Implications for the EU of cross-border climate change impacts

Deliverable D3A.2

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Preface

This deliverable is part of Task 3A.2 in the IMPRESSIONS project. While a main focus of the IMPRESSIONS project is on the *direct* impacts of high-end climate change in selected sub-regions of Europe and over Europe as a whole, in this report we review the *indirect*, cross-border implications for Europe of climate change impacts occurring outside Europe.

The original title for the deliverable was "*Assessment of global indirect impacts facing Europe"*. As our work on the concepts of "indirect impacts" has evolved, we have re-titled the report ***"Implications for the EU of cross-border climate change impacts***". We feel this wording more accurately and intuitively communicates the issues under examination, which at their root involve the effects of climate change that cross national borders. See Section 2.2 of this report for a discussion on terminology in this regard.

The IMPRESSIONS project identified an evidence gap around how and why climate change outside Europe might affect the EU. Task 3A.2 seeks to address this gap via this report. A second aim of Task 3A.2 is to assess the implications of cross-border impacts for the external functions of the EU. This aim is being addressed via one of the five IMPRESSIONS case studies, which works with stakeholders to focus on cross-border impacts in Central Asia, including the effects on, and potential responses from, Russia, China and the EU (the so-called "EU external" case study, or EUx). This deliverable also offers insights into how the EU's external functions might be affected by cross-border climate change impacts in general and explores the potential roles of the EU in addressing cross-border impacts both within and beyond Europe.

In this deliverable we summarise activities within the IMPRESSIONS project that have examined the implications of cross-border climate change impacts for the EU. This is a relatively immature field of research and yet it is increasingly clear that adaptation planning – and the research that informs this process – has begun to recognise the relevance of cross-border dimensions to climate risk.

The problem addressed in this report is therefore how decision-makers at the EU level can begin to incorporate cross-border climate change impacts into the adaptation portfolio.

The report is intended for stakeholders – including employees of the European Commission, European External Action Service, European Parliament and the European Council, as well as their support institutions, and policy-makers at the member state level. It is also intended to be of interest to researchers and consultants supporting adaptation decision-making and climate risk identification and assessment at various scales: local, national, European and global. The authors welcome constructive feedback from any readers.

Summary

Today, Europe is connected to almost all parts of the globe, in one way or the other. Climate change impacts in one place (e.g. damage from extreme weather events) are likely to have repercussions elsewhere, strongly implying a need for enhanced international cooperation for adaptation, especially by and within the EU. In this report we identify *climate risk pathways* that connect distant countries within and beyond the EU (Section 2). These pathways are useful for identifying different types of impacts, and ultimately for assigning responsibility for adaptation to specific EU external functions. The importance of each risk pathway and the range of risks facing the EU in the future will vary depending on future socio-economic developments, as well as on the level of future climate change. We identify three key aspects of cross-border impacts for the EU.

- *EU internal dimension* - Cross-border impacts could be significant *within Europe*, where climate impacts and adaptation actions in one member state could affect neighbouring countries or partners in the single market, or indeed the Union itself.
- *EU external dimension* – The EU depends on the European Neighbourhood, but also countries further afield, for trade, security and as partners in international development and global governance. Climate change impacts and adaptation actions in other regions will therefore impact the EU.
- *EU impacts on the rest of the world* – climate change and actions taken to adapt within and by the EU will also have effects – positive or negative – on other non-EU countries; links between the EU and the rest of the world should be considered in adaptation planning.

In Section 3 we review existing evidence on the EU's exposure to cross-border impacts. We also report the results of a quantitative indicator-based analysis of Europe's exposure and provide country risk profiles for the four IMPRESSIONS case study locations in terms of their potential exposure to cross-border impacts. We find that for certain indicators, exposure of the EU as a whole or of EU member states can be substantially higher (relative to regions elsewhere in the world) for cross-border impacts than it is for direct, localised climate impacts. We look at a number of indicators that show EU exposure is above the global average, suggesting a need for more in-depth EU-level assessment.

In Section 4 we review the current state of adaptation planning for cross-border impacts. We find that interest and awareness is on the rise. Some member states have completed or are undertaking national level assessments. The EU itself is also managing cross-border climate change impacts via a number of existing mechanisms and has recognised the importance of this issue in the EU Adaptation Strategy. We also surveyed national adaptation focal points in Europe. Our key finding is that there are high expectations – and significant opportunities – for the EU to play a leading role in adaptation to cross-border impacts. This is perhaps most evident in the context of EU internal aspects, for example in the mediation of climate impacts inside the single market and between member states; the EU Adaptation Strategy should look to increasingly focus on the unique and valuable role that the EU can play in identifying, assessing and managing cross-border cooperation for adaptation.

Cross-border climate change impacts present a number of challenges to science and policy, some of which are discussed in Section 5.

1. Introduction

1.1. Context – The European Union today

When looking at how climate change impacts in other countries might affect the EU it is first helpful to survey, in brief, some of the links between the EU and other countries that might be climate-sensitive. This snapshot looks at the EU's current trade profile, as well as other key links including tourism, migration, foreign policy and foreign aid. A key reflection here is that the EU is connected in some way to most other world regions. Whilst in some sectors there are obvious "key partners" for the EU, it is not possible to focus solely on a small handful of countries when assessing European global interconnectedness.

