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# Introducing the Transnational Climate Impacts Index: Indicators of country-level exposure – methodology report

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## ABSTRACT

Climate change mitigation is widely regarded as a global problem, but climate change impacts and adaptation are typically described as regional or local issues. This reflects the location-specific nature of physical impacts, but it fails to recognize the many interconnections among countries and regions, particularly in an increasingly globalized economy. This paper introduces a new framework for examining climate change impacts and adaptation needs from an international perspective. Based on this framework, we develop indicators of country-level exposure to what we call the transnational impacts of climate change: those that occur in one place as a consequence of climate impacts somewhere else. The indicators allow us to quantify each country's exposure across multiple dimensions. We also construct a composite index: the Transnational Climate Impacts Index. The paper explains the rationale and methodology by which indicators were selected, and invites feedback and suggestions from readers on how to further develop this research. We see significant opportunities to strengthen and deepen the quantitative assessment of exposure to transnational climate impacts, including via applications of the framework at the national rather than global level.

## CONTENTS

## FOREWORD AND ACKNOWLEDGEMENTS

This publication is an output of the Adaptation without Borders project. Other publications from this project are available at https://www.weadapt.org/knowledge-base/adaptation-without-borders, including:

- A conceptual framework for assessing the indirect impacts of climate change
- Policy brief: *National Adaptation Plans and the indirect impacts of climate change*
- Discussion brief: *Reducing vulnerability to food price shocks in a changing climate*
- Short films: *Spotlight on Senegal: Adaptation without Borders • The politics of global rice markets • Climate change and rice self sufficiency*

The concept for the index was first presented in early 2014 (Benzie 2014b). A prototype was developed by a small team during the summer of 2015 with funding from Programme Support from the Swedish International Development Cooperation Agency (Sida) under the Adaptation without Borders project, with additional support from the Mistra SWECIA programme and European Commission via the research project IMPRESSIONS (FP7 grant No. 603416).

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High-resolution graphics and numerical results for the indicators and TCI Index are available on the SEI website, at https://www.sei-international.org/publications?pid=2970. A detailed methodological note for Indicator 8: Embedded water risk is also available on that page.

The authors welcome comments and feedback on the contents of this working paper.

# 1. INTRODUCTION

Climate change mitigation is widely seen as a global problem, but until now, climate impacts and adaptation have been treated mostly as regional or even local issues. For instance, the Intergovernmental Panel on Climate Change (IPCC), in its latest report, refers to "*localized* adaptation and the longer term *global* benefits of mitigation" (Burkett et al. 2014, p.184; emphasis added). Though this accurately reflects the location-specific nature of physical impacts and vulnerability, it fails to account for our increasingly connected and globalized world. Filling this gap requires a new lens through which to view climate impacts and adaptation responses.

This paper introduces a framework for quantitative assessment of country-level exposure to what we call the *transnational impacts* of climate change. Transnational climate impacts reach across borders, affecting one country – and requiring adaptation there – as a result of climate change or climate-induced extreme events in another country. We use our framework to develop nine indicators of country-level exposure and a composite index: the Transnational Climate Impacts (TCI) Index.

The paper explains the rationale and methodology by which we selected the indicators, which we intend to further develop in the future. We see significant opportunities to strengthen and deepen the quantitative assessment of exposure to transnational climate impacts, including via applications of the framework at the national rather than global level.

The work described in this document is preliminary, intended to spark discussion and raise awareness about the potential significance of transnational climate risks. We welcome constructive feedback from readers and invite suggestions for collaboration and future research.

## 1.1 Why 'transnational' risks?

It has proven difficult to identify appropriate terminology with which to describe what can be broadly referred to as the *international dimension of climate risk* (PwC 2013). Early work on the subject at SEI used the term "indirect climate impacts" – in contrast to "direct climate impacts" that occur within a country or other decision-making system (e.g. Benzie et al. 2013; Benzie 2014a). While conceptually accurate, the term "indirect" is used in many other contexts already, to describe different things. To avoid confusion, we thus sought a clearer term to apply to this concept.

The literature already includes several alternative terms such as "systemic risk" (e.g. OECD 2003; King et al. 2015), "cascading risk" (Goldin 2013), "connected risk" (Galaz et al. 2014; Goldin and Mariathasan 2014) or "double exposure" (Leichenko et al. 2010; O'Brien and Leichenko 2000). Terms such as "second order" (Flitner and Herbeck 2009) or "secondary effects" (Hunt et al. 2009) and "spillover effects" (used by European Commission) have been used in the context of climate change, as well as the phrase "the global context for local impacts" (Liverman 2016). The IPCC's *Fifth Assessment Report* does not offer any consistent terminology and cites only a small sample of literature on the topic, under the title "Indirect, trans-boundary and long-distance effects" (Oppenheimer et al. 2014, section 19.4).

As our work has evolved and stakeholders and policy-makers have provided feedback, we have repeatedly revisited the question of terminology. We also considered "external" (though this has strong implications in economics), "inter-national" (between or among countries), and "cross-border". After considering each term's literal definition, logical applications, conceptual clarity and communicative value, we chose "transnational" climate impacts. Along with accurately describing the concept, this term aligns our work with the literature on transnational climate governance (Dzebo and Stripple 2015; Bulkeley et al. 2014; Andonova et al. 2009), and thus with discussions of potential responses by actors at various scales.

## 1.2 Research and policy context

The transnational aspects of climate change impacts have not been extensively studied. As noted above, IPCC Working Group II has touched upon the issue, noting, for example, that impacts "can have consequences beyond the regions in which they occur" (Oppenheimer et al. 2014, p.1059). Another section notes that "[c]ross-regional phenomena can be crucial for understanding the ramifications of climate change at regional scales, and its impacts and policies of response" (Hewitson et al. 2014, p.1137). However, only a few examples are presented, as no systematic analysis has yet been undertaken in the literature. Specific papers dealing with national responses to cross-border, regional or global system-level aspects of climate impacts are few and far between.

To the best of our knowledge, the greatest attention to the international dimension of climate risks has so far been in the UK (Hunt et al. 2009; Foresight International Dimensions of Climate Change 2011; PwC 2013; London Assembly 2015). A Foresight report by the UK Government Office for Science states that "the consequences for the UK of climate change occurring in other parts of the world could be as important as climate change directly affecting these shores" (Foresight International Dimensions of Climate Change 2011, p.7). However, despite this growing evidence base on the types of risks the UK may face from climate change overseas, and the UK's well-developed adaptation governance structure, the actual response has been limited. The National Adaptation Programme refers to the international dimension of climate risk,[1] but it does not make clear who "owns" those risks, or how the UK might adapt.

The recent academic literature suggests that the international dimension of climate risk still tends to be ignored in adaptation research and practice. Liverman (2016) discusses knowledge gaps and research priorities in light of the third U.S. National Climate Assessment (NCA). She notes: "The NCA and many other regional climate impact studies generally do not take account of the global context for *local* climate impacts" (italics added).

There are also some early attempts to develop conceptual frameworks for understanding transnational impacts of climate change. For example, building on the ecology literature, Liu et al. (2013) introduce the concept of "telecoupling" as socioeconomic and environmental interactions, over distances, between coupled human and natural systems. Telecoupling could be said to be the underlying mechanism for much of what we call transnational impacts of climate change. Liu et al. (2013) use two additional terms, "teleconnections" and "globalization", to denote environmental interactions between natural systems and socioeconomic interactions between human systems, respectively.

Moser and Hart (2015), in turn, develop an approach that focuses on the *impacts* of climate change. They introduce eight "crucial" teleconnections and analyse four of them qualitatively with regard to how climate change could cause far-reaching impacts. They acknowledge that their list is incomplete, but argue that those eight teleconnections are fundamental when assessing the resilience of local communities. The framework developed in this paper resembles some of their analysis, but is simpler and focuses on *quantifying* teleconnected impacts.

[1] The most specific references come under the section on objectives for business, relating to international supply chains, etc. See Defra (2013).

The question of transnational impacts of climate change, or more generally of telecoupled (or -connected) environmental problems, has also gained interest among environmental governance scholars (see, e.g., Kissinger et al. 2011; Bulkeley and Jordan 2012; Compagnon et al. 2012). However, the governance perspective is beyond the scope of this particular paper.

Still, our framework and the TCI Index are directly relevant to national adaptation planning and policy-making. Our ultimate goal is to enhance decision-makers' capacity to identify and manage the international dimension of climate risks and thus produce higher-quality adaptation plans. The framework is designed so that it can eventually be applied to different sectors and at different geographical scales. As already noted, the TCI Index must be seen as a crude tool, meant to raise awareness and provoke discussions about transboundary impacts, internationally shared climate vulnerabilities and the potential implications for national adaptation planning. The version introduced in this paper can perhaps enable some level of initial comparison between countries, but is not intended to support decision-making at any scale. Future iterations and national level indicator-based assessments of exposure will be needed to support meaningful risk assessment and decision-making.[2]

In the next section, we present the process and method that were followed to identify a set of indicators of exposure to transnational climate impacts. In Section 3, the core of the paper, we present the results of nine indicators and briefly discuss the findings of each. Section 4 describes how these indicators are combined to create the global index, and Section 5 provides a short concluding discussion.

## 2. INDICATORS OF EXPOSURE

Unlike existing global indices that aim to show *vulnerability* to climate change, the indicators in this paper focus on *exposure* and, to some extent, *sensitivity* to transnational climate change impacts. The reason we have made this distinction is to avoid the additional layers of complexity and context-dependency that are involved with comprehensive assessments of vulnerability. Vulnerability is often understood as a function of a system's exposure and sensitivity to climate hazards, as modified by its ability to anticipate or respond – its adaptive capacity (IPCC 2007; see Endbox 1). Our indicators focus on the characteristics of countries – such as their openness and reliance on other countries or global systems, and interaction with others – that may influence their risk profile. We do not attempt to assess each country's adaptive capacity, or the broader context (e.g. poverty levels, political stability) that might increase or reduce its vulnerability.

It is also important to make clear that the TCI indicators assess *current exposure*, based on actual data. No attempt is made to project how exposure may change as the result of future socio-economic, climatic or other changes. Climate risk assessment based on these indicators therefore takes as a starting point an assumption that *if each country were to maintain its current characteristics* (e.g. in terms of trade profile), it might be exposed to increasing risks resulting from climate change in other countries.

Of course some aspects of a country's profile are subject to significant changes over short time horizons – for example, the sources of imports of various commodities or of financial flows. Other aspects, such as a country's long-term strategic trade partners – or even more so, which countries it adjoins, or which transboundary rivers flow through its territory – may not

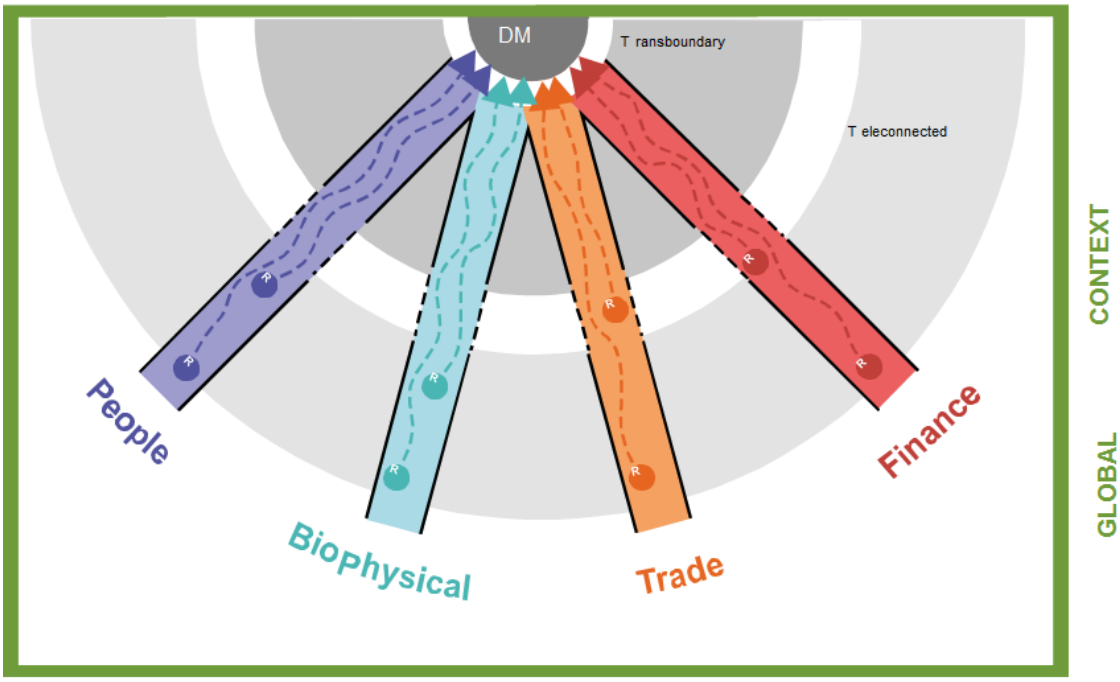
[2] Numerical results for the indicators and the TCI Index are available on the SEI website, at https://www.sei-international.org/publications?pid=2970.

change significantly or at all within current planning horizons. It is important to keep this in mind in reviewing the indicators. Their illustrative value is rooted in the world as it looks today, and at least parts of the results will need to be updated regularly to remain relevant.

## 2.1 Framing the indicators

The point of departure for the indicator assessment is that direct impacts in one country may be transferred by various flows to affect another country: what we call transnational climate impacts. We identify four climate risk pathways through which impacts can be transferred – biophysical, finance, trade and people – and also look at how risks are transmitted through global systems. Figure 1 and Box 1 below provide an illustration and details.

