last, further research is needed on the duration of migration and return migration. The vast majority of the reviewed studies do not discuss whether migration was or is likely to be temporary or permanent, as also highlighted by a recent review (359). This is especially important for weather-related shocks, for which displacement levels are already three times above those associated with conflict, and are thought likely to grow with an increased incidence of shocks – yet it is not clear how much of this displacement is permanent. Many

studies of shock impacts on migration mix, and often conflate, emergency displacement or evacuation, and subsequent migration in light of their economic impacts. Similarly, very few studies – only four – consider (barriers to) return migration. Given that shock-related migration and displacement is mostly short-term (primarily involving temporary evacuation), further research is needed on dynamics of return.

6.2.2 RECOMMENDATIONS

We make seven recommendations. First, the evidence gaps identified above point to the need for further research on specific issues, in particular on the duration of shock-related displacement and return migration, and on the Sahel, as well as on the need for research on the migration implications of long-term climate and related changes that incorporates likely adaptations and the more sociological dimensions of migration into their models.

Second, the reviewed evidence points to complex patterns of vulnerability in climate-migration relationships, showing that poverty-affected individuals and households are particularly affected by both migration pressures *and* barriers to movement, and that young people are the most likely to move in response to climatic pressures (as discussed in Section 6.1.1). These groups should therefore be explicitly considered in policy and programming responses. Existing evidence points to the influences of context-specific gendered norms and mobility dynamics on shock-related migration. Policy and programming responses should therefore explicitly consider the gendered dynamics of climate-related migration vulnerabilities and barriers, a recommendation also highlighted by others (350–352).

Third, we recommend that migration in response to climate vulnerabilities should be considered both as a form of adaptation and as involving social losses. As discussed above, there is substantial evidence in the reviewed studies of the material and social losses associated with climatic hazards and climate change. A recent synthesis of policy recommendations on climate-related migration suggests avoiding the universal promotion of migration as an adaptive response (360), a conclusion with which we agree. At the same time, we recommend that non-migration in the face of climate vulnerabilities should not be equated with adaptation. The evidence reviewed above of climatic shocks being associated with decreased migration suggests that in many contexts people and communities are being trapped in situations of extreme vulnerability. We recommend that greater attention be paid to such ‘trapped populations’, a recommendation also highlighted by others (168,361,362).

Related, we urge greater attention to the risks of climate change maladaptation. Whether undertaken by local state authorities or international donors, adaptation measures may sometimes create or worsen vulnerabilities, in the process either trapping communities or contributing to migration. The reviewed evidence suggests that climate adaptation measures such as dam-building, land acquisitions, relocations, and shifts out of agriculture can all, in certain circumstances, create or worsen vulnerabilities, in part because climate change is of such importance that the potential negative consequences of adaptation projects often do not receive the attention they deserve. We recommend greater attention to this issue.

Fifth, we advise that a narrow focus on climate change-related migration should be replaced with, or complemented by, broader consideration of environment-migration linkages. Though beyond the scope of this report, it is our expert judgement that climate change is far from the only environmental factor in migration and is perhaps not even the most important one. We recognise that there are important international policy contexts, especially the UNFCCC process and international climate adaptation planning and financing, and specific concerns from certain states and regions vulnerable to sea level rise, which underpin the current focus on climate-migration linkages amongst experts and policymakers. However, we would suggest that this narrow focus is both analytically and practically problematic, and may potentially contribute to maladaptation to climate change, as well as inattention to other pressing environment-related causes of vulnerability and migration.

Sixth, we recommend against the use of high-end projections of climate-related migration. Projections are, as studies sometimes acknowledge, not predictions; formally speaking, they should be evaluated for their utility, not their accuracy. Considered as predictions, however, high-end projections of climate-related migration are across the board not credible even when they are outcomes of high-quality research, since they are always informed by unrealistic assumptions, in particular in not allowing for future technological and economic changes or for adaptation.

Last, we encourage the use of the terms ‘climate-related migration’ or ‘climate change-related migration’ – rather than ‘climate migration’ or ‘climate-induced migration’ (as well as ‘climate migrants’ and ‘climate refugees’) – as the former more clearly reflect the mediated and indirect ways in which climate change and climatic factors may influence migration.⁷ Across all pathways and regions, the reviewed studies clearly and consistently emphasise the multi-causal nature of climate-related migration, emphasising the influence of complex and intersecting economic, political, and social factors, with environmental or climatic factors often identified as secondary drivers. We have identified no evidence that human-induced climate change is currently causing or contributing to migration in a uni-causal, direct or unmediated way. Equally, even in high-end scenarios of future climate change impacts, a large proportion of people, and possibly a large majority, may not be compelled to migrate given technological developments and local adaptations. There are also deeper concerns regarding the idea of ‘climate migration’: though beyond the scope of our database, there exists a large body of evidence which argues that, and analyses how, climate migration narratives represent ‘climate migrants’ and ‘climate refugees’ as without agency, reproduce colonial and racialised tropes, and are employed today for often questionable political reasons (e.g. 364–369). Moreover, studies reviewed for this REA suggest that climate migration discourse may contribute to both maladaptation and migration pressures, for instance by legitimising development responses that cause displacement (202,203,242,244,248–250,287), as discussed in Sections 3.4 and 3.5. ‘Climate migration’ discourse may, at worst, become a self-fulfilling prophecy. We thus recommend that it be avoided.

⁷ We are aware of ongoing discussion about legal framings of international protection in the context of climate change and disasters by the UN High Commissioner for Refugees (363), but analysis of these questions is beyond the scope of the current REA.