European Union sectors and activities with potential cross-border climate impacts

With a population of over 500 million people (around 7% of the global total) and a GDP of almost €13 trillion (23% of the global total) in 2013 (Eurostat 2014), the European Union (EU) is a major force of influence globally and has numerous international connections and relations worldwide. In trade, the EU is the leading global exporter and importer of goods and commercial services, a net importer of energy resources and other raw materials and a major exporter and importer of food, drink and agricultural products. The EU is also the world's leading supplier and recipient of foreign direct investment, the major source region and destination for international tourism, the world's largest provider of official development assistance (ODA) and a net recipient of international migration. Some key cross-border flows between the EU and the rest of the world are summarised in Table 1, all of which are potentially sensitive to climate change impacts. Some of these dependencies are also mapped in Figure 1 and Figure **2**, which illustrate how source regions for selected key imports with potential sensitivity to cross-border climate change impacts differ between sectors and activities of interest. One way of conducting a climate risk assessment would therefore be to first locate those source regions where climate hazards are most likely to cause serious negative impacts, while also assessing sensitivities to climate along the entire supply chain.

Table 1: Extent of cross-border flows between the European Union and the rest of the world for potentially climate-sensitive sectors and activities of strategic importance and the European Commission departments most closely associated with them.

Sector	Description of flows and main partner countries	Relevant Commission department[1]
Manufacturing of machinery and vehicles and other goods	***Surplus:*** €238.16 billion in 2014 (largest in extra-EU trade) ***Exports:*** Exceeded €1.7 trillion (extra-EU trade ca. 40%) Mainly: road vehicles, industrial and electrical machinery USA, China and Russia the main trade partners. Others: metal products and scientific instruments and apparatus ***Imports:*** ca. €1.43 trillion (extra-EU trade ca. 30%) Mainly: electrical machinery, telecommunications equipment & IT products China, USA and Japan main trade partners (ca. 60%) Others: clothing and metal products *Source: Eurostat 2015*	DG TRADE DG GROW DG CNECT

Sector	Description of flows and main partner countries	Relevant Commission department[1]
Manufacturing of chemicals and chemical products	***Surplus:*** €114.2 billion in extra-EU trade in 2014 ***Exports:*** ca. €755.81 billion (extra-EU trade ca. 40%) Mainly: pharmaceutical products and organic chemicals USA, Switzerland and China main trade partners (ca. 50%) ***Imports:*** ca. €640.26 billion (extra-EU trade ca. 25%) Mainly: pharmaceutical products and organic chemicals USA, Switzerland and Russia main trade partners (ca. 40%) *Source: Eurostat (2015)*	DG TRADE DG GROW DG CNECT
The energy sector	***Deficit:*** €-334.85 billion in extra-EU trade in 2014 ***Exports:*** €339.58 billion (extra-EU trade ca. 32%) Mainly refined petroleum products USA main trade partner (ca. 15%) ***Imports:*** €674.43 billion (extra-EU trade 66%) Crude oil (90% imported); natural gas (65%); solid fuels (40%); nuclear fuels (40%) Russia, Norway and Algeria main trade partners (ca. 50%) *Source: Eurostat (2015)*	DG ENER DG CNECT
Food, drink, agricultural products and live animals	***Surplus:*** ca. €5 billion in extra-EU trade in 2014 ***Exports:*** €111.9 (extra-EU trade ca. 26%) Mainly beverages, cereals, fruits, vegetables and dairy products USA, Russia, Switzerland and China main trade partners (32%) Others: metal products and scientific instruments and apparatus ***Imports:*** €106.8 billion (extra-EU trade 25%) Mainly vegetables, fruits, fish, spices, coffee and tea (by value) Brazil, USA, Argentina and Norway main trade partners (ca. 30%) *Source: Eurostat (2015)*	DG AGRI DG TRADE DG MARE
Raw materials	***Deficit:*** €30.42 billion in extra-EU trade in 2014 ***Exports:*** €128.67 billion (extra-EU trade ca. 30%) Mainly metal ores and scrap (34%) China, Turkey and USA main trade partners (41%) Others: cork and wood ***Imports:*** €158.25 billion (extra-EU trade 40%) Mainly metal ores and scrap (46%) Brazil, USA, Canada and Russia main trade partners (ca. 41%) Others: Oil-seeds and oleaginous fruits *Source: Eurostat (2015)*	DG TRADE DG CNECT
Finance and business	EU is world's largest receiver & provider of foreign direct investment (FDI) ***Outward stock of FDI:*** €5.207 trillion (2012) Mainly financial and insurance services; professional, scientific and technical activities; mining and quarrying; petroleum, chemical and pharmaceutical products (65%) USA, Offshore centres, Brazil and Russia main partners (23%) ***Inward stock of FDI:*** €3.947 trillion (2012) Mainly financial and insurance services (68%) USA, Offshore centres and Switzerland main partners (36%) *Source: Eurostat (2015)*	DG ECFIN DG CNECT