**Figure 1: The climate risk pathways framework of transnational climate impacts**




*R signifies a receptor system where the initial, direct climate impact occurs. DM signifies a decision-maker. Remote impacts of climate change can be transmitted from a nearby region (transboundary) or a distant region (teleconnected) via one of four pathways. Exposure to transnational impacts also depends on how embedded the country is in the global context (shown in green).*

The pathways operate over two different geographical scales that are relevant to decision-making and responses: *Transboundary* impacts are transmitted over borders between neighbouring countries, and could thus be addressed through regional cooperation. *Teleconnected* impacts result from more remote links, possibly due to direct climate impacts in a distant part of the globe, and may require more complex governance responses.

Countries may be more or less exposed to transnational climate impacts depending on the nature and extent of their connections with other countries and international systems. In developing indicators, we highlight two dimensions of exposure at the national level:

1. Openness to and reliance on international flows; and
2. The climate risk of other countries to which a given country is linked.

Also important are the climate sensitivity of specific flows – for example, whether a given commodity is more susceptible to climate impacts than another – as well as the capacity of each country to manage the risks associated with international flows – for example, many people or firms in high-income countries can afford to absorb price spikes affecting imported goods. These more detailed aspects are not considered in the indicators presented here because they require assessment at a very fine scale. However, we do make a distinction between openness to/reliance on international flows and the climate risk of links to specific countries in our indicators, as explained further below (see Section 2.3).

### Box 1: Climate risk pathways

The **biophysical pathway** encompasses transboundary ecosystems, such as international river basins, oceans and the atmosphere. Adverse climate impacts on one part of a transboundary ecosystem can create impacts for all the countries that share the ecosystem's services. For example, glacial melt and heavy rain upstream can create floods in downstream countries; droughts in the upper basin reduce water availability in delta cities; heat wave- and drought-induced forest fires in one country can disturb the air quality of countries far away down-wind; and so on. Furthermore, countries' responses to climate change, for example by building new dams or diverting more water into irrigation, can have massive impacts on downstream countries via this pathway.

The **trade pathway** transmits climate risks within regional and global markets and across international supply chains. For example, where severe drought decimates harvests in producer countries, the effects on commodity price are felt acutely by import-dependent countries thousands of miles away. Extreme weather events can disrupt production at manufacturing sites, causing ripple effects across just-in-time delivery systems for retailers half the world away. Countries' response to climate impacts at home, for example the growing tendency of governments to use export restrictions during poor harvests, to protect food prices in domestic markets, can trigger price shocks and negative impacts in other faraway countries.

The **finance pathway** represents the effect of climate impacts on the flow of capital, including the exposure of both publicly and privately held assets overseas that suffer lower yields or devaluation as the result of major disasters, or over time as climate change erodes the profitability and returns from various enterprises. Climate impacts will also affect private capital flows, for example when extreme weather renders migrant workers unemployed, stemming the flow of remittances "back home".

The **people pathway** encapsulates the effect of climate change on the movement of people between countries, for example as a magnifier or driver of new migration patterns, or via the economic impacts of new tourism patterns or climate-sensitive human health risks that result from the movement of people across borders.

The framework also recognizes the influence of climate change beyond a country's borders on the **global context** in which all countries' adaptation decisions are taken and implemented. Under various scenarios, climate change may alter or worsen the security situation in many regions, influencing the range of options – or the costs, benefits and rewards of specific adaptation measures, and the general scope for sustainable development. Over time, climate change may also be a factor in changing the general conditions of economic stability and structure and scope for regional and global governance, forcing individual countries to re-think their approach to adaptation at the national level.

*Source: Excerpt from Benzie* (2015).

The reasons *why* certain countries may be more exposed (i.e. being more open and reliant, and/or linked with more climate-vulnerable countries) will vary significantly and is likely to include a mix of historical dependency and political strategy, geography (in terms of proximity to others), as well as natural resource endowment, level of globalization, and each country's policy profile and market structure. While this raises interesting questions that are important for improving the accuracy and robustness of indicator-based assessments, they are beyond the scope of this particular paper.

Finally, it is important to clarify that according to our framework, transnational impacts can be both positive and negative. Although our indicators are designed from a climate risk perspective, high exposure may equate with high opportunity, and it is certainly the case that high levels of embeddedness in a global context provide multiple opportunities for risk management (or adaptation), along with potential sources of risk. Results must be interpreted with this in mind.

## 2.2 Indicator selection methodology

Indicators were identified and selected via a three-stage methodology. The majority of data used in the indicators are from freely available public sources. One indicator is produced using original modelling analysis by models developed at SEI.

### *Step 1 – Defining the characteristics of interest*

As previously highlighted, the literature on the nature and scope of transnational impacts is limited, so there is no reliable evidence base upon which to build a methodical, statistics-based set of indicators. Our approach is to use the pathways framework to identify the characteristics of a country that would be likely to expose it to changing flows across borders via each pathway. We generate hypotheses and explain and defend them (see Section 3 for details of each indicator).

In order to achieve maximum transparency in the design of the TCI Global Index, we start by stating, in simple form, the **characteristics** relevant to each climate risk pathway that we were most interested in measuring, and which we posit might make countries more prone to positive or negative impacts of climate change in other countries. For each characteristic, we added a list of the **assumptions** that underpin why we see it as relevant to the assessment.

In many cases the chosen indicator does not directly measure the characteristic of interest, but instead represents the best proxy measure available. For example, Indicator 7, "Cereal import dependency ratio", is a proxy measure for countries' dependency on food imports. For each indicator, we explain the data reviewed and why that particular indicator was selected. Füssel (2009) describes different indicator selection methodologies, including *inductive*, which refers to techniques using statistical analysis, and *deductive*– or theory-based approaches. Our approach in Step 1 comes closer to the deductive approach, as described by Füssel.

### *Step 2 – Consultation*

Next we consulted academic experts in climate change and indicator development. We presented them with a list of potential indicators, some with more than one version or alternative, along with background information on the scope and objectives of the index. We then conducted telephone interviews with each expert to gather feedback and to explore options for mobilizing the indicators in practical terms. The exercise was limited by the small amount of funding and tight time pressures associated with the project.

The experts consulted were Tim Carter of the Finish Environment Institute, Alexander Bisaro of Global Climate Forum, Hans-Martin Füssel of the European Environment Agency, and Alex de Sherbinin of Columbia University. In addition, an internal workshop was held with relevant experts at the SEI to appraise indicator options. Additional sectoral consultation was carried out for specific indicators and to locate appropriate data, where necessary.

The consultation process identified 13 potential indicators.

### *Step 3 – Data sifting*

The most limiting factor in the process of indicator selection was data availability. The TCI Index is a global index and therefore requires data covering as many countries as possible. There were many cases where high-quality data were available for some countries, but not enough to provide balanced global coverage. Table 1 provides an overview of the nine indicators chosen.

**Table 1: Nine country-level indicators of exposure to transnational climate impacts using the pathway framework.**

| # | Pathway | Indicator |
|---|---|---|
| 1 | Biophysical | Transboundary water dependency |
| 2 | Finance | Bilateral climate-weighted foreign direct investment |
| 3 | Finance | Remittance flows |
| 4 | People | Openness to asylum |
| 5 | People | Migration from climate vulnerable countries |
| 6 | Trade | Trade openness |
| 7 | Trade | Cereal import dependency |
| 8 | Trade | Embedded water risk |
| 9 | Global context | KOF Globalization Index |

We would like to add more indicators under each pathway, but as noted above, finding data with global or near-global coverage is difficult. Appendix 6 gives some examples of additional indicators that were considered but are not presented in this paper. We welcome suggestions of additional indicators for which global data are available.

## 2.3 Bilateral climate-weighted indicators

Above we identified two dimensions of exposure at the national level: a country's openness and reliance on international flows, and the climate risk in specific countries that it is linked to. The selected indicators each relate to one of these aspects.

An example of the first dimension is the global trade system, which provides access to various goods and services produced in different countries, the price and availability of which varies over time. For many commodities, it is not possible to trace a relationship between an importing country and the producer country in order to assess the importer's potential exposure to climate risk in the producer country. However, a country's dependency on *imports in general*, or for specific types of products, can be a good indicator of its exposure to climate-driven fluctuations in price or quality via the trade system. Indicators of this type aim to assess characteristics of **individual country profiles** in terms of openness to and reliance on international flows and systems.

Other indicators, such as those measuring more stable links between specific countries, are more interesting to investigate from a place-specific perspective. We have therefore developed indicators using bilateral data that describe the nature of a flow between specific countries. In two cases, using these bilateral data, we have been able to express or "weight" those links based on the climate vulnerability of the countries at the source end of the flow. We call these bilateral climate-weighted indicators. They aim to assess the nature of an individual country's **links to specific other countries,** and where possible weight those links based on climate vulnerability. For an indicator $X$, this can mathematically be expressed as:

$$I_X = \sum_i (Share\ of\ X\ in\ country\ i) * (Vulnerability\ of\ country\ i).$$

To assess a country's links to "climate vulnerable" countries, we used the ND-GAIN Country Index, which measures national climate vulnerability globally.[3] Several other such indices have been developed in recent years, such as DARA's Climate Vulnerability Monitor, The Maplecroft Climate Change Vulnerability Index and the German Watch Climate Risk Index; for a review of academic and sectoral spatial analyses of climate vulnerability, see de Sherbinin (2014). All these indices have limitations, and the methodological choices and assumptions in these studies lead to different results (de Sherbinin 2014). Still, the overall spatial pattern of vulnerability shown does not differ significantly among indices. Thus, we deemed the accessibility, format and availability of the data to be more critical in deciding which index to use in our bilateral climate-weighted indicators.

We selected ND-GAIN because it provides easily accessible national data for a large number of countries (177) and measures current vulnerability (unlike, for example, the Climate Vulnerability Monitor), which aligns with the temporal focus of the SEI TCI Index. For countries not included in the ND-GAIN index, we used proxies (see Appendix 2 for details).

## 3. THE INDICATORS

In this section we present nine indicators of exposure to transnational climate impacts, presented under each of the four climate risk pathways illustrated earlier. Note that all indicators provide a view of *relative* rather than absolute exposure. Each indicator divides countries into deciles (ranked groups, each representing 10% of the countries), numbered 1–10, with 10 indicating the highest level of exposure.

We group the indicators by pathway: biophysical, finance, people, trade, and global context. For each indicator, we begin with a table summarizing the characteristics to measure, the assumptions made, the data available, the year(s) for which data were used, how and why the data used were selected, and the overall method. We also identify countries that rated high on that indicator, and present a map showing the distribution of high and low exposure levels.

### 3.1 Biophysical pathway

We were only able to develop one indicator under this pathway: transboundary water dependency ratio. For other key characteristics of interest, we found a lack of suitable data. In future we would like to explore countries' exposure to climate-related air pollution – for example, as a result of increased forest fires and desertification – via transboundary air currents, as well as changing flows of fish catch from international oceans.

[3] ND-GAIN is the Notre Dame Global Adaptation Index. It includes 36 indicators that compose a score of *vulnerability* and 14 indicators that make up a score of *readiness*: we have only used the vulnerability score.

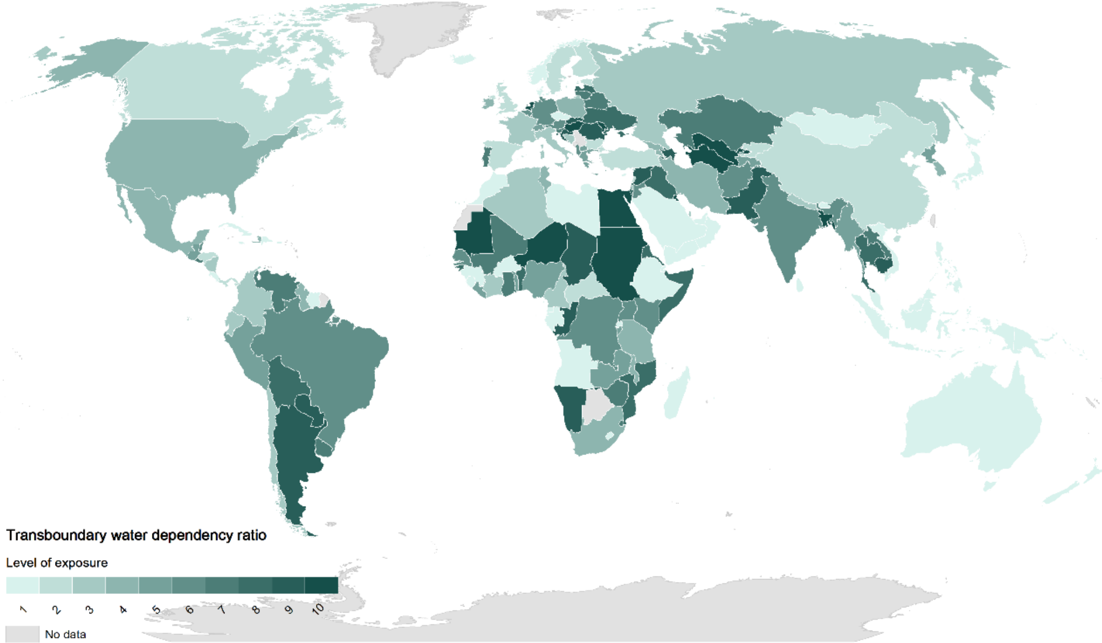
### *Indicator 1: Transboundary water dependency ratio*

| **Transboundary water dependency ratio** | |
|---|---|
| **Characteristic to measure** | The proportion of water resources in a country that originates in transboundary upstream countries. |
| **Assumptions** | The more a country relies on water from upstream transboundary rivers, the more exposed it will be to climate-related changes in transboundary river flows. For example, heavy rainfall in an upstream country can affect downstream countries by bringing floods. |
| **Data availability** | Despite extensive research in the area of transboundary waters, data gaps on downstream effects from upstream water still exist due to measuring difficulties. Available sources for proxy water data are:<br>• FAO AQUASTAT measures transboundary water dependency ratio.[4]<br>• PRIO[5] Shared River Basin Database measures characteristics of shared river basins.<br>Alternative approaches, including gathering data on the world's major transboundary river basins from basin-specific studies (via interviews and desk research) were considered. Given the large body of basin-specific research that exists, coupled with the relatively poor quality of global level data on transboundary river flows, such an approach may prove fruitful in future. However, such an approach would not constitute a true global level analysis. |
| **Data used** | 2008–2012 |
| **Data selection and justification** | As the datasets mentioned above leave out upstream/downstream information related to the water data, they were not considered suitable as a measurement for the indicator. The FAO AQUASTAT indicator on transboundary water dependency ratio was selected to proxy for the proportion of water originating in upstream transboundary countries.<br>The data selection for this indicator was made in consultation with water expert Dr. Martina Flörke, Universität Kassel. |
| **Method** | Existing indicator |

Countries that score highest on this indicator include Bangladesh, Egypt, Hungary, Kuwait, Niger, the Netherlands, Sudan, Turkmenistan and Uzbekistan. This distribution is chiefly the result of geographical distribution; many countries, at various levels of development, face challenges and opportunities associated with jointly governing shared water resources with upstream countries in a changing climate.

