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Quantifying transnational climate impact exposure: New perspectives on the global distribution of climate risk

Johanna Hedlund[a,*], Stephen Fick[b], Henrik Carlsen[b], Magnus Benzie[b]

[a] Stockholm Resilience Centre, Stockholm University, Kräftriket 2B, SE 106 91 Stockholm, Sweden
[b] Stockholm Environment Institute, Box 24218, SE 104 51 Stockholm, Sweden

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ABSTRACT

Indicators used in climate change adaptation planning are largely based on estimates of national or local climate vulnerability. However, classic vulnerability indices do not consider cross-border effects and global interconnections. We attempt to reconcile this need for a broader perspective by developing a global index of exposure to transnational climate impacts, which we define as impacts that are transferred via flows between countries. The index integrates traditional climate vulnerability indicators with spatially-explicit teleconnections between specific countries and constitutes a first approximation of the distribution of such exposure globally. Our results indicate that even though climate risks emerging from within a country's borders are highly correlated with economic development and geography, the distribution of exposure to transnational climate impacts provides a much more complex picture of global vulnerabilities, which neither geography, nor economic development alone can explain sufficiently. This highlights the need to take a cross-scale and multidimensional perspective of climate risk. In order to support more robust adaptation planning, risk assessments should consider both transboundary and far-reaching teleconnected interdependencies between countries.

1. Introduction

To accomplish the ambitious targets of the Paris climate agreement, i.e. to limit global warming well below 2 degrees and to 'pursue efforts' to limit it to 1.5 degrees, countries have submitted Intended Nationally Determined Contributions (INDCs) outlining their post-2020 climate action. Recent estimates show that the INDCs collectively imply a median of 2.6–3.1 degrees warming by 2100 (Rogelj et al., 2016), with potentially severe impacts on natural and social systems (IPCC, 2014a). As a consequence, climate change adaptation will be needed in response to climate impacts (Noble et al., 2014; Ford et al., 2015). This is also stressed in the Paris agreement, which features a new reporting mechanism under the heading of 'adaptation communication' (UNFCCC, 2015). A key challenge will be to assess whether investments in adaptation options are reducing vulnerability (Berrang-Ford et al., 2011; Ford et al., 2013) and in this context it will be important to develop more rigorous methodologies to measure progress (or lack thereof) in implementing effective climate change adaptation measures (Lesnikowski et al., 2016). Presumably, a cornerstone of such methodologies will involve quantitative indicators and metrics as instruments for measuring progress in reducing vulnerability, identifying gaps and assessing effectiveness (Baker et al., 2012; Leagnavar et al., 2015; Arnott et al., 2016).

Both scholars and policy-makers are showing increasing interest in developing and using indicators to assess exposure, vulnerability, impacts and adaptation (Arnott et al., 2016). Initiatives range from overarching methods at the national level (e.g. ND-GAIN, 2015), to tailor-made approaches for development projects (e.g. Stadelmann et al., 2014; GEF, 2014) and, for instance, climate change adaptation in urban areas (e.g. Araos et al., 2016; Brandt et al., 2016; Chen et al., 2016; Tyler et al., 2016). Of specific relevance for this paper are spatial approaches to climate vulnerability where the focus is on spatial representations of factors determining vulnerability (de Sherbinin, 2014).

Here we present the first attempt to develop a global index that quantifies transnational climate risks by introducing the Transnational Climate Impacts (TCI) Index. By transnational climate impacts we mean climate impacts that reach across borders, affecting one country – and requiring adaptation there – as a result of climate change or climate-induced extreme events in another country. There is no widely accepted terminology for describing this phenomenon and a number of different terms have been proposed in the literature (e.g. spillover effects, indirect climate impacts, traded risk, international effects, systemic risks, etc.; for a review see Benzie et al., 2017). Literature on climate change vulnerability has previously acknowledged the relevance of

* Corresponding author.
E-mail addresses: johanna.hedlund@su.se (J. Hedlund), stephen.fick@sei.org (S. Fick), henrik.carlsen@sei.org (H. Carlsen), magnus.benzie@sei.org (M. Benzie).

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Table 1
The nine index indicators along with the underlying assumptions, data sources, coverage (N representing number of countries covered and Y representing the year of the data) and method behind developing the indicators. The data was collected in 2014.

Indicator	Description: rationale and assumptions	Source	Coverage	Method
BIOPHYSICAL PATHWAY				
1. Transboundary water dependency	The proportion of water resources in a country that originates in transboundary upstream countries. 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.	FAO Aquastat	N: 187 Y: 2008–2012	Existing indicator (%)
FINANCE PATHWAY				
2. Bilateral climate-weighted foreign direct investment	The extent to which a country invests in climate vulnerable countries expressed as a function of the climate vulnerability of a country's total foreign direct investments. 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.	UNCTAD ND-GAIN	N: 130 Y: 2008–2012	New indicator (index): Coupled data with ND-GAIN Index
3. Remittance flows	A country's dependence on the inflow of remittances. The more a country relies on remittance flows the more exposed it is to climate-related disruption in countries where migrant workers are based.	World Bank's Development Prospects Group	N: 151 Y: 2012	Existing indicator (%)
PEOPLE PATHWAY				
4. Openness to asylum	The tendency of a country to grant political asylum. 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.	UNHCR	N: 143 Y: 2012	New indicator (sum of %): Coupled data of granted political asylum with total stock of refugee population
5. Migration from climate vulnerable countries	The extent to which a country has in-migration from climate vulnerable countries. Climate change could have a significant impact on migration patterns (see Oppenheimer et al., 2014). This indicator assumes that current migration links are an indicator of potential future migration patterns. Additionally, it assumes that countries that are particularly vulnerable to (direct) climate change are more likely to experience changes in migration patterns. These are two significant assumptions that simplify the complexity of climate-migration linkages.	The World Bank's Development Prospects Group ND-GAIN	N: 183 Y: 2010 (World Bank), 2012 (ND-GAIN)	New indicator (index): Coupled data with ND-GAIN Index
TRADE PATHWAY				
6. Trade openness	A country's level of openness to trade: the sum of the country's imports and exports as a share of the country's total GDP. 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.	UNCTAD	N: 146 Y: 2012	Existing indicator (%)
7. Cereal import dependency	The dependency of a country on imported staple foods. 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.	FAO	N: 181 Y: 2007–2009	Existing indicator (%)
8. Embedded water risk	The level of consumption of embedded water that originated in water-stressed countries. The more key commodities that a country consumes that contain embedded water from water-stressed parts of the world, the more exposed it will be to climate-related change in water availability in those producer countries that are already high risk.	SEI	N: 203 Y: 2007	New indicator (index): Original modelling
GLOBAL CONTEXT				
9. KOF Globalisation Index	The level of global integration and interconnectedness of a country. The more globalised a country is, the more exposed it is to the transnational impacts of climate change.	KOF Globalisation Index	N: 191 Y: 2011	Existing indicator (index)