Sector	Description of flows and main partner countries	Relevant Commission department[1]
Tourism	***Inward to EU:*** Europe is world's most popular destination for international tourists (52% of all arrivals in 2013). Of nights spent by foreigners in EU destinations, 28% from outside the EU (12% Europe; 16% other continents) Income: over €300 million ***Outward from EU:*** Europe is the world's largest source region for international tourists, generating over half of all international departures 14.6% of all outbound trips by EU residents were made to destinations outside of Europe in 2012 Main destinations: USA, Turkey, Morocco and Russia *Source: UNWTO (2014)*	DG CNECT DG MOVE DG EAC
Migration	***Immigration to EU:*** 1.7 million immigrants from outside the EU in 2012 During 2009-2012, India, Morocco, China and Pakistan accounted for the largest numbers of immigrants into the EU Of 2.1 million residence permits issued to non-EU nationals in 2012, 32% for family reasons, 23% for work, 22% for education, 23% for other reasons ***Asylum in EU:*** Over 435 000 in 2013 (more than 20% of applications were from Syria and Russia) *Source: DG HOME (2014)*	DG MOVE DG HOME
Foreign policy and international security	***Security:*** Climate change identified as one of eight key threats in areas neighbouring the EU (CFSP 2008) In 2014, the EU had 11 civilian missions and five military operations ongoing in Africa, the Middle East or Eastern Europe (EEAS 2014)	DG DEVCO FPI DG HR
Development assistance and humanitarian aid	***Official development assistance (ODA):*** EU and member states collectively the world's largest providers of ODA (€56.5 billion in 2013 (>50% of total) Collectively, development aid through the EU had an allocated budget of €14.86 billion in 2013. Countries receiving the largest sums of ODA in 2013 were Turkey, Mali, Syria, Morocco and Afghanistan *Source: European Commission (2014)*	DG ECHO DG DEVCO

[1] FPI (Service for Foreign Policy Instruments); Directorate General (DG) ENER (Energy); ECHO (Humanitarian Aid & Civil Protection); DEVCO (International Cooperation and Development); CLIMA (Climate Action); AGRI (Agriculture and Rural Development); TRADE (Trade); GROW (Internal Market, Industry, Entrepreneurship and SMEs); ECFIN (Economic and Financial Affairs); ENV (Environment); NEAR (Neighbourhood and Enlargement Negotiations); CNECT (Communications Networks, Content and Technology); MOVE (Mobility and Transport); MARE (Maritime Affairs and Fisheries); HOME (Migration and Home Affairs); HR (Human Resources and Security); EAC (Education, Youth, Sport and Culture)