[4] AQUASTAT is the UN Food and Agriculture Organization (FAO) global water information system. It is the most quoted source on global water statistics.
[5] PRIO is the Peace Research Institute Oslo.

**Figure 2: Exposure map for transboundary water dependency ratio**




## 3.2 Finance pathway

There are two indicators under this pathway: bilateral climate-weighted foreign direct investment (FDI) and remittance flows.

***Indicator 2: Bilateral climate-weighted foreign direct investment***

| **Bilateral climate-weighted foreign direct investment** | |
|---|---|
| **Characteristic to measure** | The extent to which a country invests in climate vulnerable countries. |
| **Assumptions** | The larger share of GDP that is invested in climate vulnerable countries, the more exposed a country is to transnational climate impacts in that country.<br>Additionally, climate impacts in a given country will affect the economic situation in that country such that assets may lose value and returns on investment may be disrupted or reduced either suddenly or gradually over time.[6] |
| **Data availability** | The United Nations Conference on Trade and Development (UNCTAD) measures bilateral FDI statistics.[7] This source collects the most comprehensive data, covering 206 countries, on FDI outflows, which is complemented by data obtained from international organizations such as the ones below.<br>The International Monetary Fund (IMF) measures outward direct investments.<br>The World Bank measures FDI outflows. |
| **Data used** | 2008–2012 |

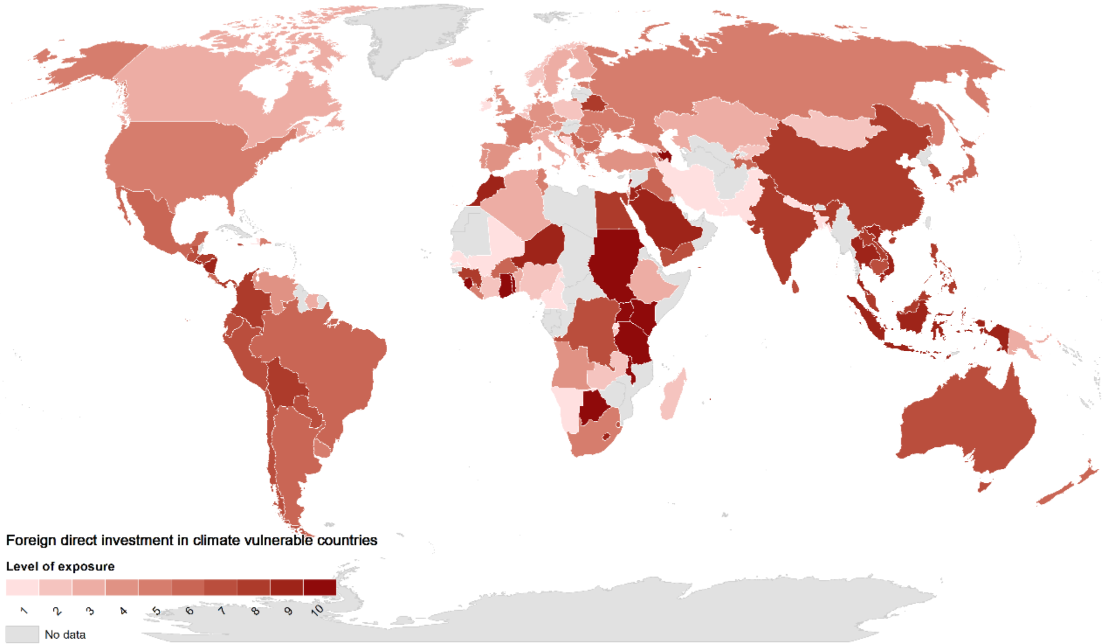
[6] If a climate event occurs in a country, studies show that this in many cases will have an effect on the economic situation of the country (Raddatz 2009; Hallegatte et al. 2007).
[7] See: http://unctad.org/en/Pages/DIAE/FDI%20Statistics/FDI-Statistics-Bilateral.aspx.

| | |
|---|---|
| **Data selection and justification** | The dataset "Bilateral FDI Statistics" provided by UNCTAD has been used to collect bilateral data on foreign direct investment outflows. UNCTAD is the only source known to distribute this kind of data at a global level. |
| **Method** | The indicator measures net outflows (% of GDP) as a function of the climate vulnerability of the country receiving the investment.<br>Foreign direct investment is the sum of three components: equity, reinvested earning, and other capital (intra-company loans). All values have been calculated as positive, since high positive and negative sums measure the level of interest in another country all the same. These have been averaged for a five-year period from 2008 to 2012 and calculated as a percentage by the country's total amount of investments. In case of missing data, an average of the years with available data has been calculated.<br>The percentage data have been coupled with climate vulnerability data from the ND-GAIN index. For countries that are not included in the ND-GAIN index, proxies have been used (see Appendix 2). Finally, the coupled data have been summed into a result that makes up the score used in the index.<br>The UNCTAD dataset includes investment numbers on both regions and individual countries. But as the dataset partly builds on mirror data (data reported by the partner countries), it is not bilaterally complete. Another complicating factor is that differences between regional data and individual country data occur. Despite this, individual country data have been used consistently when producing the indicator. There might also be cases of misrepresentation, since not all countries have reported their FDI outflows.<br>The indicator includes the top 130 countries of the World Bank's list of countries with highest GDP in 2013. |

The countries that score highest on this indicator include Azerbaijan, Botswana, Ghana, Kenya, Lebanon, Lesotho, Sudan, Thailand, Tanzania and Uganda. The results are interesting in that they reveal the level of FDI that occurs regionally, meaning that several developing countries, including regional "hegemons" or economic leaders, share a significant proportion of their neighbours' climate risks via financial investments. The indicator suggests that understanding and tackling climate-related investment risk will be an important issue for regions of emerging economies (Southeast Asia, India, China, Latin America and parts of sub-Saharan Africa).

In the future, it would be interesting to compare between national-level FDI (as measured here) and the climate risk exposure of assets held by private, public and development institutions. "Ownership" of financial risks related to climate change is blurred between public and private actors, where even personal/private and public investments are managed by private actors. It would also improve results to distinguish between investments in different sectors, where climate risk "weights" could be applied, based on the vulnerability of the sector to climate impacts in a given country.

**Figure 3: Exposure map for bilateral climate-weighted FDI**




***Indicator 3: Remittance flows***

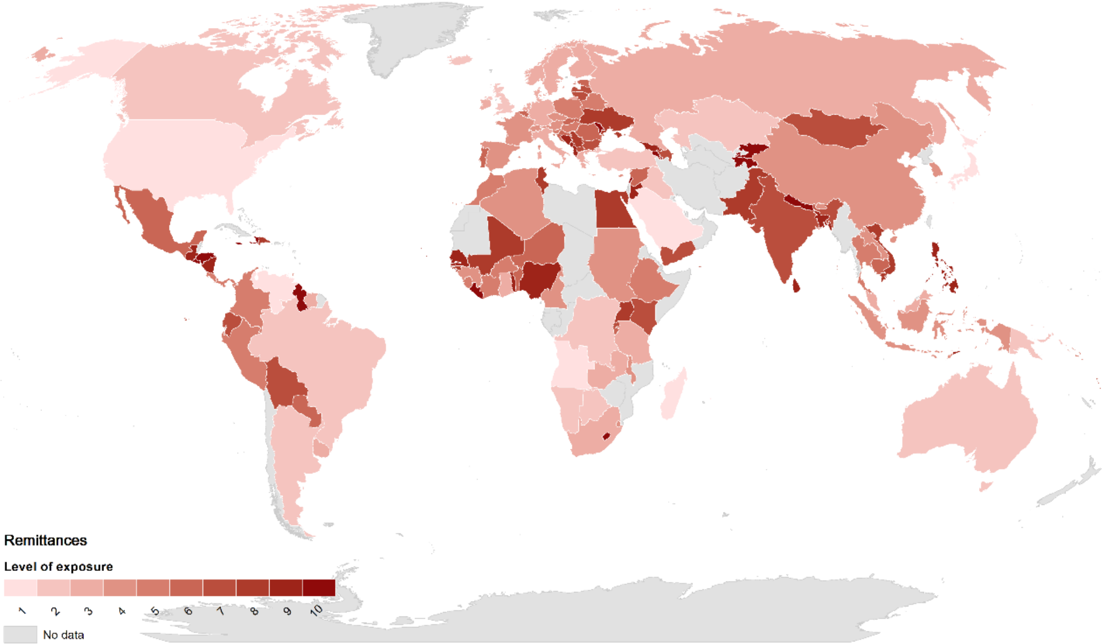
| **Remittance flows** | |
|---|---|
| **Characteristic to measure** | A country's dependence on inflow of remittances. |
| **Assumptions** | The more a country relies on remittance flows the more exposed it is to climate-related disruption in countries where migrant workers are based.<br>If direct impacts were to happen in the host country of the migrant worker, the climate shock could lead to economic disruption. This might have an influence on the remittance flows as the economic situation for the migrant worker in the host country is often highly insecure (migrant workers are often temporarily employed and more likely to become unemployed or otherwise unable to transfer money "home" in the aftermath of disruption from extreme weather events, etc.). |
| **Data availability** | The World Bank's Development Prospects Group measures remittance inflows.<br>World Bank Open Data measures personal remittances received.<br>IMF measures remittance statistics.<br>Both datasets are based on IMF's Balance of Payment Statistics. |
| **Data used** | 2012 |
| **Data selection and justification** | The indicator measures remittance flows as a percentage of GDP.<br>The World Bank's Development Prospects Group has the most comprehensive database when it comes to economic prospects and global remittance flows. As The World Bank's Development Prospects Group offers additional bilateral data on remittances that could be used in an improvement of this indicator, this source was also selected for the current version of the indicator. |
| **Method** | Existing indicator |

Countries that score highest on this indicator include Armenia, Gambia, Honduras, Haiti, Jamaica, Kyrgyzstan, Lebanon, Liberia, Nepal, El Salvador and Tajikistan.

Research shows that major extreme events (climate and non-climate related), can disrupt remittance flows (Bettin and Zazzaro 2013; Mohapatra et al. 2012; Yang 2008). It was our intention to combine remittance data with information on climate risk in the host countries, from which remittances are being sent "back home". To do this, we required a global data set on extreme weather (or even natural disaster) risk, at the national or even city level. We were unable to identify such a data set. Expressing the results as a function of the climate vulnerability of host countries (e.g. using the ND-GAIN Country Index, as for other climate-weighted indicators), was considered less relevant, given the potentially bigger role of extreme events, rather than slow-onset climate change, in disrupting remittance flows.[8]

Still, remittance dependency, on its own, remains a potentially useful indicator of exposure to transnational climate impacts, especially for the countries shown in dark red on the map, which are extremely dependent on stability abroad for significant shares of household income. A future improvement for this indicator would therefore be to express each country's reliance on remittances from disaster-prone countries, or as a function of the disaster risk in "host" countries.

**Figure 4: Exposure map for remittances**




## 3.3 People pathway

Under the people pathway we look at openness to providing asylum, refugee population, and migration.[9] Indicator 4 assesses two things: a) the acceptance rate of asylum applications, and b) the proportion of refugees in the total population. These two aspects (a "flow" and a "stock" measurement of the same phenomenon) are combined into one indicator. Indicator 5 looks at economic migration.

---

[8] "Vulnerability" to extreme events may be similar or overlap with vulnerability to climate change, as assessed by existing global indicators such as ND-GAIN, but we prefer to develop this indicator further in future in the context of disaster risk, ideally at the city level, because migrant labour often tends to be concentrated in a small number of "host" cities.

[9] An asylum-seeker is someone who has made an application for asylum in a particular country. If accepted (under the terms of the 1951 Refugee Convention), that person becomes a refugee and is granted the right to stay.

### Indicator 4: Openness to asylum

| **Openness to asylum** | |
|---|---|
| **Characteristic to measure** | The tendency of a country to grant political asylum. |
| **Assumptions** | Countries that grant a higher proportion of asylum applications are more likely to be affected (positively or negatively) by an increase in the number of people seeking asylum, if this turns out to be one of the consequences of climate change in other parts of the world.<br>Climate and migration is a highly debated research field. Migration is a complex phenomenon which cannot be linked to one single driving force. In the latest assessment report by the IPCC the section on human migration and displacement's first sentence reads: "Human migration is one of many possible adaptive strategies or responses to climate change". The report acknowledges the complexity of the subject and clearly spells out that research is not sufficient for providing region-specific analyses of climate impacts on migration. The report's judgement is on a more general level: "Climate change will bear significant consequences for human migration flows at particular times and places, creating risks as well as benefits for migrants and for sending and receiving regions and states (high confidence)" (Oppenheimer et al. 2014, section 19.4.2.1).<br>Thus, it is reasonable to expect that climate change might result in changing numbers of asylum applications and refugee movements. This potential motivates our interest to examine which countries might be most affected by such a change in "flow", based on their current policies and openness. We recognize, at the same time, the rapid changes that can occur both in asylum applications and immigration policy, as the current "refugee crisis" attests. |
| **Data availability** | UNHCR Statistical Online Population Database[10] measures the total number of applications, decisions and rejections on political asylums (first part of the indicator).<br>World Bank Open Data[11] measures refugees by country or territory of asylum (second part of the indicator).<br>UNHCR Statistical Yearbook measures refugee population statistics. |
| **Data used** | 2012 (all data – asylum and population figures) |
| **Data selection and justification** | Due to UNHCR's extensive information on granted political asylum applications, it was selected as a source for the indicator.<br>Both decisions on convention status as well as complementary protection[12] status are included in the final data used for the index. The data represent the migrants' country of origin (in contrast to source of arrival).<br>The World Bank bases its refugee population data on the UNHCR Statistical Yearbook and data files. The World Bank was selected as a source due to advantages in the data format. |

[10] See: http://popstats.unhcr.org.