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APPENDIX A: LITERATURE SEARCHES, CODING AND ASSESSMENT

Databases searched	Organisations searched
<p>3ie Development Evidence Portal</p> <p>Climig database</p> <p>Eldis</p> <p>International Bibliography of the Social Sciences (IBSS)</p> <p>Migrating Out of Poverty database</p> <p>Nature</p> <p>ProQuest Politics Collection</p> <p>Science</p> <p>ScienceDirect</p> <p>Scopus</p> <p>UN University collection</p> <p>Web of Science</p>	<p>African Development Bank Group</p> <p>Asian Development Bank</p> <p>Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED)</p> <p>Centre on Migration, Policy and Society</p> <p>Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)</p> <p>Council for the Development of Social Science Research in Africa</p> <p>Environment for Development</p> <p>Food and Agriculture Organization</p> <p>Global Knowledge Partnership on Migration and Development (KNOMAD)</p> <p>Governance and Social Development Resource Centre (GSDRC)</p> <p>Hugo Observatory</p> <p>Institute for Security Studies</p> <p>Institute of Development Studies</p> <p>International Centre for Climate Change and Development</p> <p>Internal Displacement Monitoring Centre</p> <p>International Institute for Environment and Development</p> <p>International Migration Institute</p> <p>International Organization for Migration</p> <p>Joint Data Center on Forced Displacement</p> <p>Migration Data Portal</p> <p>Migration Policy Institute</p> <p>Mixed Migration Centre</p> <p>Observer Research Foundation</p> <p>OECD publications database</p> <p>Overseas Development Institute</p> <p>Refugee Studies Centre</p> <p>Research for Development Outputs</p>

	<p>Rift Valley Institute</p> <p>Secure Livelihoods Research Consortium</p> <p>South African Institute of International Affairs</p> <p>Stockholm Environment Institute</p> <p>World Bank Open Knowledge Repository</p>
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Table A1. Databases and organisations included the review

Topic	Search terms
Migration	migration OR migrant* OR refugee* OR displace* OR mobility OR movement OR relocation OR asylum OR “trapped population*”
Climate change	“climat* change” OR “climate emergency” OR “global warming” Or “global heating” OR “greenhouse gas*” OR emissions OR “climat* variation*” OR “climat* variability” OR “climat* shock*” OR “climat* extreme*”
Climate change-related environmental, economic, and political developments	“environmental change*” OR “environmental destabili*ation” OR “sea level” OR “sea-level” OR drought* OR desertification OR flood* OR temperature* OR heat OR precipitation OR rainfall OR “extreme weather” OR “weather event*” OR hurricane* OR typhoon* OR storm* adaptation OR mitigation OR renewable* OR solar OR wind OR dam* OR irrigation OR “land grab*” OR “green grab*” OR “rare earth minerals”
Estimates and projections	migration OR migrants OR refugees OR displaced, displacement OR mobility OR movement) AND (“climate change” OR “global warming” OR “climatic variation” OR “climatic variability” OR “climate shocks” OR “climate extremes”) AND (model OR modelling OR estimated OR estimates OR estimations OR projected OR projections OR prediction OR forecast OR figures)

Table A2. Keywords used in database and web searches

	Studies included	Studies excluded
Year of publication	Since 2005	Prior to 2005
Language	English	Any other language
Publication type	Academic journal articles, expert studies (estimates and projections include policy briefs)	Research briefs, books and book chapters, conference papers, unpublished papers and working papers, dissertations, student papers
Study type and approach	Any research using primary quantitative, qualitative or mixed research methods to examine	Purely theoretical and conceptual research on the impacts of climate change on migration

	present or future impacts of climate change on migration, including everything from global assessments to national and local case studies	
	Secondary reviews of research on present or future impacts of climate change on migration and impacts of environmental change that include discussion of climate change ⁸	
Study focus	Research which analyses causal pathways, processes or mechanisms through which climate change affects migration but does not quantify the scale of migration, and vice-versa	Research which neither analyses causal pathways, nor quantifies the scale of migration
	Research which examines only exposure to effects of climate change but does not analyse socio-economic factors, especially vulnerabilities and adaptations, and vice versa ⁹	Research which examines neither exposure nor socio-economic factors
	Research on the social, economic and political consequences of environment- and climate-related migration, where there is evidence or analysis of secondary migration occurring as a result	Research on the social, economic and political consequences of environment- and climate-related migration, where there is no evidence or analysis of secondary migration
	Research on historical environmental change-migration linkages which identifies long-term trends relevant to understanding present-day or future climate-related migration	Research on historical environmental change-migration linkages that does not consider implications for present or future climate-related migration
	Research on 'trapped populations' who are unable to move despite severe climatic or environmental changes	Studies which, despite using keywords 'climate change' and 'migration', include little or no analysis of links between them
		Research on the politics of 'climate migration' and 'climate refugee' discourse (except where a factor in displacement or migration)

⁸ We include a wide range of reviews here, not only formal systematic reviews, to avoid excluding potentially important analyses and insights.

⁹ Research on climate migration emerges from a wide array of natural and social science disciplines, examining climate change-migration relationships from potentially very different angles. Some earth sciences studies, for example, examine only *exposure* to climate change-related effects, with no consideration of socio-economic factors (e.g. specific vulnerabilities or adaptive capacities).

Table A3. Inclusion and exclusion criteria

Component	Description
Author(s)	Author name(s)
Year	Year of publication
Publication type	Peer-reviewed journal article Government report International NGO report International organisation report Other
Research type	Primary research study Secondary review study
Research method	Quantitative Qualitative Mixed methods
Scale	Global Regional National Subnational/ local
Region and country	Name of region and country (for regional, national, and subnational studies)
Pathways and sub-pathways	Climatic shocks: drought, flooding, storm, temperature shocks, precipitation shocks, other Long-term climatic and related changes: temperature, precipitation, sea level rise, other Environmental pull factors Adaptation and mitigation Perceptions and narratives
Type of finding	Estimate (i.e. of number of current or historical migrants) Projection (i.e. of future number) Mechanisms/processes (i.e. qualitative findings)
Climate-migration relationship examined	Exposure (i.e. direct and indirect impacts) Vulnerability (i.e. who will be affected) Adaptations to climate migration pressures Barriers to migration or return