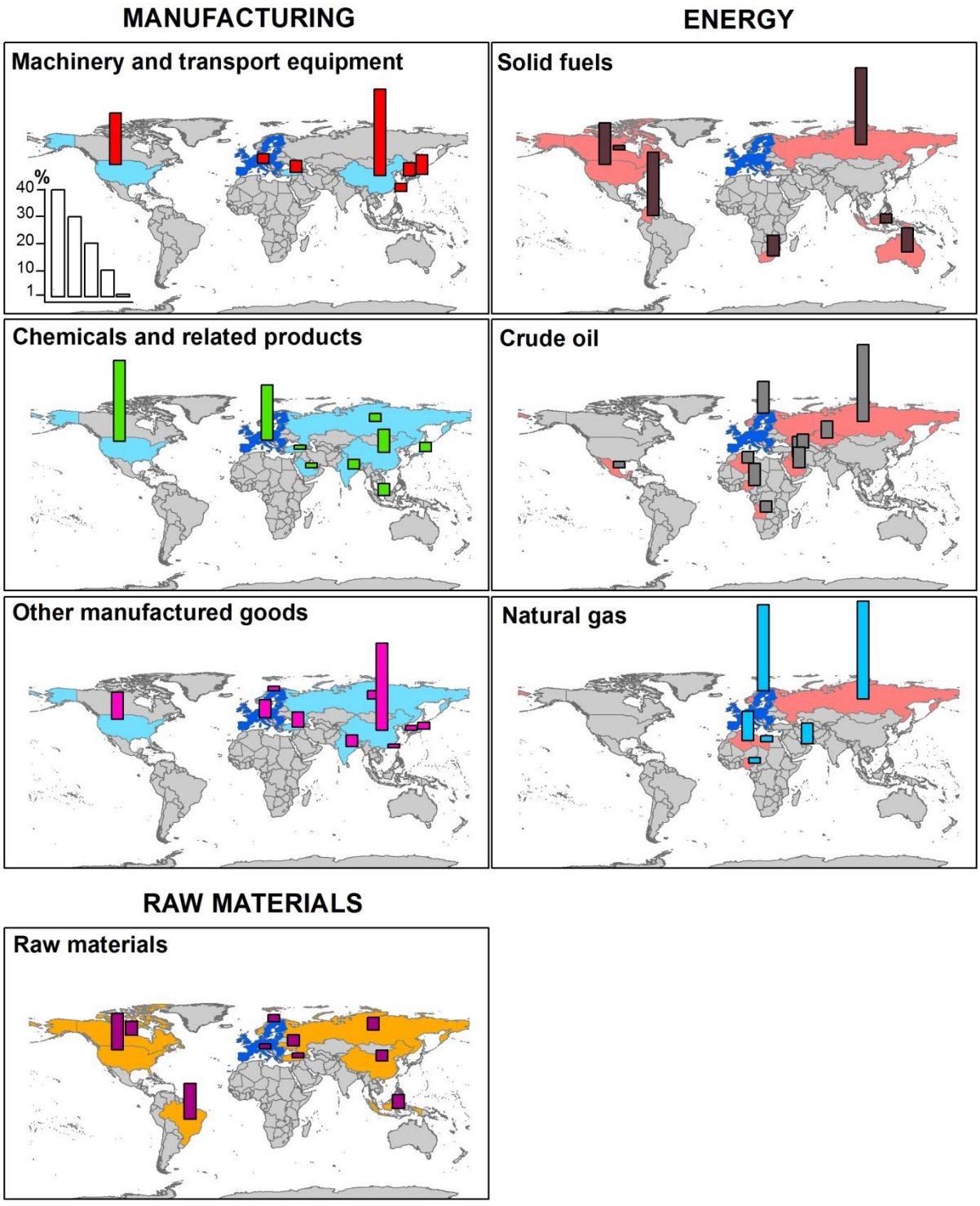

Figure 1: Location of leading partner countries from which the EU imports different manufactured products (left: top three panels), energy products (right: top three panels) and raw materials (left: bottom panel) that may be sensitive to cross-border impacts of climate change. Heights of bars indicate percentages of total extra-EU imports in 2015. Values and rankings may differ from those shown in Table 2, which are for one year earlier. Source: Eurostat (2016).

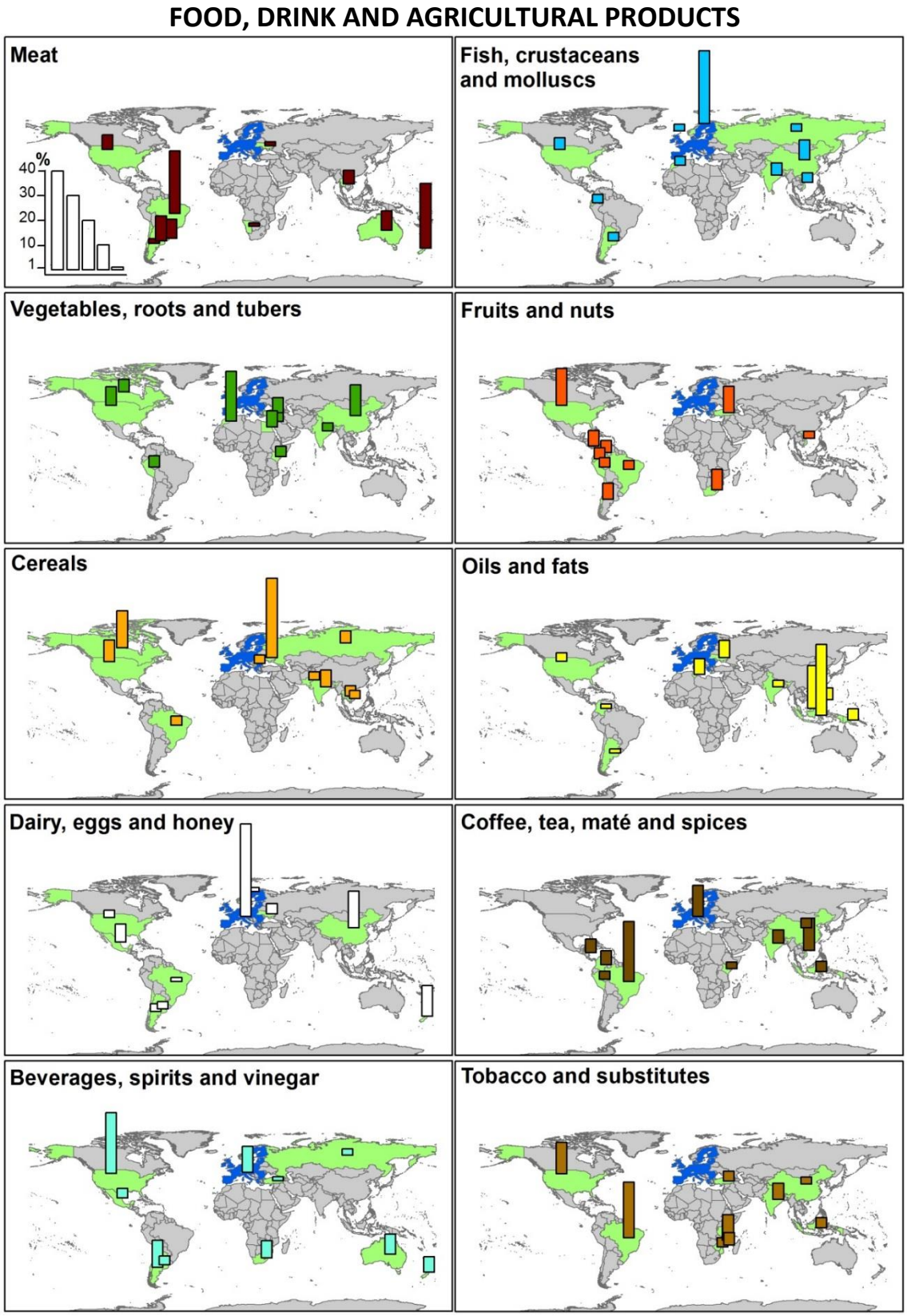

Figure 2: Location of leading partner countries from which the EU imports ten different categories of food, drink and agricultural products. Heights of bars indicate percentages of total extra-EU imports in 2015. Values and rankings may differ from those shown in Table 2, which are for one year earlier. Source: Eurostat (2016).