[11] See: http://data.worldbank.org/indicator/sm.pop.refg.

[12] "The term 'complementary protection' has emerged over the last decade or so as a description of the increasingly-apparent phenomenon in industrialized countries of relief from removal being granted to asylum seekers who have failed in their claim for 1951 Convention refugee status. It is essentially a generic phrase, with the actual terminology used by states to describe such forms of protection in their territory, including any attached immigration status, varying enormously: 'subsidiary protection', 'humanitarian protection' and 'temporary asylum' to name but a few examples." (Mandal 2005)

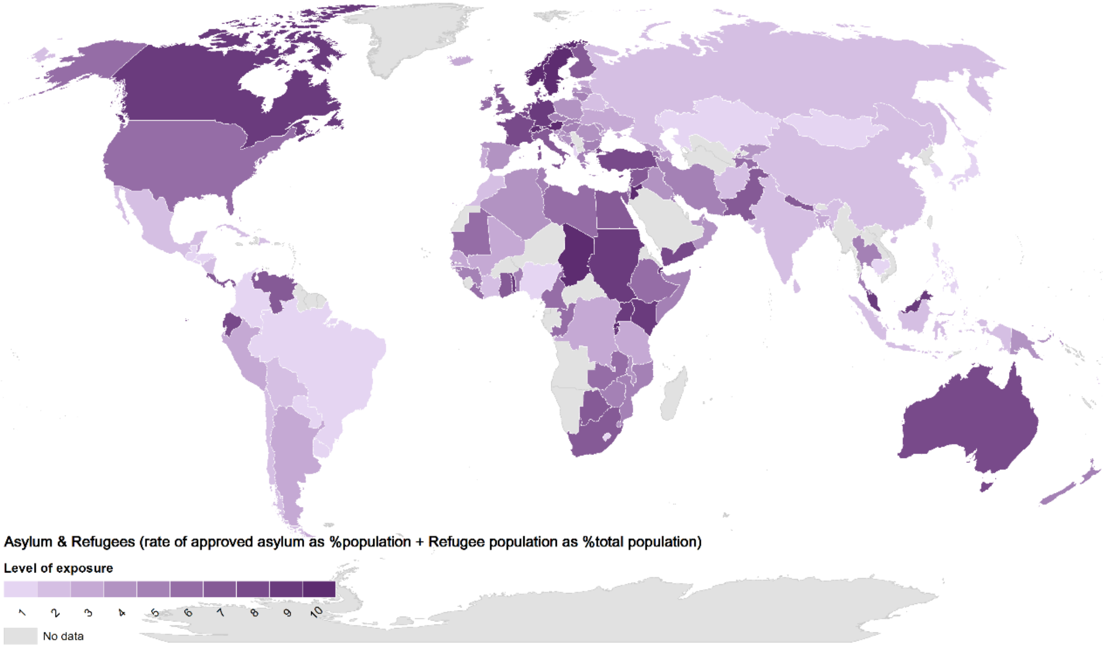
| | |
|---|---|
| **Method** | The indicator measures positive decisions of asylum applications and refugee status determination (as a percentage of total population) and Refugee population by country or territory of asylum (also as a percentage of total population.<br>The indicator has been developed by calculating the number of positive decisions from political asylum applications as a proportion of the country's total population. This was done in order to investigate the annual number of political refugees being accepted into the country (i.e. a "flow" measure).<br>Similarly, refugee population was calculated as the size of a country's refugee population as a proportion of its total population (i.e. a "stock" measure).<br>Because granted political asylum is measured annually, the data were coupled with total stock of refugee population to give a complete picture of the total number of migrants with refugee status in a country. The coupling was made by normalizing the data for each indicator, and averaging these into one combined indicator. |

The countries that score highest on this indicator are Austria, Burundi, Djibouti, Chad, Germany, Jordan, Kenya, Lebanon, Malaysia, Malta, Norway, Togo, Rwanda, Sudan, Sweden and Uganda.

The distribution of countries with high rates of approval and high relative populations of refugees show that human displacement and asylum is more often an issue dealt with at the regional scale, with the majority of high scoring countries being those near to refugees' country of origin. On top of this, there is a smaller number of countries that have more open policies on asylum, despite being geographically removed from the countries of origin. Both groups may be affected, perhaps in different ways, with different kinds of opportunities and challenges, by any future change in refugee patterns.

One potential weakness of the method applied here is that total number of asylum application (rather than the rate of successful applications, as used in the indicator) is also relevant; this might show the attractiveness of a country to those seeking asylum, in situations where there is a choice. More innovative ways of presenting the indicator results would allow for this information to be presented on the world map, alongside current results, to enrich its overall message. This is something we aim to explore in future versions.

**Figure 5: Exposure map for openness to asylum**




### *Indicator 5: Migration from climate vulnerable countries*[13]

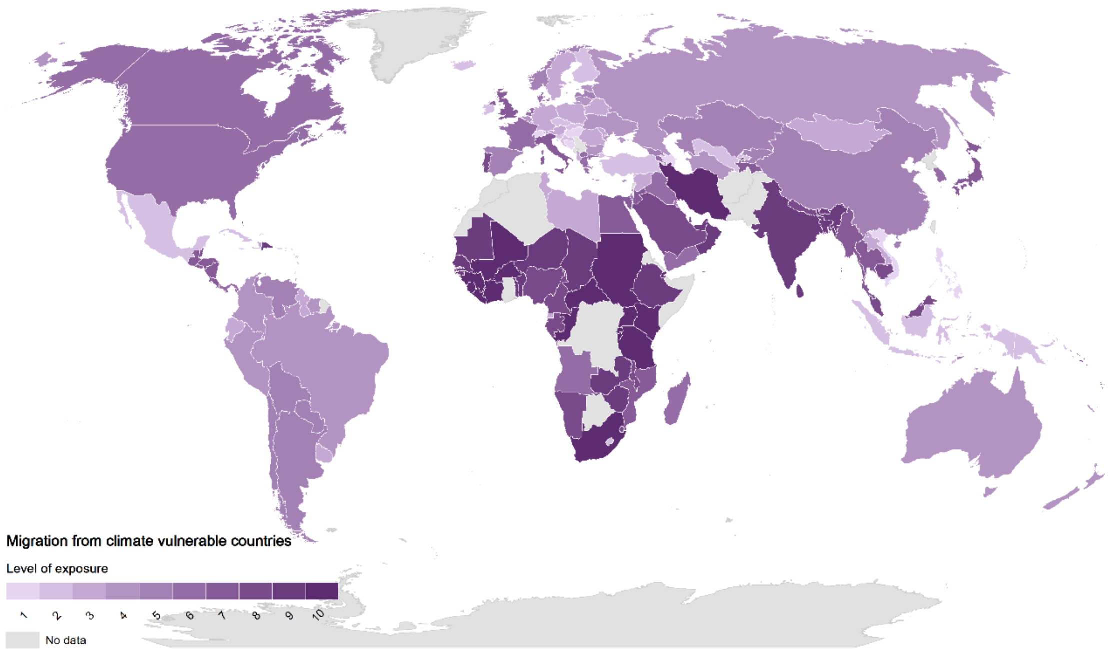
| **Migration from climate vulnerable countries** | |
|---|---|
| **Characteristic to measure** | The extent to which a country has in-migration from climate vulnerable countries. |
| **Assumptions** | This indicator assumes that current migration links are an indicator of potential future migration patterns, which is a significant assumption to make.<br>Additionally it assumes that countries that are particularly vulnerable to (direct) climate change are more likely to experience changes in migration patterns. Again, this is a significant assumption that simplifies the complexity of climate-migration linkages (see above).<br>Nevertheless, an assessment of the current pattern of migration between "particularly vulnerable" countries and destination countries is thought to be a useful exercise in beginning to assess potential exposure (negative or positive) from any future change in migration patterns that could be influenced by climate change, based on the further assumptions that the most vulnerable countries may experience the biggest changes in migration flows (again, an oversimplifying assumption that is very easy to challenge). |
| **Data availability** | The World Bank's Development Prospects Group[14] measures bilateral migration.<br>The World Bank's Global Bilateral Migration Database[15] measures bilateral migration. |
| **Data used** | 2010 (World Bank), 2012 (GAIN) |

[13] This is a climate-weighted indicator.
[14] See: http://go.worldbank.org/1JAUQGCYL0.
[15] See: http://data.worldbank.org/data-catalog/global-bilateral-migration-database.

| | |
|---|---|
| **Data selection and justification** | As The World Bank's Development Prospects Group's data on bilateral migration are more recent, as well as provided in a more usable format, it was selected as a source for the indicator. However, to be able to provide data for China, the United Nations Global Bilateral Migration Database was used because of lack of data on this country in the dataset from World Bank's Development Prospects Group.<br>Due to the lack of bilateral data on migrant flows during the development of the index, proxy data on migrant stocks were used for the indicator. However, the indicator would be strengthened by recent data that have recently become available on bilateral migrant flows (for example, (Sander et al. 2014). |
| **Method** | The indicator was developed by calculating the percentage of migrants from different countries, weighted with data on climate vulnerability from the ND-GAIN Country Index for each "source" country. For countries that are not included in ND-GAIN, proxies have been used (see Appendix 2). Finally, the coupled data have been summed into a result that makes up the score used in the index. |

The countries that score highest on this indicator are Iran and most states in sub-Saharan Africa. However, given the complexity of the climate-migration dynamic, it is unwise to draw too many conclusions from these indicator results, although the overriding message perhaps is that neighbours of particularly vulnerable countries and transit countries may be most exposed to changes in migration flows, based on the current pattern of migration. This may (or may not) help to recast the discussion of "climate migration" as an issue for developing and vulnerable countries, rather than as a narrative of "influx" and "inundation" for wealthier nations. For example, this could lead to more pragmatic discussions about ways to boost capacities in transit or target countries in the region, rather than more politically charged debates about asylum policies in wealthier countries.

**Figure 6: Exposure map for migration from climate vulnerable countries**



## 3.4 Trade pathway

There are three indicators under this pathway.

### *Indicator 6: Trade openness*

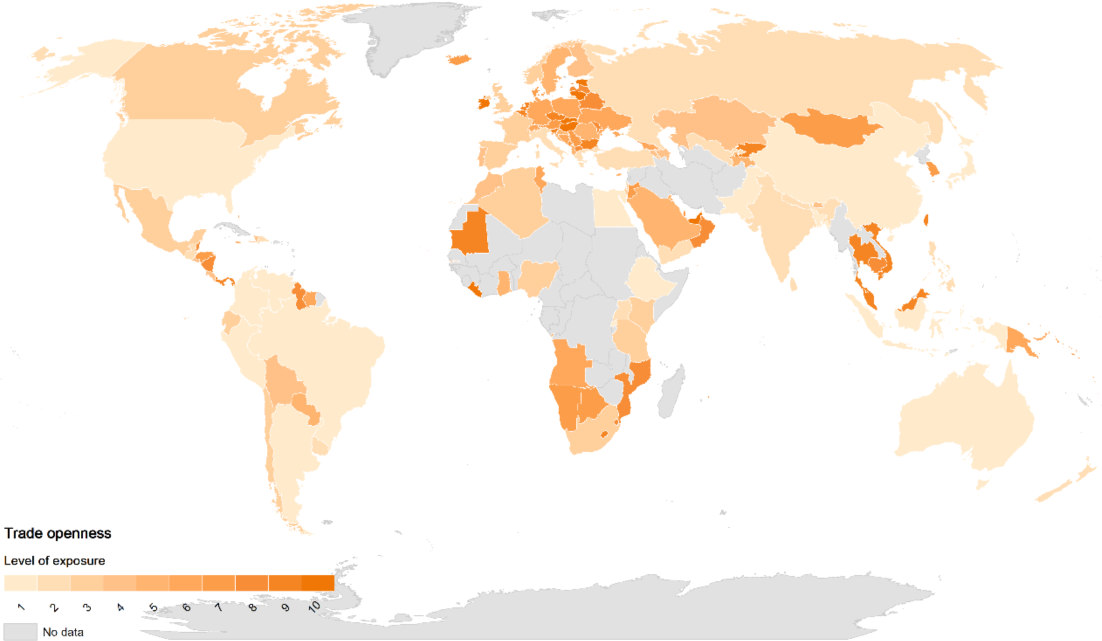
| **Trade openness** | |
|---|---|
| **Characteristic to measure** | A country's level of openness to trade |
| **Assumptions** | A country that is more open to – or engaged in – trade is more likely to be impacted by climate-related shocks and events in other (trading) countries.<br>Openness in trade can be defined as the extent to which a country permits or is engaged in trade with other countries. It is the sum of the country's imports and exports as a share of the country's total GDP.<br>By having a higher dependency on imports and exports, a country could be more exposed to transnational impacts if supply and demand chains were to change as a consequence of a climate event in another country. Both goods and services are considered relevant measurements of this indicator.<br>High exposure to trade-related shocks may well be compensated by the positive adaptation (risk-spreading or hedging) options afforded by trade openness. Thus, high scores under this indicator do not necessarily mean countries are ill-prepared to cope or adapt. |
| **Data availability** | UNCTAD[16] measures trade openness.<br>The World Bank[17] measures trade as a sum of imports and exports. |
| **Data used** | 2012 |
| **Data selection and justification** | This indicator measures trade openness as a percentage of GDP.<br>UNCTAD provides a large database that is well represented on data related to trade, and was hence selected as a source for the indicator. |
| **Method** | Existing indicator |

Countries that score highest on this indicator include United Arab Emirates, Belgium, Estonia, Hong Kong, Hungary, Ireland, Liberia, Lithuania, Luxembourg, Malta, Singapore and Slovakia – i.e. many small countries.