Migration type	International, internal or unspecified Permanent, temporary or unspecified Forced, voluntary or unspecified Multiple waves of migration
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Table A4. Coding framework for reviewed studies

Component	Assessment questions ¹⁰	Scoring
Rigour	<p>1) Does the study present a specific research question and a conceptual or theoretical framework?</p> <p>2) Does the study comprehensively engage with existing research on the topic?</p> <p>3) Does the study clearly identify and explain its research design and data collection methods, and are the methods appropriate to the research question? <i>Secondary reviews:</i> Does the review clearly describe where and how studies were identified and selected for inclusion, and are the methods appropriate to the research question?</p> <p>4) Is the study transparent in presenting both the research context and the data it analyses?</p> <p>5) Does the study demonstrate internal validity (i.e. does it clearly explore relationships or effects between variables or phenomena, with attention to potential effects of alternative factors)?¹¹ <i>Secondary reviews:</i> Does the author assess the quality of studies reviewed based on clear assessment criteria?</p> <p>6) Are the conclusions clearly based on/substantiated by the study data and findings?</p>	<p>Score out of 6</p> <p>For each question: 'yes' = 1, 'no' = 0</p> <p>5 or 6: high 3 or 4: moderate 0 to 2: low</p>

¹⁰ Reliability was not identified as a specific quality assessment factor, given that specific study measures and the study's replicability may not be rapidly assessable for most of the studies identified (including estimate and projection studies). Cultural sensitivity was also not identified as a specific assessment factor given that some studies of climate change-migration linkages do not involve any social research (and acknowledgement of the potential effects of context-specific factors on relationships between variables or phenomena might also be considered in assessments of validity). Relevance was not considered as a specific factor as we assumed that all studies which passed the inclusion criteria outlined were of relevance to the REA.

¹¹ 'Alternative factors' include 'confounding' variables, considering both claims of causal impact as well as correlations and links between phenomena (for instance, whether alternative factors potentially affecting these relationships are considered). Acknowledgement of the potential effects of context-specific factors on relationships between variables or phenomena are also be considered in assessments of validity.

Confidence	<ol style="list-style-type: none"> 1) Are the study's central findings on estimates and/or projections based on credible assumptions?¹² 2) Are the study's central findings on estimates and/or projections based on credible data and data analysis?¹³ 3) Where the study's central findings on estimates and/or projections have been analysed within other expert studies and expert commentary, have they generally been deemed credible?¹⁴ 	
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Table A5. Quality appraisal framework for individual studies

¹² Three main types of assumption are considered: 1) assumptions about projected environmental changes (e.g. about the extent of sea level rise or global temperature changes); 2) assumptions about causality (in cases where causal dynamics have been improperly inferred from correlations); and 3) assumptions about adaptation to projected environmental changes (including assumptions that there will be little/no adaptation, and assumptions that there will be 100% adaptation). Where possible, we use IPCC and other international reports and methods plus expert commentary, as our baselines for assessing the credibility of assumptions (e.g. we identify the climate or socio-economic scenarios that they are based on, and identify any major criticisms of them).

¹³ Key here is whether findings are underpinned by analysis of a dataset, or conversely, whether they simply reproduce estimates from compilations of government, NGO, media and/or other sources. This question was needed because, while in most studies the issue of data collection would be covered by question 3, there also exist a small number of studies which are in most respects highly rigorous but which alongside this make weakly substantiated claims about migration numbers.

¹⁴ This element of the confidence assessment involved reviewing a) primary and secondary studies which are already part of our dataset, b) expert commentary in the media for select highly cited or high-profile studies (identified through Google searches).

APPENDIX B: SUMMARY OF REA STUDIES

Coding notes:

- **Publication type (PT):** PRJA = peer-reviewed journal article, INGO = international NGO report, IOR = international organisation report, ORR = other research report
- **Research type (RT):** PRS = primary research study, SRS = secondary research study
- **Research method (RM):** Qn = quantitative, Ql = qualitative, MM = mixed methods
- **Scale (S):** G = global, R = regional, N = national, SN = subnational or local
- **Region (R):** SIS = small island states, BB = Bay of Bengal, EAs = East Asia, SEA = Southeast Asia, SAs = South Asia, WAs = West Asia, SSA = Sub-Saharan Africa, EAf = East Africa, SAf = Southern Africa, WAf = West Africa, Sah = Sahel, NAF = North Africa, ME = Middle East, Car = Caribbean, CAm = Central America, SAm = South America
- **Pathway (P):** P1 = climatic shocks, P2 = long-term climatic and related changes, P3 = environmental pull factors, P4 = adaptation and mitigation, P5 = perceptions and narratives
- **Finding type (FT):** MP = mechanisms and processes, E = estimate, P = projection
- **Rigour assessment (RA):** H = high, M = moderate, L = low

Author(s)	Year	PT	RT	RM	S	R	P	FT	RA
Abel, Brottrager, <i>et al.</i>	2019	PRJA	PRS	Qn	G	--	P1	MP	H
Abu, Codjoe, Sward	2014	PRJA	PRS	Qn	SN	WAf	P5	MP	M
Adam, Kjosavik, Shanmugaratnam	2018	PRJA	PRS	Ql	SN	BB	P4	MP	H
Adams	2016	PRJA	PRS	Qn	SN	SAm	P5	MP	H
Adger, de Campos, <i>et al.</i>	2021	PRJA	PRS	Qn	SN	BB, WAf	P1, P5	MP	H
Adri, Simon	2018	PRJA	PRS	MM	SN	BB	P1, P5	MP	H
Afifi, Govil, <i>et al.</i>	2012	ORR	PRS	Ql	R	EAf	P5	MP	M
Afifi, Liwenga, Kwezi	2014	PRJA	PRS	MM	SN	EAf	P1, P5	MP	M
Afifi, Milan, <i>et al.</i>	2016	PRJA	PRS	MM	SN	BB, SEA, EAf, WAf, CAm, SAm	P1, P5	MP	M
Ahmad, Afzal	2020	PRJA	PRS	Qn	SN	SAs	P1	MP	M
Ahmed, Hassan, <i>et al.</i>	2012	ORR	PRS	MM	SN	BB	P1, P5	MP	M
Alam, Alam, Mushtaq	2017	PRJA	PRS	Qn	SN	BB	P5	MP	M
Alam, Alam, Mushtaq	2020	PRJA	PRS	MM	SN	BB	P5	MP	M
Anderson, Silva	2020	PRJA	PRS	MM	SN	SAf	P5	MP	H
Antwi-Agyei, Dougill, <i>et al.</i>	2018	PRJA	PRS	MM	SN	WAf	P1, P5	MP	H
Anzellini, Benet, <i>et al.</i>	2021	IOR	SRS	Qn	R	ME, NAF	P1	E, P	M
Arnall	2014	PRJA	PRS	Ql	SN	SAf	P4	MP	M
Arnall, Kothari	2015	PRJA	PRS	Ql	N	SIS	P2, P5	MP	H
Assaduzzaman, Filatova, <i>et al.</i>	2020	PRJA	PRS	Ql	SN	BB	P1, P5	MP	M