2. Problem definition

2.1. Cross-border impacts and climate risk pathways

Earlier work

Research on cross-border impacts of climate change is still in its infancy. The issue is referred to in the IPCC Fifth Assessment Report (AR5) as "cross regional phenomena", requiring "knowledge of critical but geographically remote associations and of dynamic cross-boundary flows" (Hewitson et al., 2014). Aspects brought together under that heading (but also treated separately in other AR5 chapters) include impacts of climate change on international trade, on financial flows and on human migration and migration of natural ecosystems (Hewitson et al., 2014).

Most of the few studies reported in the literature that are dedicated to this theme focus on the ramifications of cross-border impacts at the national scale (primarily in Europe). Examples include studies for Finland (Kankaapää and Carter, 2007; Hildén et al., 2016), Switzerland (INFRAS, 2007), the United Kingdom (Foresight, 2011; PwC, 2013) and the Netherlands (Vonk et al., 2015). Many of these have been reviewed in the context of Europe's vulnerability to impacts outside Europe in a recent report by the European Environment Agency (Lung et al., 2017). Some of their main conclusions are described in Section 4.2, below.

For a global perspective on national vulnerabilities to cross-border impacts of climate change, a "Transnational Climate Impacts Index" has been developed as part of the Adaptation without Borders project (Benzie et al., 2016). Vulnerabilities to the regional impacts of climate change on manufactured and agricultural commodities that are traded on the global market are examined by Lewis and Witham (2012a; 2012b). Coastal regions and ports have been a focus of some studies that recognise their importance for international trade, infrastructure and supply chains (e.g., Becker et al., 2013; Nicholls and Kebede, 2012), while the sub-national jurisdictional implications of cross-border impacts at the local and state level have also been highlighted (e.g., Singh-Peterson et al. 2013 for Australia; Gotangco et al. 2017 for Metro Manila, Philippines). Other initiatives have sought to analyse the potential for climate risks to propagate via global networks, especially via global food networks (e.g. Bren d'Amour et al, 2016; Suweis et al, 2015; Liu et al, 2014; Costinot et al, 2012) or global economic cascade effects across sectors (e.g. Wenz & Leverman, 2016). Whilst all of these studies add highly valuable insight into the nature of the risk, few studies have yet been completed to support assessment and decision-making for adaptation to cross-border impacts (Liverman, 2015).

Pathways of impacts

Several studies organise their analysis of cross-border impacts according to *pathways of impacts* (Table 1). This concept was first mooted in work at the Stockholm Environment Institute, which identified four climate risk pathways through which impacts can be transferred (Benzie et al, 2013; Benzie 2015; Benzie et al., 2016):

- The *biophysical* pathway, which encompasses cross-border ecosystems where impacts in one region of an ecosystem may create impacts for all regions that share the ecosystem's services (e.g. floods or droughts upstream in a river basin as well as actions to regulate these may affect water availability downstream; weather-induced forest fires in one region may cause

air pollution in other regions remote from the fires, or climate impacts on cross-border ecosystems such as oceans).

- The *trade* pathway, which transmits climate change impacts via the global market, through changes in production, volatility in prices and disruption of supply chains to import-dependent regions. Policy responses to such disruptions, such as export restrictions, might themselves act as magnifiers of the impacts
- The *finance* pathway, for which climate change impacts may disrupt the flow of public and private capital, such as overseas investments, remittances from migrant workers or international insurance.
- The *people* pathway, which refers to the movement of people across borders, where climate change impacts may contribute to driving factors leading to economic migration, may affect tourist flows and may result in an altered burden of health risks in recipient regions.

This framework is built around the concept of connected systems that are linked by critical *flows*, for example of resources (biophysical), goods and services (trade), capital (trade) and people (people). A "receptor system" will be impacted by climate change, altering the flow between it and another system (e.g. a "decision-making system"), which may need to adapt. This conceptual framework recognises that the pathways operate within a *global context* that defines the general conditions of stability and security within which itself will be impacted by climate change, altering the decision space and context in which adaptation occurs (Benzie, 2015).

Table 1: Pathways of cross-border climate change impacts based on three sources: SEI (Benzie et al., 2016); EEA (Lung et al., 2017); FIN (Hildén et al., 2016). The cognitive pathway reported by Hildén et al. (2016) is re-interpreted here as a cognitive filter.