While data are missing for many developing countries (particularly in Africa and the Middle East), a clear message is that trade openness could expose both rich and poor countries to climate risks in global markets. Particularly small countries, in Europe, Central America and Southeast Asia, but generally worldwide, have high levels of trade dependency. For these countries especially, more specific assessments of their trade-related climate risk profile would seem an important next step.

[16] See: http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_ChosenLang=en.
[17] See: http://data.worldbank.org/indicator/NE.TRD.GNFS.ZS.

**Figure 7: Exposure map for trade openness**




***Indicator 7: Cereal import dependency ratio***

| **Cereal import dependency ratio** | |
|---|---|
| **Characteristic to measure** | The dependency of a country on imported food staples |
| **Assumptions** | The more dependent a country is on food imports from abroad, the more exposed it is to climate-related disruptions in the availability, price or quality of food products.<br>Cereal import is taken as a proxy for measuring food imports. This indicator investigates the necessity of countries to attain crucial commodities from foreign countries. |
| **Data availability** | FAO[18] measures food security indicators, including a specific indicator on "cereal import dependency ratio (%)". |
| **Data used** | 2007–2009 |
| **Data selection and justification** | FAO was selected as a source for the indicator due to its accessible data as well as being the main provider of data in the field of agriculture and food. |
| **Method** | Existing indicator |

Countries that score highest on this indicator include Belgium, Costa Rica, Iceland, Jamaica, The Netherlands, New Zeeland, Palestine, United Arab Emirates and Vietnam.

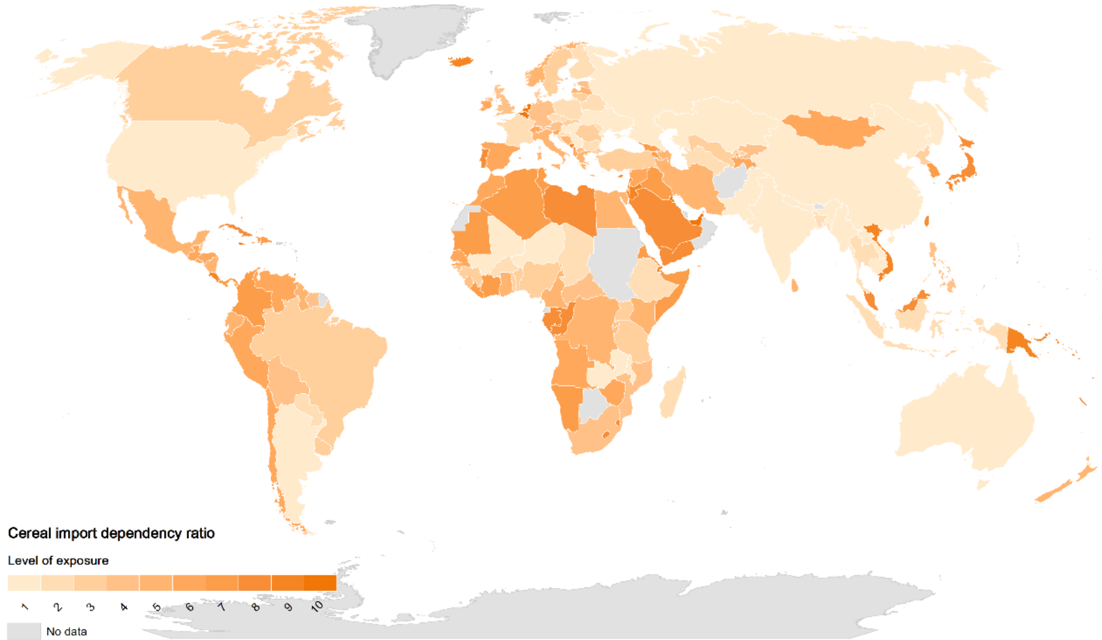
Given the political sensitivity of food prices in middle- and low-income countries and the growing risk of price volatility in globally traded food staples, particularly under a changing climate (see Benzie and John 2015), it is important for these countries to understand the nature of their risk exposure and follow balanced strategies for hedging and reducing climate-related risks to food imports. A large number of countries are highly import-dependent,

[18] See: http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.VemQf5dBmqN.

including very poor as well as middle-income and some very wealthy countries where agriculture capacity is low or underdeveloped.

A future improvement to this indicator would be to couple import dependency data with poverty indicators, to produce an indicator that incorporates a country's ability to afford and therefore absorb price shocks. Very poor countries likelier to be impacted by price shocks.

**Figure 8: Exposure map for cereal import dependency**




### *Indicator 8: Embedded water risk*

This indicator is similar to the climate-weighted indicators, in that it incorporates information about each country's exposure to specific climate risks, namely drought risk. However, it does so by incorporating data on water stress, not explicit climate risk data.

| **Embedded water risk** | |
|---|---|
| **Characteristic to measure** | The level of dependency of a country on embedded water in key commodities that were grown in highly water-stressed areas of the world. |
| **Assumptions** | The more import dependent a country is on embedded water, the more exposed it is to climate-related changes in water availability in producer countries.<br>Additionally, the higher the proportion of embedded water in a nation's imports that originate from countries that currently experience high levels of water stress, the bigger the risk to the importing country. |
| **Data availability** | The IOTA[19] model, developed at SEI, supplemented with the data from WRI's Aqueduct database on baseline water stress.[20] |
| **Data used** | 2007 |

[19] IOTA is the Input-Output and Trade Analysis Model, developed at SEI York. See: https://www.york.ac.uk/sei/researchhighlights/trade-impactfromproducertoconsumer/.
[20] See: http://www.wri.org/our-work/project/aqueduct.

| | |
|---|---|
| **Data selection and justification** | We chose to focus on embedded water in food products. This is because of the strategic nature of food imports to human well-being (and therefore human and political security) and because of the generally high level of embedded water in food. For some countries, non-food products are also highly strategic to the economy and human well-being, but these vary significantly between countries and are therefore less relevant to a global assessment.<br>Increasing temperatures can have large negative effects on the production and availability of important food commodities, which can affect import-dependent countries. Four types of food staples (rice, wheat, soy and sugar) have been selected as proxies for key food commodities. These four commodities represent a spread of the staple foodstuffs that are to be found in most world regions, hence their inclusion. To make the indicator more comprehensive it would be desirable to include all imported commodities in the analysis.<br>The data for the indicator were exclusively developed with the IOTA model at SEI by Chris West and Simon Croft (SEI York) and Elena Dawkins (SEI Stockholm).<br>The indicator measures embedded water from highly water stressed areas. For more information on the methodology developed to produce this indicator, see the Methodology Note posted with this paper: https://www.sei-international.org/publications?pid=2970.<br>The data include 129 global regions, as defined within the GTAP[21] dataset (GTAP, 2013). The regional score has been given to countries that are only included in the regional aggregations. |
| **Method** | Original modelling |

Countries that score highest on this indicator include Afghanistan, China, India, Turkey, Nepal, Pakistan and all five Central Asian states (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan).

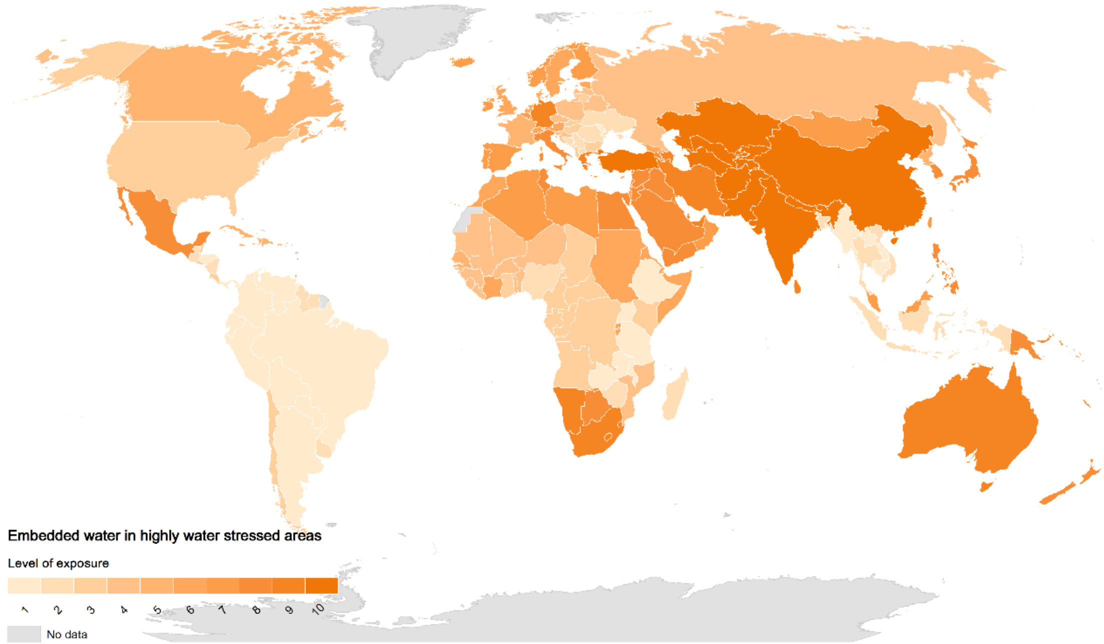
The analysis carried out to produce this indicator is novel and reveals insights that are otherwise hard to come by. There is not always an obvious reason why some countries score high: historical as well as regional and political/strategic trade arrangements may have led certain countries to import food crops that are produced (or processed) in highly water-stressed areas. By revealing this previously hidden layer of risk, such an analysis asks questions that deserve further investigation: why is embedded water from highly water-stressed areas so high in this nation's consumption? How can the climate risk to consumption be assessed more clearly to support decision-makers? How well placed are these countries to manage, adapt and reduce these risks?

We believe it would be very useful to extend this kind of analysis to other imported products and begin using the modelling techniques that were tested in the production of this indicator to carry out more nuanced country-level of assessments of trade-related climate risk.[22]

[21] GTAP is the Global Trade Analysis Model. See: https://www.gtap.agecon.purdue.edu.

[22] For developments in this area, see the Transformative Transparency platform: https://ttp.sei-international.org/index.php, and the work of the SEI Initiative on Producer to Consumer Sustainability: http://www.sei-international.org/projects?prid=2166.

**Figure 9: Exposure map for embedded water risk**




### 3.5 Global context

Along with indicators for the four risk pathways, we wanted to quantify countries' relative level of globalization, in economic, social and political terms. As noted below, we considered two existing globalization indices, and chose the KOF Globalization Index,[23] developed at the Swiss Federal Institute of Technology Zürich.

***Indicator 9: KOF Globalization Index***

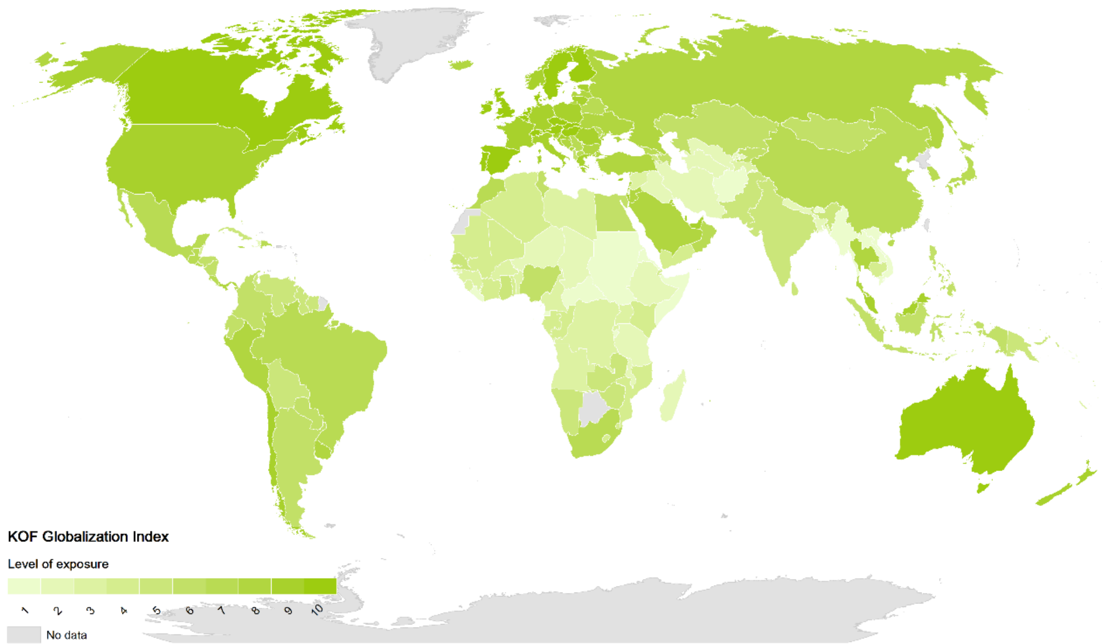
| **KOF Globalization Index** | |
|---|---|
| **Characteristic to measure** | The level of global integration and interconnectedness of a country |
| **Assumptions** | The more globalized a country is, the more exposed it is to the transnational impacts of climate change.<br>Recognizing that globalization is a two-way process that opens up countries to significant opportunities in the global market place, but also at the same time to new sources of risk, this indicator aims to assess overall engagement in the process of globalization. |
| **Data availability** | The KOF Globalization Index and the CSGR Globalization Index[24] – the latter developed at Warwick University – both the economic, social and political dimensions of globalization. |
| **Data used** | 2011 |
| **Data selection and justification** | The KOF Globalization Index is the most recognized and available source to produce globalization data, so we selected it as our globalization indicator. |
| **Method** | Existing indicator |

Although this indicator does not produce surprising results when considered on its own, it is useful to consider alongside other indicators of more specific climate risk pathways, especially in order to see where countries that are globally integrated in a general sense, as

[23] See: http://globalization.kof.ethz.ch.
[24] See: http://www2.warwick.ac.uk/fac/soc/csgr/index/.

shown by the KOF Index, are also highly exposed via specific pathways to additional layers of climate risk in other countries. See Appendix 6 for a short discussion of how this indicator could be incorporated with other data.