Atuoye, Luginaah, <i>et al.</i>	2021	PRJA	PRS	Qn	SN	Eaf	P4	MP	H
Ayeb-Karlsson	2020b	PRJA	PRS	MM	N	BB	P1	MP	H
Ayeb-Karlsson	2020a	PRJA	PRS	QI	N	BB	P1	MP	H
Ayeb-Karlsson, Kniveton, Cannon	2020	PRJA	PRS	MM	SN	BB	P1	MP	H
Ayeb-Karlsson,van der Geest, <i>et al.</i>	2016	PRJA	PRS	QI	SN	BB	P1	MP	H
Backhaus, Martinez- Zarzoso, Muris	2015	PRJA	PRS	Qn	G	--	P1	MP	M
Baez, Caruso, <i>et al.</i>	2017a	PRJA	PRS	Qn	R	SIS (Car), CAm	P1	MP	M
Baez, Caruso, <i>et al.</i>	2017b	PRJA	PRS	Qn	R	SIS (Car), CAm	P1	MP	M
Bakaki	2021	PRJA	PRS	Qn	G	--	P1	MP	H
Barbieri, Domingues, <i>et al.</i>	2010	PRJA	PRS	Qn	SN	SAm	P2	P	H
Barrios Puente, Perez, Gitter	2016	PRJA	PRS	Qn	N	CAm	P2	MP	M
Barrios, Bertinelli, Strobl	2006	PRJA	PRS	Qn	R	SSA	P2	MP	H
Bawakyillenuo, Yaro, Teye	2016	PRJA	PRS	MM	SN	Waf	P1, P5	MP	M
Beine, Parsons	2015	PRJA	PRS	Qn	G	--	P1, P2	MP	H
Beine, Parsons	2017	PRJA	PRS	Qn	G	--	P1	MP	M
Bell, Wrathall, <i>et al.</i>	2021	PRJA	PRS	Qn	N	BB	P2	P	H
Berlemann, Steinhardt	2017	PRJA	PRS	QI	G	--	P1, P2	MP	M
Bernzen, Jenkins, Braun	2019	PRJA	PRS	Qn	N	BB	P1	MP	H
Bertana	2020	PRJA	PRS	QI	SN	SIS	P2, P5	MP	H
Beyerl, Mieg, Weber	2018	PRJA	PRS	MM	N	SIS	P2, P5	MP	H
Bhatta, Aggarwal	2016	PRJA	PRS	MM	R	BB, SAs	P1	MP	M
Birk, Rasmussen	2014	PRJA	PRS	QI	N	SIS	P2	MP	H
Bohra-Mishra, Oppenheimer, Hsiang	2014	PRJA	PRS	Qn	N	SEA	P1	MP, E	M
Bohra-Mishra, Oppenheimer, <i>et al.</i>	2017	PRJA	PRS	Qn	N	SEA	P1	MP	H
Bola, Mabiza, <i>et al.</i>	2014	PRJA	PRS	MM	SN	Saf	P1, P5	MP	M
Borderon, Sakdapolrak, <i>et al.</i>	2019	PRJA	SRS	QI	R	SSA	P1, P2	MP	M
Bordner, Ferguson, Ortolano	2020	PRJA	PRS	QI	N	SIS	P2, P5	MP	H
Buchori, Pramitasari, <i>et al.</i>	2021	PRJA	PRS	MM	SN	SEA	P1, P2	MP	H
Buchori, Pramitasari, <i>et al.</i>	2018	PRJA	PRS	Qn	SN	SEA	P1, P2	MP	H
Burnham, Ma	2018	PRJA	PRS	QI	SN	EAs	P4	MP	H
Cai, Feng, <i>et al.</i>	2016	PRJA	PRS	Qn	G	--	P1	MP	M
Call, Gray, <i>et al.</i>	2017	PRJA	PRS	Qn	SN	BB	P1	MP	H
Call, Gray	2020	PRJA	PRS	Qn	N	Eaf	P1	MP	H
Campbell, Oakes, Milan	2016	ORR	PRS	MM	N	SIS	P2, P5	MP	H
Carrico, Donato	2019	PRJA	PRS	Qn	N	BB	P1	MP	H