Pathway (SEI)	Pathway (EEA)	Pathway (FIN)		Example climate impacts on:
Finance	Finance	Financial	Cognitive filter Climate impacts perception/adaptation	• Economy (extreme events) • Remittances
People	Human mobility	Human mobility		• Climate-related migration • Tourist flows
Trade	Trade (non-agricultural commodities)	Trade		• Raw materials • Manufacturing
	Trade (agricultural commodities)			• Food price volatility • Reliability of supply
	Infrastructure	Infrastructural		• Transport links • Reliability of energy supply
Biophysical		Biophysical		• River basin management • Invasive species
Global context	Geopolitical risks	Geopolitical		• Arctic resources • Access to water

Work in Finland has applied the same four climate risk pathways (labelled *biophysical, trade, financial* and *human mobility*) but added two more (Hildén et al., 2016):

- The *infrastructural* pathway, which channels impacts on infrastructure that connects a region with the rest of the world via transport or communication routes, such as storm damage affecting coastal ports, electricity distribution or electronic networks.

- The *geopolitical* pathway, which covers implications of climate change impacts that may lead to changes in international cooperation in peacekeeping, crisis management, natural resource exploitation, defence or humanitarian assistance, or in regional or international climate policies. An example could be the resource, security and environmental implications of an increasingly ice-free Arctic Ocean. In the SEI framework, this is part of the "global context" in which the pathways operate, which itself will be subject to the influences of climate change.

Six pathways are also identified in the EEA report (Lung et al., 2017), but their typology differs from the Finnish study by defining two trade pathways (for agricultural and non-agricultural commodities) and excluding the biophysical pathway.

Finally, the Finnish study also identifies (Hildén et al., 2016):

- The *cognitive* pathway, which describes the understanding by key actors of how climate impacts occurring in one region may be of importance in another. The overall impact of a remote climate event may hence be ameliorated or magnified (or not) depending on how it is perceived and acted upon at different steps along the chain of cause and effect.

However, it could be argued that instead of its representation as an impact pathway, human cognition rather serves as a filter that modifies impacts occurring through each of the other pathways. This cross-cutting role is how it is interpreted in Table 1.

A similar approach to the pathways-based studies listed above is adopted by Moser & Hart (2015). The authors refer to "societal teleconnections" that will be impacted by climate change, which are: trade and economic exchange; insurance and reinsurance; energy systems; food systems; human health; population migration; communication; and strategic alliances and military interactions.

Pathways of climate risk may operate over different scales. Benzie et al (2016) distinguish between *transboundary* impacts, which are transmitted over borders between neighbouring administrative zones, such as countries, and *teleconnected* impacts, which result from more remote links, including between distant parts of the globe via international network or systems. Transboundary impacts imply a need for common efforts between neighbouring countries to address shared climate risks, for example via regional cooperation. Teleconnected impacts imply a need for more complex international mechanisms of cooperation. Whilst this may imply bilateral cooperation between two countries that are directly linked over a large distance, for example where one country exports a raw material directly to another, in some cases, teleconnected impacts may require global mechanisms in order to achieve systemic solutions that reduce climate risks from teleconnected impacts.

2.2. Three aspects of cross-border impacts for the European Union

In applying the transboundary and teleconnnected dimensions of climate risk to the context of the European Union, with its special characteristics as a supra-national political union, we here identify three aspects of cross-border impacts relevant to the current study.

"EU internal" (EU_i)

These are climate change impacts in one EU member state that create risks for other EU member states. This includes spillover effects across internal EU borders and via intra-EU flows of resource,

goods, capital and people. *EU internal* impacts will have been strongly conditioned by the market, social and infrastructural integration that has taken place in Europe in recent decades. The political integration that has occurred also means that there are several mechanisms via which member states can seek to adapt to these *internal* impacts via the EU. EU internal impacts therefore create significant opportunities for the EU Adaptation Strategy (see below).

Similarly, the implementation of adaptation actions in one country will affect flows between member states, potentially in ways that require adaptation elsewhere in the EU. A classic example is offered by transboundary river basins, where increased abstraction or retention of water upstream will affect water availability or even flood risk downstream. Other, more conceptually complex examples also apply, for example concerning adaptations to infrastructure, trade or migration policy. Hence,there will also be an internal dimension to adaptation dynamics in Europe, which may require a role for the EU.

"EU external" (EU_x)

These are climate change impacts beyond the EU's borders that create risks for the EU as a whole, as well as its member states individually. This includes spillover effects from impacts in the countries of the European Neighbourhood[1], as well as those further afield that are linked to the EU via the climate risk pathways, as described above. Likewise, adaptation actions beyond the EU – in addition to climate change impacts themselves – will have cross-border ramifications, and therefore require adaptation within the EU itself.

"EU impacts on the Rest of the World" ($EU_{\rightarrow ROW}$)

These are climate change impacts within the EU will affect countries outside the EU because of the links and dependencies that exist between the EU and its global partners. Likewise, adaptation measures taken by and within the EU will have consequences on the rest of the world, including in ways that enhance or deplete the adaptive capacity of non-EU countries. This may be the result of deliberate decisions by the EU to change the terms of relations with other countries (e.g. changes to development cooperation spending, migration policy, etc.) or deliberate decisions to adapt EU systems that have knock-on effects on other parts of the world (e.g. changes to the Common Agriculture Policy that influence the price of globally traded agriculture commodities), or decisions that create unknown and/or unplanned consequences for non-EU countries (e.g. resulting from adaptation within EU insurance and re-insurance markets, or as a result of enhanced climate risk assessment in EU-based financial investments overseas). EU impacts on the rest of the world are likely to include both negative and positive consequences.