**Figure 10: Exposure map for KOF Globalization Index**




## 4. THE TRANSNATIONAL CLIMATE IMPACTS INDEX

Each of the nine indicators presented above offers a lens through which to view the issue of exposure to transnational climate impacts and the distribution of related risks across the globe. For the purposes of summarizing and communicating the key issues captured by this analysis, we have developed the Transnational Climate Impacts (TCI) Index, which combines indicators into a single, overall score.

### 4.1 Index methodology

A total of 203 countries are included in the analysis, coded by the ISO3[25] standardized country codes. The index maps use the Robinson map projection and have been created in ArcGIS software. The data are from the years 2007–2013.

The Index is a simple composite index that combines the results from each indicator. They are unweighted, as we have found little justification for giving more or less weight to specific indicators at this stage. The index is calculated as follows:

$$I_{A,B} = \frac{\sum_{k=1}^{n} I_k}{n}, \qquad (1)$$

with $I_k$ being the index score for indicators $k$, and $n$ being the number of indicators.

[25] ISO is the International Organization for Standardization.

As noted earlier, the results for each indicator were grouped into deciles (ranked groups, each representing 10% of the countries), according to the distribution of the data. We chose this approach, known as the quantile method, because it emphasizes the relative position of a result, which serves our purpose of mapping the global distribution of countries to TCI. The method is suitable when using linearly distributed data (Brewer and Pickle 2002), which is the case for the majority of indicators in this paper. Results produced using this method are also easy to visualize on a colour-coded map. A shortcoming of this method is that it can sometimes distort differences between countries – for example, if the results are not widely distributed but highly concentrated. Our response to this potential shortcoming was to use a relatively high number of classes.[26]

Ideally, we would have complete data for all countries across all indicators. However, in reality we are missing data for one or more indicators for some countries, particularly in sub-Saharan Africa, the Middle East and parts of Southeast Asia (see Appendix 3 for a map of data strength). Rather than exclude countries with incomplete data from the results, we chose to include countries with data for seven or more indicators. Given that our intention is to present an overview of the global distribution of exposure to transnational climate impacts, we consider it a necessary and appropriate compromise to include countries with incomplete data.

A list of excluded countries is provided in Appendix 1. The threshold of seven or more indicators is to some extent arbitrary, but reflects our judgement that missing data for three or more of the nine indicators would skew the overall results, but missing one or two indicators would not significantly affect the overall index. Moreover, the data gaps did not significantly overlap across indicators. This enabled us to include not only the 86 countries for which we had all nine indicators, but a total of 152 with at least seven each.[27]

It is also possible to summarize the results for each of the climate risk pathways in our conceptual framework (i.e. to combine indicators to give an overall "trade pathway result", etc.). We experimented with this approach, but for the sake of simplicity and clarity, we present only the global index results in this paper.[28]

## 4.2 Index results

This section does not provide a thorough analysis of the results – only some preliminary remarks. We begin by presenting the results of the Transnational Climate Impacts Index as a shaded map, in Figure 10. For comparison, in Figure 11 we map countries' scores on the ND-GAIN Country Index of vulnerability to (direct) impacts of climate change.

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[26] Other options of classification are also available, such as the Jenks Natural Breaks and Equal Intervals. If another classification method had been used, the breaks between indicator scores would have been slightly different. For example, the Jenks Natural Breaks is more suited for unevenly distributed data and minimizes the sum of absolute deviations from the class means. Using this method would thus have made it more difficult to show the spread of country values, and it would have obstructed map comparison, as the class breaks are customized for the distribution of the specific dataset.

[27] In order to assess how the number of indicators influences the ranking of the countries we calculated the Spearman coefficient between the ranking lists based on seven and nine indicators, respectively, for the subset of 86 countries with data for all nine indicators. For discrete integers, the Spearman coefficient is a measure of how well the rankings of two lists match each other; it equals 1 if the two lists are identical. When calculating the index for the 86 countries with seven indicators, the two indicators with lowest contribution to the composite index were subtracted for each country. If the ranking of each country after this transformation (from being based on nine indicators to being based on seven indicators) would stay exactly the same, the Spearman coefficient would be equal to 1. The calculation resulted in a Spearman value of 0.985; hence, the rankings of countries were roughly similar with nine and seven indicators.

[28] Data for pathway-based indices are available in the data and results spreadsheet via the SEI website, but have not been presented in mapped form in this paper.

**Figure 10: Exposure map for the Transnational Climate Impacts Index**

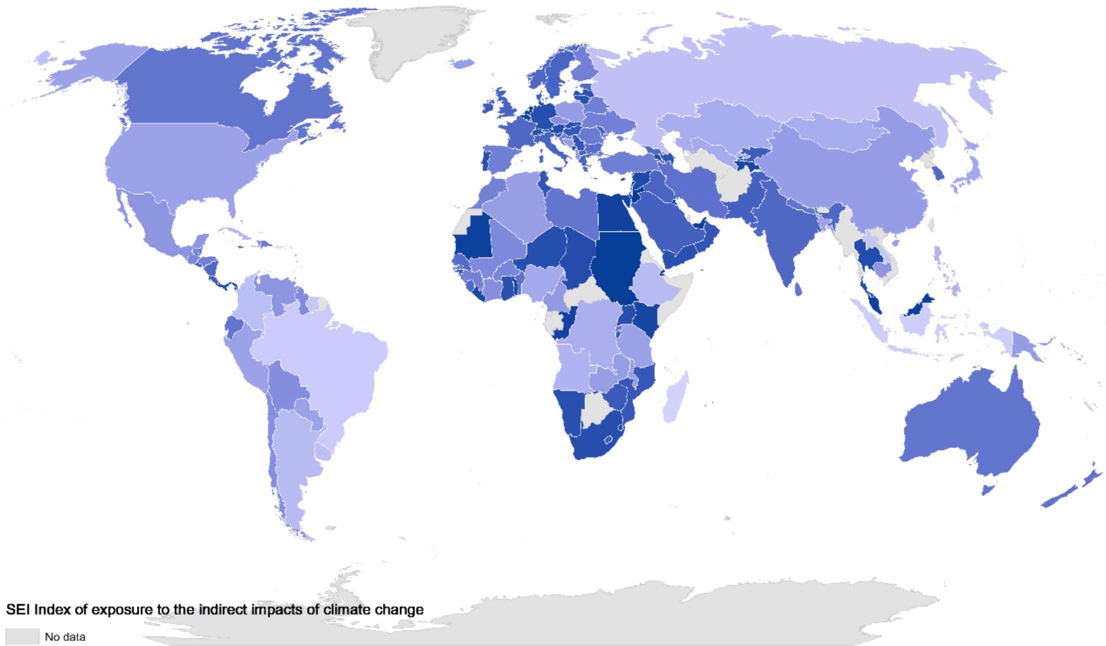
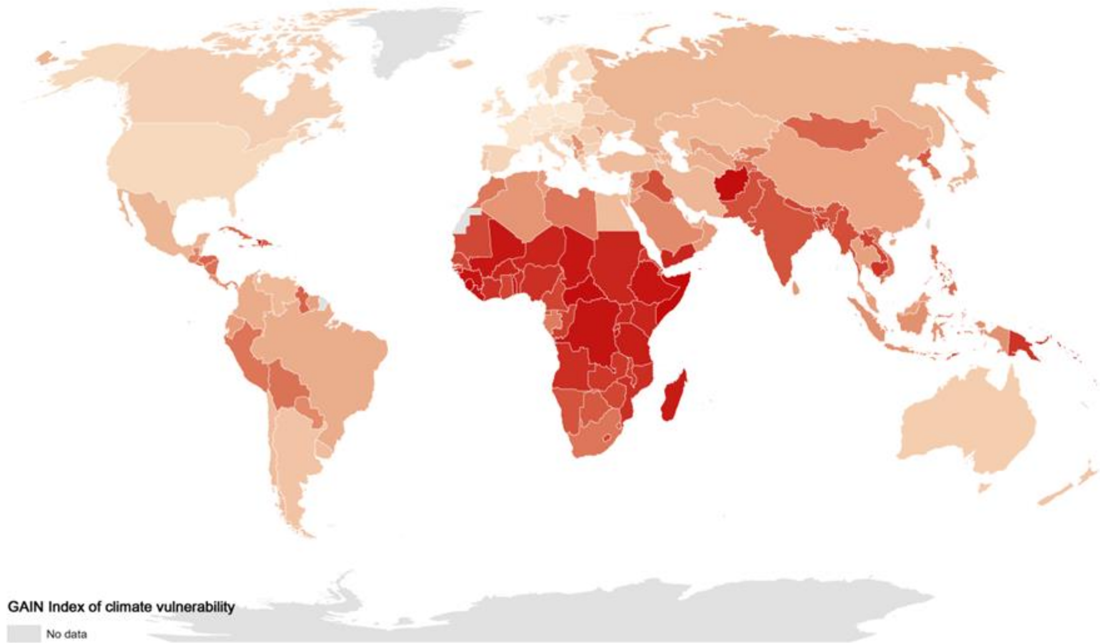



**Figure 11: The ND-GAIN Country Index of vulnerability to (direct) climate impacts**




*Note: Map produced by the authors, with new colour-coding, using data downloaded from the ND-GAIN website.*

Comparing the TCI Index and ND-GAIN results (see the maps as well as Figure 12 below), we find that although the whole of Europe is ranked low in the ND-GAIN index, several European countries show considerable exposure to transnational impacts. They include the Benelux countries, Germany, and the Scandinavian and Baltic states. All of those countries except Latvia have top scores on global context (Indicator 9). Germany also scores very high on the biophysical pathway indicator, given its reliance on transboundary rivers, and on the people pathway, given its openness to asylum-seekers and migrants. In trade, especially, the

Netherlands and Belgium score high. Another country with a high TCI Index score is Portugal, partly due to its very high score for the biophysical pathway.

**Table 2: Comparison of the top 30 countries on ND-GAIN and the TCI Index**

| ND-GAIN Country Index | | | | TCI Index | | | |
|---|---|---|---|---|---|---|---|
| Rank | Country | Score | Region | Rank | Country | Score | Region |
| 1 | Somalia | 0.62 | SSA | 1 | Jordan | 8.11 | MENA |
| 2 | Burundi | 0.59 | SSA | 2 | Lebanon | 7.86 | MENA |
| 3 | Sierra Leone | 0.59 | SSA | 3 | Kuwait | 7.57 | MENA |
| 4 | Afghanistan | 0.58 | MENA | 4 | United Arab Emirates | 7.43 | MENA |
| 5 | Central African Republic | 0.58 | SSA | 5 | Sudan | 7.14 | SSA |
| 6 | Togo | 0.58 | SSA | 6 | Netherlands | 7.11 | Eur |
| 7 | Liberia | 0.57 | SSA | =7 | Mauritania | 7.00 | SSA |
| 8 | Dem. Rep. of the Congo | 0.57 | SSA | =7 | Belgium | 7.00 | Eur |
| 9 | Ethiopia | 0.55 | SSA | =7 | Luxembourg | 7.00 | Eur |
| 10 | Guinea | 0.55 | SSA | 10 | Malaysia | 6.89 | SE Asia |
| 11 | Mali | 0.54 | SSA | 11 | Egypt | 6.78 | MENA |
| 12 | Chad | 0.54 | SSA | 12 | Gambia | 6.75 | SSA |
| 13 | Solomon Islands | 0.54 | SIDS | 13 | Togo | 6.63 | SSA |
| 14 | Madagascar | 0.54 | SIDS | =14 | Tajikistan | 6.56 | CE & C |
| 15 | Haiti | 0.54 | SIDS | =14 | Swaziland | 6.56 | SSA |
| 16 | United Rep. of Tanzania | 0.54 | SSA | 16 | Liberia | 6.44 | SSA |
| 17 | Guinea-Bissau | 0.54 | SSA | =17 | Portugal | 6.33 | Eur |
| 18 | Timor-Leste | 0.53 | SIDS | =17 | Kenya | 6.33 | SSA |
| 19 | Burkina Faso | 0.53 | SSA | =19 | Maldives | 6.29 | SIDS |
| 20 | Kenya | 0.53 | SSA | =19 | Montenegro | 6.29 | Eur |
| 21 | Niger | 0.53 | SSA | 21 | Malta | 6.25 | Eur |
| 22 | Yemen | 0.53 | MENA | =22 | Armenia | 6.22 | CE & C |
| 23 | Sudan | 0.53 | SSA | =22 | Thailand | 6.22 | SE Asia |
| 24 | Uganda | 0.52 | SSA | 24 | Latvia | 6.13 | Eur |
| 25 | Rwanda | 0.52 | SSA | 25 | Fiji | 6.11 | SIDS |
| 26 | Benin | 0.52 | SSA | =26 | Azerbaijan | 6.00 | CE & C |
| 27 | Angola | 0.52 | SSA | =26 | Jamaica | 6.00 | SIDS |
| 28 | Mozambique | 0.51 | SSA | =26 | Mauritius | 6.00 | SIDS |
| 29 | Cote d'Ivoire | 0.50 | SSA | =26 | Austria | 6.00 | Eur |
| 30 | Nigeria | 0.50 | SSA | =26 | Lithuania | 6.00 | Eur |