Cattaneo, Peri	2016	PRJA	PRS	Qn	G	--	P2	MP	H
Chandra, McNamara, <i>et al.</i>	2017	PRJA	PRS	Ql	SN	SEA	P5	MP	H
Chann	2021	PRJA	PRS	Ql	SN	SEA	P5	MP	M
Chen, Mueller	2019	PRJA	PRS	Qn	N	BB	P1, P2	MP, P	H
Chen, Mueller	2018	PRJA	PRS	Qn	N	BB	P1, P2	MP, P	H
Chen, Mueller, <i>et al.</i>	2017	PRJA	PRS	Qn	N	BB	P1	MP	M
Chen, Caldeira	2020	PRJA	PRS	Qn	G	--	P2	P	M
Chort, de la Rupelle	2016	PRJA	PRS	Qn	N	CAM	P1	MP	H
Christian Aid	2007	INGO	SRS	Ql	G	--	P1	P	L
Chun	2014	IOR	PRS	MM	SN	SEA	P1, P3	MP	M
Codjoe, Nyamedor, <i>et al.</i>	2017	PRJA	PRS	Qn	SN	Waf	P2	MP	H
Coniglio, Pesce	2015	PRJA	PRS	Qn	G	--	P1	MP	H
Connell, Lutkehaus	2017	PRJA	PRS	Ql	N	SIS	P2	MP	H
Constable	2017	PRJA	PRS	Ql	R	SIS	P2	MP	H
Dallmann, Millock	2017	PRJA	PRS	Qn	N	SAs	P1	MP, E	H
Dasgupta, Laplante, <i>et al.</i>	2007	IOR	PRS	Qn	G	--	P2	P	M
Davis, Bhattachan, <i>et al.</i>	2018	PRJA	PRS	Qn	N	BB	P2	P	M
De Longueville, Ozer, <i>et al.</i>	2020	PRJA	PRS	Qn	N	Sah	P1, P5	MP	H
De Longueville, Zhu, Henry	2019	PRJA	PRS	Qn	N	Sah	P1	MP	H
Defrance, Ramstein, <i>et al.</i>	2017	PRJA	PRS	Qn	R	Sah	P2	MP, P	M
Delazeri, Da Cunha, Oliveira	2021	PRJA	PRS	Qn	SN	SAm	P1	MP	H
Deshingkar, Wood, Béné	2015	ORR	PRS	Ql	N	Eaf, SAf	P1, P5	MP	H
Dillon, Mueller, Salau	2011	PRJA	PRS	Qn	SN	Sah	P1	MP	M
Drabo, Mbaye	2015	PRJA	PRS	Qn	G	--	P1	MP	M
Dumenu, Obeng	2016	PRJA	PRS	Qn	N	Waf	P1, P5	MP	H
Dun	2011	PRJA	PRS	Ql	SN	SEA	P1	MP	M
Edwards	2013	PRJA	PRS	Ql	SN	SIS	P2, P5	MP	H
Enete, Obi, <i>et al.</i>	2016	PRJA	PRS	Qn	SN	Waf	P1	MP	M
Entwisle, Williams, <i>et al.</i>	2016	PRJA	PRS	Qn	SN	SEA	P1	MP	H
Entwisle, Williams, Verdery	2020	PRJA	PRS	Qn	SN	SEA	P1	MP	H
Entzinger, Scholten	2016	IOR	PRS	MM	SN	SEA	P1, P3	MP	M
Etana, Snelder, <i>et al.</i>	2020	PRJA	PRS	Qn	SN	Eaf	P1	MP	H
Etzold, Ahmed, <i>et al.</i>	2014	PRJA	PRS	MM	SN	BB	P1, P5	MP	H
Evertsen, van der Geest	2020	PRJA	PRS	Ql	N	BB	P2	MP	H
Falco, Galeotti, Olper	2019	PRJA	PRS	Qn	G	--	P1	MP	H

Farbotko, Lazrus	2012	PRJA	PRS	QI	N	SIS	P2, P5	MP	M
Farbotko, Stratford, Lazrus	2016	PRJA	PRS	QI	N	SIS	P2, P5	MP	H
Feng, Krueger, Oppenheimer	2010	PRJA	PRS	Qn	N	CAm	P1	MP, P	M
Gautam	2017	PRJA	PRS	MM	SN	SAs	P5	MP	H
Ginnetti, Milano	2019	IOR	PRS	Qn	G	--	P1	P	M
Gioli, Khan, <i>et al.</i>	2014	PRJA	PRS	MM	SN	SAs	P1, P5	MP	M
Goldbach	2017	PRJA	PRS	Qn	SN	SEA, Waf	P1, P2, P5	MP	M
Grace, Hertrich, <i>et al.</i>	2018	PRJA	PRS	Qn	N	Sah	P1	MP	H
Gray, Bilsborrow	2013	PRJA	PRS	Qn	N	SAm	P1	MP	M
Gray, Mueller	2012a	PRJA	PRS	Qn	N	Eaf	P1	MP	H
Gray, Wise	2016	PRJA	PRS	Qn	R	Eaf, Sah	P1	MP	M
Gray, Mueller	2012b	PRJA	PRS	Qn	N	BB	P1	MP	H
Groth, Ide, <i>et al.</i>	2020	PRJA	PRS	QI	SN	Eaf	P1	MP	H
Haeffner, Baggio, Galvin	2018	PRJA	PRS	MM	SN	CAm	P1	MP	H
Hassani-Mahmooei, Parris	2012	PRJA	PRS	Qn	N	BB	P1	P	M
Hauer, Fussell, <i>et al.</i>	2020	PRJA	SRS	QI	G	--	P2	MP	M
Henderson, Storeygard, Deichmann	2017	PRJA	PRS	Qn	R	SSA	P1	MP	H
Henrique, Tschakert	2019	PRJA	PRS	QI	SN	SAm	P4	MP	H
Hermann, Kempf	2017	PRJA	PRS	QI	N	SIS	P2, P5	MP	H
Hermans, Garbe	2019	PRJA	PRS	MM	SN	Eaf	P1	MP	H
Hillmann, Spaan	2017	PRJA	PRS	MM	SN	SEA, Waf	P2	MP	H
Hirvonen	2016	PRJA	PRS	Qn	SN	Eaf	P1	MP	M
Ho, Milan	2012	ORR	PRS	MM	SN	SAm	P1, P5	MP	M
Hoffmann, Dimitrova, <i>et al.</i>	2020	PRJA	SRS	Qn	G	--	P1	MP	M
Hummel	2016	PRJA	PRS	MM	N	Sah	P1, P5	MP	H
Hunter, Murray, Riosmena	2013	PRJA	PRS	Qn	N	CAm	P1	MP	H
Ingham, Islam, Hicks	2019	PRJA	PRS	QI	N	BB	P1	MP	H
Institute for Economics and Peace	2020	IOR	PRS	Qn	G	--	P1, P2	E, P	L
IDMC	2020	IOR	SRS	Qn	G	--	P1	E	L
IDMC	2021	IOR	SRS	Qn	G	--	P1	E	L
IDMC	2019	IOR	SRS	Qn	G	--	P1	E	L
IDMC	2018	IOR	SRS	Qn	G	--	P1	E	L
IDMC	2015	IOR	SRS	Qn	G	--	P1	E	L
IDMC	2014	IOR	SRS	Qn	G	--	P1	E	L
IDMC	2016	IOR	SRS	Qn	G	--	P1	E	L
IDMC	2012	IOR	SRS	Qn	G	--	P1	E	L
IDMC	2017	IOR	SRS	Qn	G	--	P1	E	L
Iqbal, Roy	2015	PRJA	PRS	Qn	N	BB	P1	MP, P	H