These three aspects – EU internal, EU external and EU impacts on the rest of the world – create a need for strategic assessment of cross-border dynamics in the EU's adaptation efforts at various levels and across various sectors. Section 4 uses these three aspects when contemplating the EU's exposure to cross-border impacts. Section 6 looks in more detail at potential EU responses to these three aspects of cross-border impact.

[1] Those countries to the east and south of the EU; for a full list see: https://ec.europa.eu/culture/policy/international-cooperation/neighbourhood_en

A note on terminology

As a relatively immature research area, there is no widely accepted terminology with which to describe climate change impacts that occur in one place, creating effects somewhere else. This report has adopted the term "cross-border" to describe impacts that operate across jurisdictional boundaries, without necessarily implying a direct crossing from one neighbour to another. Other terms have been used in studies that address the same or similar phenomenon, each of which has different strengths and limitations. The search continues for an intuitive term that describes the full range of climate change impacts across space.

Table 2: Alternative terms used to describe "cross-border" impacts (adapted from Benzie et al, 2016).

Term	Pro	Con
Transnational (e.g. Benzie et al, 2016)	Literal – across countries, without implying border or boundaries; key term used in climate change governance literature	Technical; not all jurisdictional boundaries are national
Indirect impacts/ Indirect effects (e.g. Hunt , Watkiss & Horrocks, 2009; Benzie et al, 2013)	Intuitive	Not spatially-explicit; used in many other contexts
International dimensions (e.g. Foresight, 2011; Challinor et al., 2016)	Explicit reference to impacts outside a national context	May refer to in situ impacts in several countries without cross-border consequences
Long distance (e.g. IPCC - Oppenheimer et al. 2014, section 19.4)	Explicitly spatial	Not all impacts will occur over long distances.
Teleconnected (e.g. Adger et al, 2009)	Technically accurate	Too technical
Telecoupled (e.g. Liu et al, 2013)	Technically relevant	Too technical; specific use in human-natural systems
Transboundary (e.g. IPCC - Oppenheimer et al. 2014, section 19.4)	Accurate for effects on either side of a boundary	Often assumed to imply impacts across neighbouring boundaries only, ignoring impacts across larger spaces
Spillover effects (used by the European Commission)	Intuitive	Assumed by some to ignore impacts across larger spaces
Traded risks (e.g. Tait & Bruce, 2001)	Transboundary risks transmitted via trade, in this case relating to food trade	Specific to trade
Pathways of effects (e.g. Government of Canada, 2012)	Describe cause-effect relationships over space, especially in natural science	Too vague
Systemic emerging risk OECD (2003)	Captures systemic nature of risk	Not all risks are system-wide; heavy connotations of macro-economics
Second-order effects (e.g. Flitner and Herbeck 2009)	Intuitive	Not spatially-explicit; used in many other contexts
Secondary effects (e.g. Hunt , Watkiss & Horrocks, 2009)	Logical	Not spatially-explicit; used in many other contexts

Term	Pro	Con
Cascading risk (e.g. Goldin, 2013; World Economic Forum)	Intuitive, sequential without specifying scale	Not all climate risks will be transmitted in this pattern
Connected risk (e.g. Galaz et al, 2014; Goldin & Mariathasan, 2014)	Emphasises connection	Not spatially-explicit
External impacts	Intuitive	Could be misinterpreted to mean impacts that occur externally without consequence
Non-localised impacts	Generic; allows for different dimensions (e.g. regional to global)	Too vague

We asked adaptation experts to assess different terms for describing cross-border climate change impacts (see Section 4.1.3 and Annex I for more details about the survey from which these results are taken). Figure 3 shows the degree of meaningfulness and/or confusion of the nine terms proposed. The left side of the graph shows the extent of confusion about of each term, whilst the right side shows what percentage of respondents thought the different terms were meaningful.

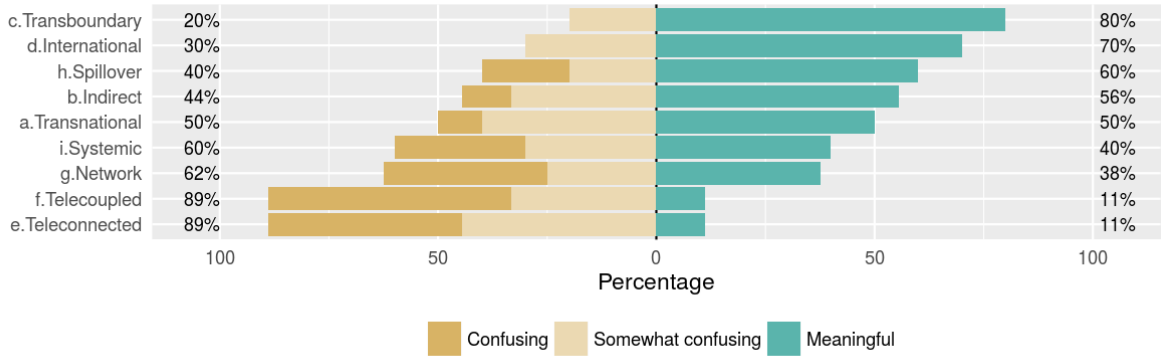

Figure 3: Adaptation expert survey on terminology. Responses to the question: *Which of the following terms are meaningful to you with regards to "transnational climate change impacts" (defined and explained earlier in the survey)? Which terms are confusing?*

Among the nine terms proposed, we can see from Figure 3, that respondents feel that the top terms that are meaningful are 'transboundary' (80%), followed by 'international' (70%), 'spillover' (60%), and 'indirect' (56%). The most confusing terms considered by the ten respondents of this survey are 'teleconnected' (89%), 'telecoupled' (89%), 'network' (62%), followed by 'systemic' (60%). Interestingly, 'transnational' is considered both meaningful (50%) and confusing (50%).