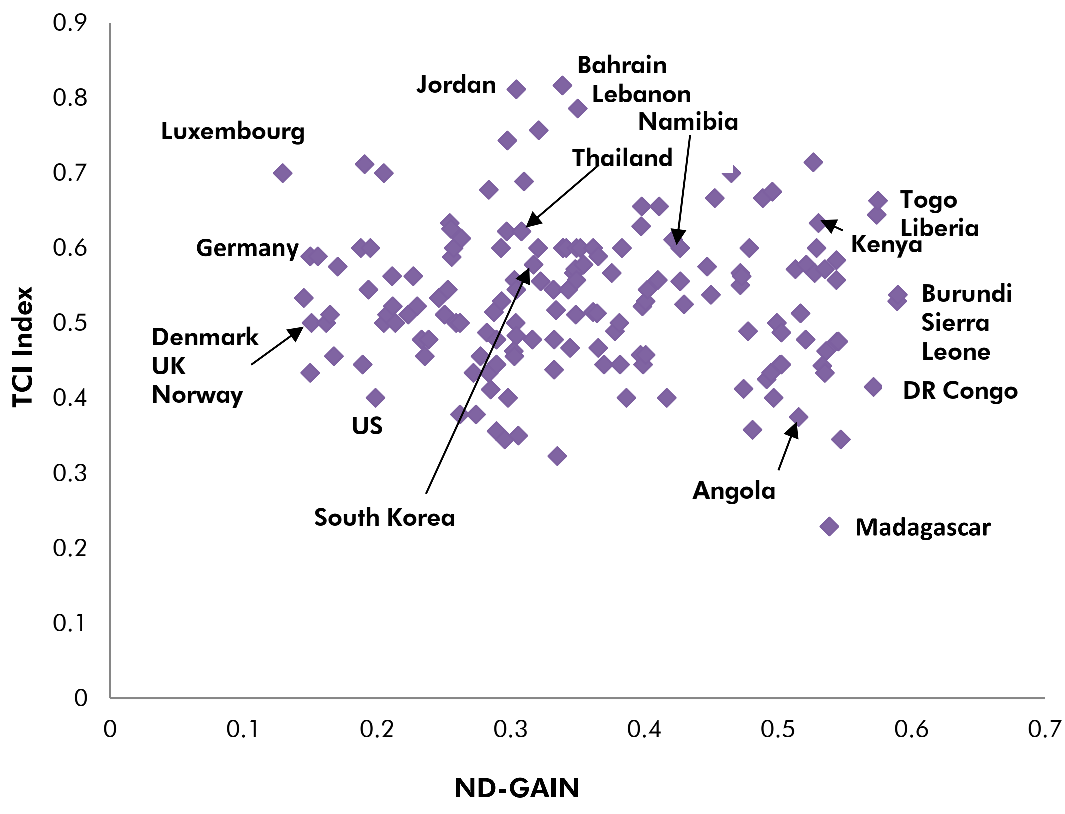
| | | % Top 30 | |
|---|---|---|---|
| **Legend** | | ND GAIN | TCI Index |
| SSA | Sub-Saharan Africa | 80% | 23.3% |
| MENA | Middle East and North Africa | 6.7% | 16.7% |
| SIDS | Small Island Developing States | 13.3% | 13.3% |
| Eur | Small European states | 0% | 30% |
| CE & C | Central Asia and the Caucasus | 0% | 10% |
| SE Asia | Southeast Asia | 0% | 6.7% |

Table 2 above compares the top 30 countries in both the ND-GAIN and TCI Index. Altogether, 30% of the top 30 countries on the TCI Index are small European nations, including the Netherlands, Belgium, Luxembourg, Portugal, Montenegro, Malta, Austria and Lithuania. This makes Europe the most heavily represented region, reflecting the high dependency of small industrialized countries on neighbours and global systems. By contrast, no European countries feature in the top 30 of the ND-GAIN Index.

Whereas the ND-GAIN top 30 only features countries from Sub-Saharan Africa, MENA and SIDS, the TCI Index provides a much more mixed picture, with a variety of countries at all stages of development scoring high – notably smaller (e.g. the European states, Gambia, Fiji, and others), landlocked (e.g. Tajikistan, Swaziland, Armenia, Mauritania), highly trade-dependent (e.g. Malaysia and Thailand) and MENA countries (e.g. Jordan, Lebanon, Kuwait and United Arab Emirates – the four highest-scoring countries). Four countries feature in the top 30 of both indices, all from sub-Saharan Africa (Togo, Liberia, Kenya and Sudan).

Another clear difference between the two indices is the scores for sub-Saharan African countries. While on ND-GAIN, they almost all score high, the scores are much more varied on the TCI Index; Angola, the Democratic Republic of Congo and Nigeria all score low, for example. For those countries that score high on both indices, the pattern of scores is still scattered. For example, South Africa scores particularly high on the people pathway, while Namibia and Mozambique score high on the people and biophysical pathways, and Kenya scores high on the finance pathway, due to its high level of investment in climate vulnerable economies on the African continent and dependence on remittances.

**Figure 12: Correlation between the TCI Index and the ND-GAIN Country Index**



The patterns over North and South America as well as South and Southeast Asia show stronger similarities – i.e. countries affected by direct impacts are also exposed to transnational impacts. But of course also here there are regional differences. For example, Thailand and South Korea appear to be much more exposed to transnational impacts than they are vulnerable to direct impacts.

Overall, the index results show much less correlation between exposure and wealth, or with human development when compared with traditional climate vulnerability indices (see discussion below and Appendix 5), suggesting that the factors influencing transnational climate risk are more complex and country-specific.

## 5. DISCUSSION AND FUTURE RESEARCH

This paper lays out the basic structure of a framework for analysing exposure to the transnational impacts of climate change. The goal of the framework and the TCI Index is to facilitate quantitative analysis of this emerging concern in climate impacts and adaptation research. An important question is whether *meaningful* quantification of this highly complex phenomenon is at all possible, or even worthwhile. *Are we better off for having this index?*

Previous indicator and index studies have put forward a rather uniform view of "which countries are vulnerable to climate change", based on a conception of vulnerability that is limited to what this paper calls "direct" climate impacts, meaning those occurring within national borders. This is despite these studies employing a range of different methodologies, with wildly different levels of detail and ambition (Füssel 2009; Benzie 2014b). Appendix 5 shows how one such study (the ND-GAIN Country Index, which has been used as an input to this paper) correlates to the Human Development Index (HDI). It is questionable whether such indices tell us anything beyond what we already know: that poor countries with low levels of human development will be most affected by climate change, and that wealthy, industrialized countries are largely immune to the effects of climate change in poor countries. Such results give the impression that "vulnerability" can be understood by looking at countries in isolation: that the vulnerability of rich (and poor) countries can be understood independently of their connections and interdependencies with other countries.

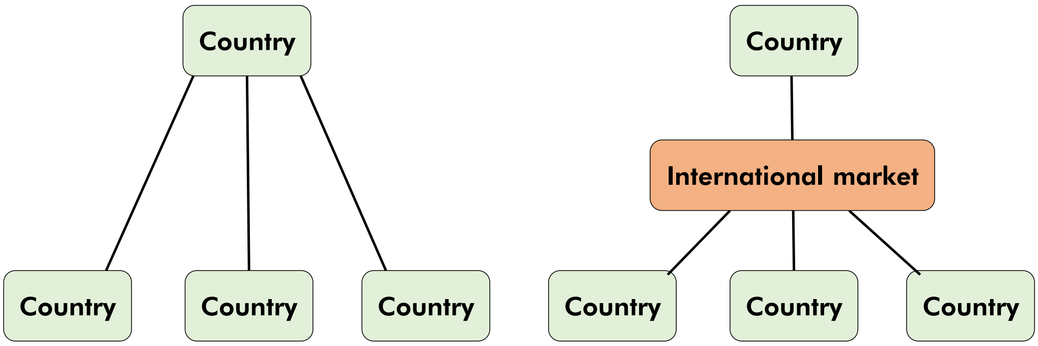
There is little doubt that countries at the lower end of the HDI are likely to struggle most in a changing climate. However, a key contribution of the framework put forward in this paper, and the initial results of the TCI Index, is to offer a complementary and more complex perspective on how exposure to climate risk may be experienced in the real world. The many links and flows between countries mean no country is fully insulated from the negative impacts of climate change outside its borders.

In this paper we argue that it is possible to move beyond a general recognition of this problem; we hope the maps for each indicator and for the TCI Index provide a good starting point for such a discussion. We also hope to further develop the framework in the future to provide more support to decision-makers who wish to explore climate risk profiles at the national or regional level. For example, the framework could be adapted and applied to assess transnational climate impacts across the European Union, or the African Economic Community, perhaps to support regional adaptation responses. It could help countries identify the cities, states or provinces most exposed to climate change impacts abroad (e.g. because they are financial or manufacturing hubs), or identify sectors that require special attention.

That said, it is important to recognize that what we are trying to quantitatively assess is a system with huge degrees of complexity, and as with all such indices, the results depend on the indicators chosen. Hence, the selection process needs to be transparent, and the ultimate choice of indicators needs to be well justified and explained. We have striven to make clear the limitations of the study as a decision support tool and to be entirely transparent about the level of analysis. ***Our view is that the indicator results presented here and TCI Index should be used to raise awareness and start discussions, but not yet to inform decision-making.***

The work presented here could be further improved in several ways. First, the framework emphasizes the properties of individual countries and the relationships between countries. One obvious reaction to this is that in many cases, trade (for instance) is happening between an actor in a country and a *market*; see the schematic illustration in Figure 13. Global markets vary depending on the commodity; in some commodity markets, trade is relatively stable, with buyer-seller relationships that change infrequently, while in others the demand is satisfied by a market with a wide range of suppliers that are highly substitutable. This has implications for the management of climate risks to supply chains, and requires deeper and more sophisticated methodologies – and better data – in order to provide more accurate indicators of risk exposure at the national level. The area of trade-based indicators of climate risk exposure is something that deserves significant attention in future research.

**Figure 13: Schematic illustration of country to country relationship vs. country to market relationship**




A second area for improvement is based in the observation that the "climate-weighted indicators" only assesses one country's exposure to transnational impacts via other countries' exposure to *direct* impacts, via the ND-GAIN index. Hence, in the analysis the target country is linked to other countries, but these other countries are not linked to one another. In a "complete" model, the target country's exposure to transnational impacts of climate change should include other countries' exposure to transnational impacts. This would entail an analysis of the fully connected network and might yield interesting insights. For example, if some countries – for whatever reasons – were both highly exposed to transnational impacts, and highly reliant on other countries that were also highly exposed to transnational impacts, this would significantly raise the risk. Such an analysis could help shed light on the propensity for *cascading risks* in the global economy as a result of climate change.

This is the theoretical ideal. In practice, under current conditions, such a complete analysis would be difficult to carry out. We also need to balance completeness and sophistication on one side, and transparency and clarity on the other. Our framework and index, in their current form, are rather crude, but they are easy to explain and visualize. Future developments that apply more complex data and methodologies only make sense *if they provide better insights for decision-making*. Still, it would be interesting to expand the framework to incorporate elements of a more "complete" model. In general, adaptation research should adopt methodologies and framings that enable a network-based perspective of climate risk to be explored and communicated to stakeholders and decision-makers.

As a third area for improvement, further investigation on the correlation between indicators would strengthen the quality on the indicator selection and might provide a more detailed background to the analysis of the results. It might be especially revealing to identify clusters of countries with similar risk profiles, using a correlation analysis, for example.

Finally, the framework presented here has been developed to produce a global index of exposure to the transnational impacts of climate change. A secondary aim of this framework is to facilitate quantitative analysis at the national or sectoral level. We are currently working on such an analysis at the national level, for Sweden, and hope to extend this to a sectoral analysis of national economic sectors in a global context, funding permitting.

We invite feedback on all aspects of the assessment covered in this paper. A spreadsheet containing results for all indicators and the global index is available on the SEI website.

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## APPENDIX 1: LIST OF COUNTRIES EXCLUDED DUE TO LACK OF DATA

| | |
|---|---|
| AIA | Anguilla |
| ALA | Åland Islands |
| AND | Andorra |
| ASM | American Samoa |
| ATA | Antarctica |
| ATF | French Southern and Antarctic Lands |
| BLM | Saint Barthelemy |
| CCK | Cocos (Keeling) Islands |
| COK | Cook Islands |
| CXR | Christmas Island |
| ESH | Western Sahara |
| FLK | Falkland Islands (Malvinas) |
| GGY | Guernsey |
| GIB | Gibraltar |
| GLP | Guadeloupe |
| GRL | Greenland |
| GUF | French Guiana |
| GUM | Guam |
| HMD | Heard Island and McDonalds Islands |
| IMN | Isle of Man |
| IOT | British Indian Ocean Territory |
| JEY | Jersey |
| MAF | Saint Martin |
| MNP | Northern Mariana Islands |
| MTQ | Martinique |
| MYT | Mayotte |
| NFK | Norfolk Island |
| NIU | Niue |
| NRU | Nauru |
| PCN | Pitcairn Islands |
| REU | Reunion |
| SGS | South Georgia South Sandwich Islands |
| SHN | Saint Helena |
| SJM | Svalbard |
| SPM | Saint Pierre and Miquelon |
| TCA | Turks and Caicos Islands |
| TKL | Tokelau |
| TUV | Tuvalu |
| UMI | United States Minor Outlying Islands |
| VAT | Holy See (Vatican City) |
| VGB | British Virgin Islands |
| VIR | United States Virgin Islands |
| WSM | Samoa |

## APPENDIX 2: PROXIES FOR COUNTRIES WITH NO ND-GAIN SCORE

Below is a list of proxy scores for countries or territories excluded from the ND-GAIN index. Proxies have been selected based on the geographical location and/or equivalent level of development. "Countries" are defined according to the ISO3 Standardized country codes, which include some principalities and autonomous regions that are normally not considered to be separate countries.