Ishtiaque, Nazem	2017	PRJA	PRS	Qn	SN	BB	P1, P5	MP	M
Islam	2018	PRJA	PRS	MM	N	BB	P2	MP	H
Islam, Hasan	2016	PRJA	PRS	MM	SN	BB	P1	MP	M
Jamero, Onuki, <i>et al.</i>	2019	PRJA	PRS	QI	SN	SEA	P2	MP	M
Jamero, Onuki, <i>et al.</i>	2017	PRJA	PRS	MM	SN	SEA	P2	MP	H
Jha, Gupta, <i>et al.</i>	2018	PRJA	PRS	Qn	SN	SAs	P5	MP	M
Joarder, Miller	2013	PRJA	PRS	Qn	N	BB	P1	MP	M
Johnson, Mortensen, <i>et al.</i>	2021	PRJA	PRS	QI	N	SIS, SEA	P2, P4	MP	H
Kabir, Serrao-Neumann, <i>et al.</i>	2018	PRJA	PRS	Qn	SN	BB	P1	MP	H
Kabir, Alauddin, Crimp	2017	PRJA	PRS	MM	SN	BB	P1, P5	MP	M
Kabir, Cramb, <i>et al.</i>	2017	PRJA	PRS	MM	SN	BB	P1, P5	MP	M
Kaczan, Orgill-Meyer	2020	PRJA	SRS	QI	G	--	P1	MP	H
Kakinuma, Puma, <i>et al.</i>	2020	PRJA	PRS	Qn	G	--	P1	MP	H
Kam, Aznar-Siguan, <i>et al.</i>	2021	PRJA	PRS	Qn	G	--	P1, P2	P	M
Kartiki	2011	PRJA	PRS	QI	N	BB	P1	MP	H
Kattumuri, Ravindranath, Esteves	2017	PRJA	PRS	MM	SN	SAs	P1, P5	MP	M
Kelley, Mohtadi, <i>et al.</i>	2015	PRJA	PRS	Qn	N	WAs	P1	MP, E	M
Kelman, Orlowska, <i>et al.</i>	2019	PRJA	PRS	QI	N	SIS	P2, P5	MP	H
Kelman, Upadhyay, <i>et al.</i>	2017	PRJA	PRS	QI	SN	BB, SIS	P2, P5	MP	H
Khanian, Serpoush, Gheitarani	2019	PRJA	PRS	Qn	SN	WAs	P1, P5	MP	H
Khavarian-Garmsir, Pourahmad, <i>et al.</i>	2019	PRJA	PRS	MM	SN	WAs	P5	MP	H
Khoa, Thao, van der Geest	2012	ORR	PRS	MM	SN	SEA	P1, P5	MP	M
Kothari	2014	PRJA	PRS	QI	N	SIS	P5	MP	M
Koubi, Spilker, Schaffer, Bernauer	2016	PRJA	PRS	Qn	N	SEA	P1, P5	MP	M
Koubi, Spilker, Schaffer, Böhmelt	2016	PRJA	PRS	Qn	N	SEA, Eaf, Waf, CAm, SAm	P1, P5	MP	M
Koubi, Stoll, Spilker	2016	PRJA	PRS	Qn	N	SEA	P1, P5	MP	M
Kubik, Maurel	2016	PRJA	PRS	Qn	N	Eaf	P1	MP	M
Lewin, Fisher, Weber	2012	PRJA	PRS	Qn	N	SAf	P1	MP	M
Leyk, Runfola, <i>et al.</i>	2017	PRJA	PRS	Qn	N	CAm	P1	MP	H
Lilleør, Van den Broeck	2011	PRJA	SRS	QI	G	--	P1	MP	M
Lindegaard	2020	PRJA	PRS	QI	SN	SEA	P2, P5	MP	H
Liwenga, Kwezi, Afifi	2012	ORR	PRS	MM	SN	Eaf	P1, P5	MP	M
Loebach	2016	PRJA	PRS	Qn	N	CAm	P1	MP	H
Loebach, Korinek	2019	PRJA	PRS	Qn	N	CAm	P1	MP	H
Lu, Wrathall, <i>et al.</i>	2016b	PRJA	PRS	Qn	N	BB	P1	MP	M

Lu, Wrathall, <i>et al.</i>	2016a	PRJA	PRS	Qn	SN	BB	P1	MP	M
Lunstrum	2016	PRJA	PRS	Ql	SN	SAf	P4	MP	M
Lustgarten	2020	ORR	PRS	Qn	R	CAm	P1, P2	P	L
Magnan, Schipper, <i>et al.</i>	2016	PRJA	SRS	Ql	G	--	P4	MP	H
Maharjan, de Campos, <i>et al.</i>	2020	PRJA	PRS	Qn	R	BB, SAs	P5	MP	H
Maharjan, Tuladhar, <i>et al.</i>	2021	PRJA	PRS	MM	R	SAs	P1, P5	MP	M
Maia, Schons	2020	PRJA	PRS	Qn	SN	SAm	P1	MP	H
Marchiori, Maystadt, Schumacher	2012	PRJA	PRS	Qn	R	SSA	P1	MP, E, P	H
Marino, Lazrus	2015	PRJA	PRS	Ql	SN	SIS	P5	MP	M
Martin, Billah, <i>et al.</i>	2014	PRJA	PRS	Ql	SN	BB	P5	MP	H
Mastrorillo, Licker, <i>et al.</i>	2016	PRJA	PRS	Qn	N	SAf	P1	MP	M
Maurel, Tuccio	2016	PRJA	PRS	Qn	G	--	P1	MP	H
Mavhura, Collins, Bongo	2017	PRJA	PRS	MM	SN	SAf	P1, P4	MP	H
McMichael, Katonivualiku	2020	PRJA	PRS	Ql	N	SIS	P2, P5	MP	H
McMichael, Dasgupta, <i>et al.</i>	2020	PRJA	SRS	Ql	G	--	P2	E	M
McMichael, Katonivualiku, Powell	2019	PRJA	PRS	Ql	N	SIS	P2	MP	H
McNamara, Des Combes	2015	PRJA	PRS	Ql	SN	SIS	P2	MP	M
Milan, Ho	2014	PRJA	PRS	MM	SN	SAm	P1, P5	MP	M
Milan, Ruano	2014	PRJA	PRS	Qn	SN	CAm	P1, P5	MP	M
Milan, Oakes, Campbell	2016	ORR	PRS	MM	N	SIS	P2	MP, P	M
Missirian, Schlenker	2017	PRJA	PRS	Qn	G	--	P2	P	M
Morrissey	2013	PRJA	PRS	Ql	SN	EAF	P1, P5	MP	H
Mortreux, Barnett	2009	PRJA	PRS	Ql	SN	SIS	P2, P5	MP	H
Mortreux, de Campos, <i>et al.</i>	2018	PRJA	PRS	Ql	SN	SAs	P1, P2	MP	H
Motsholapheko, Kgathi, Vanderpost	2011	PRJA	PRS	MM	SN	SAf	P1	MP	H
Mueller, Gray, Hopping	2020	PRJA	PRS	Qn	N	EAF, SAf	P1	MP	M
Mueller, Gray, Kosec	2014	PRJA	PRS	Qn	N	SAs	P1	MP	M
Mueller, Sheriff, <i>et al.</i>	2020	PRJA	PRS	Qn	R	EAF	P1	MP	H
Murali, Afifi	2012	ORR	PRS	MM	SN	SAs	P1, P5	MP	M
Nawrotzki, Bakhtsiyarava	2017	PRJA	PRS	Qn	N	Sah	P1	MP	H
Nawrotzki, DeWaard	2016	PRJA	PRS	Qn	N	CAm	P1	MP	H
Nawrotzki, DeWaard	2018	PRJA	PRS	Qn	N	SAf	P1	MP	H
Nawrotzki, DeWaard, <i>et al.</i>	2017	PRJA	PRS	Qn	N	CAm	P1	MP	M
Nawrotzki, Hunter, <i>et al.</i>	2015	PRJA	PRS	Qn	N	CAm	P1	MP	M

Nawrotzki, Riosmena, Hunter	2013	PRJA	PRS	Qn	N	CAm	P1	MP	H
Nawrotzki, Riosmena, <i>et al.</i>	2015	PRJA	PRS	Qn	N	CAm	P1	MP	H
Nawrotzki, Schlak, Kugler	2016	PRJA	PRS	Qn	N	Sah	P1	MP	M
Neef, Bengel, <i>et al.</i>	2018	PRJA	PRS	MM	SN	SIS	P2, P5	MP	H
Ng'ang'a, Bulte, <i>et al.</i>	2016	PRJA	PRS	Qn	SN	EAF	P3	MP	H
Nguyen	2021	PRJA	PRS	Qn	N	SEA	P1	MP	H
Nicholls, Marinova, <i>et al.</i>	2011	PRJA	PRS	Qn	G	--	P2	P	M
Nichols	2019	PRJA	PRS	QI	SN	SIS	P2	MP	H
Oakes	2019	PRJA	PRS	MM	R	SIS	P2, P5	MP	H
Oakes, Milan, Campbell	2016	ORR	PRS	MM	N	SIS	P2, P5	MP, P	M
Ocello, Petrucci, <i>et al.</i>	2015	PRJA	PRS	Qn	N	EAF	P1	MP	M
Oliveira, Pereda	2020	PRJA	PRS	Qn	N	SAm	P2	MP, P	M
Omerkhil, Kumar, <i>et al.</i>	2020	PRJA	PRS	Qn	SN	SAs	P5	MP	H
Opondo	2013	PRJA	PRS	MM	SN	EAF	P1, P5	MP	M
Owain, Maslin	2018	PRJA	PRS	Qn	R	EAF, SAF	P1	MP	H
Owen, Wesselbaum	2020	PRJA	PRS	Qn	G	--	P1	MP	M
Owusu-Daaku	2018	PRJA	PRS	QI	SN	WAF	P4	MP	M
Pajaron, Vasquez	2020	PRJA	PRS	Qn	N	SEA	P1	MP	H
Paprocki	2020	PRJA	PRS	QI	SN	BB	P4, P5	MP	H
Paprocki	2019	PRJA	PRS	QI	SN	BB	P4, P5	MP	H
Paprocki	2018	PRJA	PRS	QI	SN	BB	P4, P5	MP	H
Parsons, Chann	2019	PRJA	PRS	MM	N	SEA	P5	MP	H
Penning-Rowell, Sultana, Thompson	2013	PRJA	PRS	QI	N	BB	P1	MP	M
Perumal	2018	PRJA	PRS	QI	SN	SIS	P2, P5	MP	H
Piggott-McKellar, McNamara, <i>et al.</i>	2019	PRJA	PRS	QI	SN	SIS	P2, P5	MP	H
Promburom, Sakdapolrak	2012	ORR	PRS	MM	SN	SEA	P1, P5	MP	M
Radel, Schmook, <i>et al.</i>	2018	PRJA	PRS	MM	SN	CAm	P5	MP	H
Rademacher-Schulz, Mahama	2012	ORR	PRS	MM	SN	WAF	P1, P2, P5	MP	H
Rahman, Paul, <i>et al.</i>	2015	PRJA	PRS	Qn	SN	BB	P1	MP	M
Rajan	2009	INGO	PRS	Qn	R	BB	P3	P	L
Rakib, Sasaki, <i>et al.</i>	2019	PRJA	PRS	MM	SN	BB	P2	MP	M
Ransan-Cooper	2016	PRJA	PRS	QI	SN	SEA	P5	MP	H
Raoul	2015	PRJA	PRS	QI	SN	SAm	P2	MP	H
Rigaud, de Sherbinin, <i>et al.</i>	2018	IOR	PRS	Qn	G	--	P2	P	M
Riosmena, Nawrotzki, Hunter	2018	PRJA	PRS	Qn	N	CAm	P1	MP	H