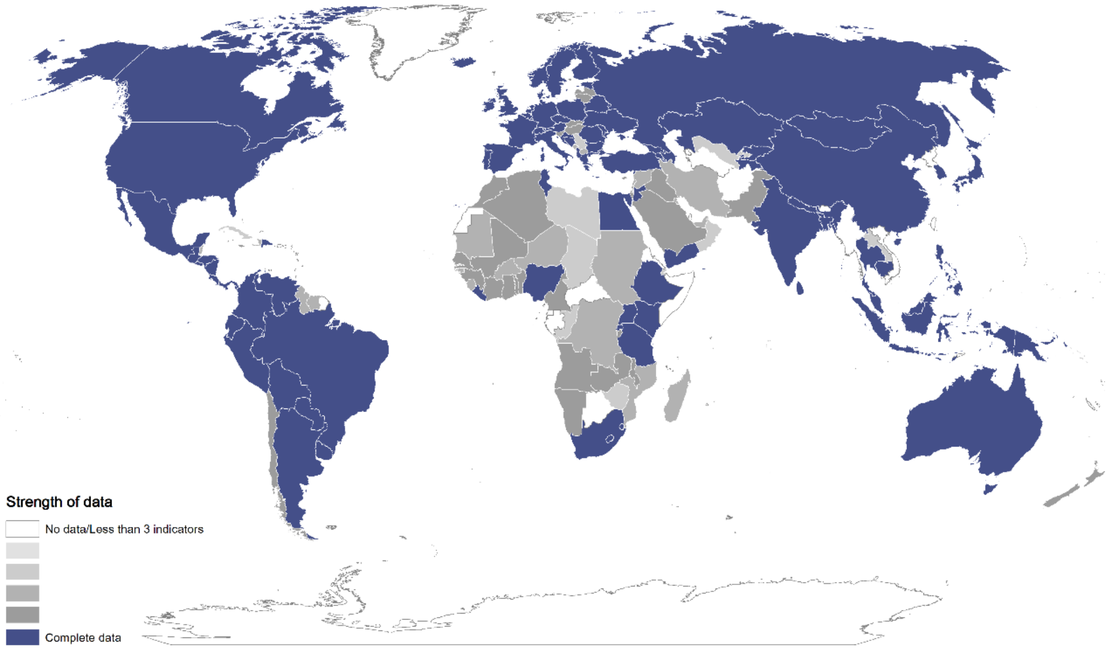
| Countries with no ND-GAIN score | Proxy countries |
|---|---|
| Montenegro | Average of Albania, Serbia, Bosnia and Croatia |
| Western Sahara | Average of Algeria, Mauritania and Morocco |
| Hong Kong, Macao, Taiwan | China |
| Lichtenstein | Average of Switzerland and Austria |
| Serbia & Montenegro | Serbia |
| Åland | Finland |
| Faroe Islands | Iceland |
| Falkland Islands | Argentina |
| Gibraltar | Spain |
| Vatican | Italy |
| Guernsey | France |
| Greenland | Iceland |
| Isle of Man | United Kingdom |
| Jersey | France |
| Palestine | Syria |
| San Marino | Italy |
| Svalbard | Norway |
| Antarctica, French Southern and Antarctic Lands, Heard Islands and McDonald Islands, South Georgia South Sandwich Islands, Bouvet Islands | Somalia (i.e. top ND-GAIN score)[29] |
| Caribbean Islands (Anguilla, Aruba, Bermuda, Aruba, British Virgin Islands, Cayman Islands, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, Puerto Rico, Saint Barthelemy, Saint Martin, Turks & Caicos Islands, United States Virgin Islands): | Dominican Republic[30] |
| Pacific Islands (American Samoa, Cook Islands, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Norfolk Islands, Northern Mariana Islands, Pitcairn Islands, Palau, Tokelau, Tuvalu, Wallis and Futuna Islands, United States Minor Outlying Islands: | Solomon Islands[31] |
| Indian Ocean (Christmas Islands, British Indian Ocean Territory, Cocos (Keeling) Islands | Maldives[32] |
| French Guiana | Average of Brazil and Suriname |

[29] These polar territories are assumed to be highly vulnerable to climate change, hence the use of the top ND-GAIN score for vulnerability (which is for the country of Somalia) as a proxy.
[30] It is assumed that all islands in the region represent a similar level of vulnerability to a SIDS (Small Island Developing State) like the Dominican Republic.
[31] It is assumed that all islands in the region represent a similar level of vulnerability to a SIDS like the Solomon Islands.
[32] It is assumed that all islands in the region represent a similar level of vulnerability to a SIDS like the Maldives.

| | |
|---|---|
| Mayotte | Comoros |
| Reunion | Mauritius |
| Saint Pierre and Miquelon | Canada |
| Saint Helena | Sao Tome and Principe |
| Andorra | Spain |
| Channel Islands | France |
| Kosovo | Average of Albania, Montenegro, Serbia and Macedonia |

## APPENDIX 3: STRENGTH OF DATA AVAILABILITY FOR EACH COUNTRY

**Figure A1: Strength of data availability for each country, by number of indicators**




## APPENDIX 4: LIST OF AVAILABLE MAPS

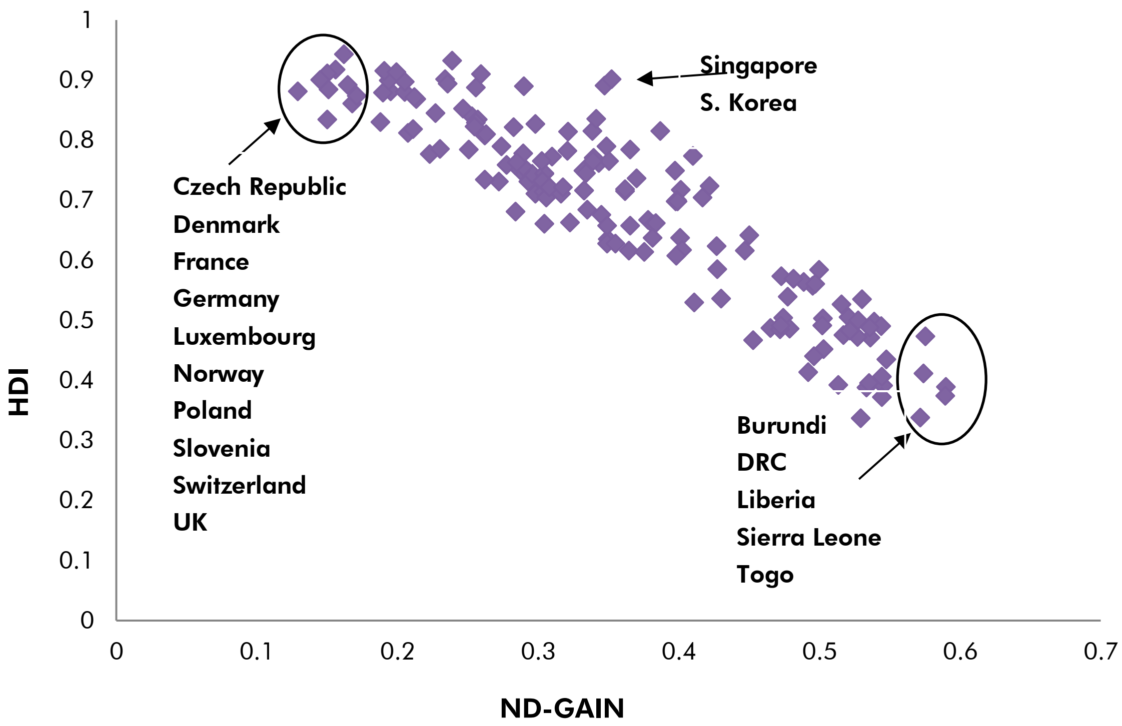
1. Result averaged by indicators available when ≥ 7
2. Result averaged by indicators for countries with complete data
3. Result averaged by pathway for countries with complete data
4. Biophysical pathway
5. Finance pathway
6. People pathway (without Global Migration Barometer)
7. People pathway (with Global Migration Barometer)
8. Trade pathway
9. Global context
10. Transboundary water dependency ratio
11. Foreign direct investments in climate vulnerable countries
12. Remittances
13. Attractiveness and accessibility to migrants (Global Migration Barometer)

14. Granted political asylums
15. Refugee population
16. In-migration from climate vulnerable countries
17. Trade openness
18. Cereal import dependency ratio
19. Embedded water in highly water stressed areas
20. Military expenditure
21. KOF Globalization Index
22. Physical proximity to climate vulnerable countries
23. KOF Globalization Index + Military expenditure
24. KOF Globalization Index + Physical proximity to climate vulnerable countries
25. Military expenditure + Physical proximity to climate vulnerable countries

## APPENDIX 5: CORRELATION BETWEEN ND-GAIN AND HDI

The graph below shows the correlation between country scores in the Human Development Index (data for 2013) and the ND-GAIN Index of climate vulnerability (data for 2012). The strong correlation raises an important question: do climate vulnerability indices tell us anything we don't already know about vulnerability?

**Figure A2: Correlation between ND-GAIN and Human Development Index**



## APPENDIX 6: ALTERNATIVE INDICATORS

The present version of the global index comprises nine indicators. It is of course possible to add additional indicators in the framework; here we present three and explain why we considered but ultimately discarded them. They are: "attractiveness and accessibility to migrants", "military expenditure (as % of GDP)", and "physical proximity to climate vulnerable countries". We provide details for each of these indicators in tables below.

The first indicator would provide a very accurate measure of a characteristic of countries that could be quite relevant to the people pathway. However, the available data source, the Global Migration Barometer, only covers 61 countries. That would have been problematic when combining the indicator results for the overall TCI Index.

The two other indicators were considered as part of our global context analysis, but we found them insufficiently robust as measurements of the desired characteristics of interest. We also experimented with combinations of indicators. For example, we developed a map using geographic information systems (GIS) software to indicate proximity to particularly vulnerable countries as a proxy of exposure to transboundary impacts, coupled with the KOF Globalization Index as a proxy of exposure to teleconnections. We do not present the results here, but they may help to inform the future development of the TCI Index.

| **People pathway indicator: Attractiveness and accessibility to migrants (Global Migration Barometer)** | |
|---|---|
| **Characteristic to measure** | The attractiveness and accessibility of a country to migrants |
| **Assumptions** | The greater a country's attractiveness and accessibility is to migrants, the more exposed it is to transnational impacts of climate change.<br>The Global Migration Barometer (Economist Intelligence Unit 2008) measures "attractiveness to migrants" as a country's appeal to migrants (rather than explain existing stocks of migrants) and "accessibility for migrants" as ease of entry, integration and the legal environment for migrants in the host country. Countries with higher scores are likely to receive more applications from economic migrants if a climate event were to occur somewhere else. |
| **Data availability** | The Global Migration Barometer measures a country's attractiveness and accessibility to migrants.<br>Data available for 2008 |
| **Data selection and justification** | Given that it is produced by a well-respected source (the Economist Intelligence Unit), we consider the Global Migration Barometer a robust data source; however, given that it covers only 61 countries, it is not suitable for a global analysis. |
| **Method** | Existing indicator |

| **Global context indicator: Military expenditure (% of GDP)** | |
|---|---|
| **Characteristic to measure** | A country's level of involvement in military interventions abroad |
| **Assumptions** | The more prone a country is to engage in foreign military and humanitarian interventions, the more exposed it is to transnational effects of climate change. If a country is largely involved by military operations in a country that is affected by direct impacts of climate change, the consequences might be that the demand for the level of involvement, such as financial contribution or operational intervention, might suddenly change. |
| **Data availability** | The Swedish International Peace Research Institute (SIPRI) measures military expenditure.[33] The World Bank measures military expenditure.[34] The UN Office for Disarmament Affairs (UNODA) measures military expenditure.[35] |
| **Data selection and justification** | SIPRI provides a consistent and annually updated database on military expenditure. It is also the source of origin for many other publishers of military expenditure data, such as the World Bank. Therefore, it has also been used as a data source in this particular case. |
| **Method** | Existing indicators |

| **Global context indicator: Physical proximity to climate vulnerable countries** | |
|---|---|
| **Characteristic to measure** | The extent to which a country is physically close to climate vulnerable countries |
| **Assumptions** | The larger physical proximity a country has to other climate vulnerable countries, the more exposed it is to transnational impacts of climate change.<br>This indicator reflects a pure spatial dimension that transnational impacts might take. To some extent, the indicator can capture spatial implications of transnational impacts that are difficult to measure, such as ecological or infrastructural connections. By being physically linked to climate vulnerable countries, proximate countries can be indirectly influenced by direct climate impacts occurring in those countries. |
| **Data availability** | The U.S. Central Intelligence Agency (CIA) World Factbook measures the length of the total country boundaries as well as individual lengths for contiguous country boundaries.[36] The Peace Research Institute Oslo (PRIO) measures international country boundaries.[37]<br>Data are available for 2014. |
| **Data selection and justification** | The data for this indicator were produced by GIS analysis at SEI. In parallel, the data were compared against the numbers from the CIA World Factbook. The reason for not only using the CIA data is that the data are published in a difficult-to-use format. However, because the CIA World Factbook provides recent information on country boundaries, it was selected as an additional source for this indicator. |
| **Method** | Original analysis. The data have been developed using GIS analysis. The individual lengths of the contiguous country boundaries have been calculated as a proportion of the total country boundary excluding coastline. As map projections distort the exact units of the distances, the proportions have been reviewed against the CIA World Factbook data. |

[33] See: https://www.sipri.org/databases/milex.
[34] See: http://data.worldbank.org/indicator/MS.MIL.XPND.GD.ZS.
[35] See: https://www.un.org/disarmament/convarms/Milex/.
[36] See: https://www.cia.gov/library/publications/the-world-factbook/fields/2096.html.
[37] See: https://www.prio.org/Data/Geographical-and-Resource-Datasets/Length-of-International-Boundaries/.

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