Robalino, Jimenez, Chacón	2015	PRJA	PRS	Qn	N	CAm	P1	MP	H
Roland, Curtis	2020	PRJA	PRS	Qn	N	SIS	P1	MP	H
Ruano, Milan	2014	ORR	PRS	MM	SN	CAm	P1, P5	MP	M
Ruehr	2021	PRJA	PRS	QI	SN	SIS	P2, P5	MP	H
Sakdapolrak, Promburom, Reif	2014	PRJA	PRS	MM	SN	SEA	P1, P5	MP	M
Scheffran, Marmer, Sow	2012	PRJA	SRS	QI	N	Sah	P1	MP	M
Schmidt	2019	PRJA	PRS	QI	SN	CAm	P2	MP	H
Sedova, Kalkuhl	2020	PRJA	SRS	Qn	N	SAs	P1	MP, E	H
See, Wilmsen	2020	PRJA	PRS	MM	SN	SEA	P1, P2, P4	MP	H
Shen, Gemenne	2011	PRJA	PRS	QI	N	SIS	P2, P5	MP	M
Shi, Lyu, <i>et al.</i>	2019	PRJA	PRS	Qn	SN	EAs	P5	MP	M
Shi, Sun, <i>et al.</i>	2019	PRJA	PRS	Qn	SN	EAs	P5	MP	M
Shinn	2018	PRJA	PRS	MM	SN	SAf	P1, P4	MP	H
Shinn, King, <i>et al.</i>	2014	PRJA	PRS	MM	SN	SAf	P1, P4	MP	H
Simatele, Simatele	2015	PRJA	PRS	QI	SN	SAf	P1, P5	MP	H
Singh	2019	PRJA	PRS	MM	SN	BB	P5	MP	H
Singh, Basu	2020	PRJA	PRS	QI	SN	BB	P5	MP	H
Singh, Rahman, <i>et al.</i>	2018	PRJA	PRS	MM	SN	BB	P5	MP	M
Smith	2013	PRJA	PRS	QI	SN	SIS	P2, P5	MP	M
Speelman, Nicholls, Dyke	2017	PRJA	PRS	Qn	N	SIS	P2	MP	H
Spencer, Urquhart	2018	PRJA	PRS	Qn	R	SIS (Car), CAm	P1	MP, E	H
Stojanov, Duži, <i>et al.</i>	2017	PRJA	PRS	Qn	SN	SIS	P2, P5	MP	M
Suckall, Fraser, Forster	2017	PRJA	PRS	MM	N	SAf	P5	MP	H
Sultan	2017	IOR	PRS	MM	N	SIS	P5	MP	M
Sultana, Thompson, Wesselink	2020	PRJA	PRS	MM	SN	BB	P1	MP	M
Tan	2017	PRJA	PRS	Qn	SN	EAs	P5	MP	H
Thiede, Gray	2017	PRJA	PRS	Qn	N	SEA	P1	MP	H
Thiede, Gray, Mueller	2016	PRJA	PRS	Qn	R	SAm	P1	MP	M
van der Geest, K.	2011	PRJA	PRS	MM	N	Waf	P3, P5	MP	M
van der Geest, Burkett, <i>et al.</i>	2020	PRJA	PRS	MM	N	SIS	P2, P5	MP	M
van der Land, Hummel	2013	PRJA	PRS	MM	SN	Sah	P1	MP	M
Warner, Afifi	2014	PRJA	PRS	MM	SN	BB, SEA, Eaf, Waf, CAm, SAm	P1, P5	MP	H
Warner, Afifi, <i>et al.</i>	2012	ORR	PRS	MM	N	BB, SEA, Eaf, Waf, CAm, SAm	P1, P5	MP	H
Weinreb, Stecklov, Arslan	2020	PRJA	PRS	Qn	R	SSA	P2	MP	H

Wesselbaum	2019	PRJA	PRS	Qn	G	--	P1	MP	M
Wesselbaum, Aburn	2019	PRJA	PRS	Qn	G	--	P1	MP	H
Williams, Arguillas, Arguillas	2020	PRJA	PRS	Ql	SN	SEA	P1, P2	MP	H
Wrathall, Bury, <i>et al.</i>	2014	PRJA	PRS	MM	SN	Cam, SAm	P1, P2	MP	M
Xu, Kohler, <i>et al.</i>	2020	PRJA	PRS	Qn	G	--	P2	P	L
Xu, Zhang, Chen	2021	PRJA	PRS	Qn	N	EAs	P1	MP	H
Zander, Richerzhagen, Garnett	2019	PRJA	PRS	Qn	N	SEA	P5	MP	H
Zickgraf	2019	PRJA	PRS	Ql	SN	SEA, Sah	P1, P2	MP	H

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