Other insights from the survey include:

- "Transboundary" implies impacts across directly adjoining borders, which is only one specific case of globally connected impact chains;
- "Indirect" implies lower priority;
- More specific terms are meaningful for specific impacts, e.g. "food security impacts";

- "Transnational" and "transboundary" imply a focus on physical geography or physical impacts;
- "Tele-" implies information technology, despite the etymological route of the term.

Additional terms suggested via the survey included: "interconnected" and "cross-border" – a suggestion that has been adopted in this report.

2.3. The relevance of socio-economic development to cross-border impacts

The distribution and magnitude of future impacts of climate change will be strongly influenced by the resilience and adaptive capacity of the systems affected (IPCC, 2014). For human systems, these characteristics are closely related to trends in future socio-economic development. The Shared Socioeconomic Pathways (SSPs), developed by a broad team of researchers from the IAV (impacts, adaptation, and vulnerability) and IAM (integrated assessment modelling) communities, are an attempt to describe five alternative plausible narratives of future global socio-economic development (see Box 1). Four of these pathways have been adopted in the IMPRESSIONS project: SSP1, SSP3, SSP4 and SSP5 (see Deliverable D2.2; Kok and Pedde, 2016).

Box 1: Brief basic narratives of the five Shared Socioeconomic Pathways (SSPs) (Source: Shortened from O'Neill et al., 2016).

SSP1: Sustainability – Taking the green road. A world shifting gradually towards a future characterised by substantial gains in sustainability. Broader emphasis on human well-being and commitment to achieving development goals, increasing environmental awareness, and a less resource-intensive lifestyle.
Relatively low challenges for climate change mitigation and adaptation.

SSP3: A rocky road. A breakdown in international cooperation and trade stemming from resurgent nationalism, competition and security concerns. Slow economic development and high consumption with thriving materialistic attitudes. Inequalities persist or worsen with pockets of extreme poverty remaining.
High challenges for both climate change mitigation and adaptation.

SSP4: Inequality – A road divided. Unequal investments in education and disparities in economic opportunity. Power becomes more concentrated, social cohesion suffers and conflict and unrest become increasingly common. Markets suffer from uncertainty, however technological development remains high in selected sectors and geographies.
Low challenges for climate change mitigation but high challenges for adaptation.

SSP5: Fossil-fueled development – Taking the highway. Global markets are increasingly integrated due to the successes, in economic and human capital terms, of both industrialised and emerging economies. There is full exploitation of fossil fuel resources driven by a resource-intensive and consumption-heavy lifestyle.
High challenges for climate change mitigation but low challenges for adaptation.

The SSP storylines emphasise how global socio-economic development depends on multiple interconnected elements, and illustrate the many different trajectories that these might take. Table 3 compares two of these (SSP1 and SSP3), presenting potential future developments of some key elements that might be relevant for cross-border impacts affecting the EU.

Table 3: Comparison between elements of two Shared Socioeconomic Pathways with possible relevance for cross-border impacts: SSP1 (representing sustainability with low challenges to both adaptation and mitigation) and SSP3 (representing fragmentation and high challenges to adaptation and mitigation). LIC/MIC/HIC = low/medium/high income countries.

Element	SSP1	SSP3
Economic growth	High in LICs and MICs, medium in HICs	Slow
International trade	Moderate	Strongly constrained
Population growth	Relatively low	High in LICs and MICs, low in HICs
Tourism	International	Regional
Migration	Medium	Not specified
Agricultural production	Improvements in agricultural productivity, rapid diffusion of best practices, strong regulation to avoid environmental trade-offs	Expansion of agriculture with competition for land and deforestation, low technology development, restricted trade
Energy	Rapid technological change directed towards efficiency and renewables	Slow technological change directed towards domestic energy sources; high energy intensity

As **Table 3** implies, the risks from cross-border impacts would be quite different in different socio-economic futures. For example, high levels of trade in SSP1 would present good opportunities for "risk spreading" by importing countries, but may open up countries to global trade shocks – which would not be a major risk in the constrained world of SSP3. However, high levels of tension and competition for resources in SSP3 might create negative cross-border effects as a result of deforestation (e.g. on flood risk downstream, or from forest fires) or even the spillover effects of conflict and forced migration across borders.

A thorough examination of the implications of different socio-economic pathways for risks associated with cross-border impacts would be a highly worthwhile exercise. This could include, for example, an assessment of how the various climate risk pathways presented in Section 2.1 might develop in each of the global scenarios.

3. Exposure to cross-border impacts in Europe

The first part of this section summarises the findings of existing studies on European exposure to cross-border impacts. First it draws on a recent EEA report (EEA, 2017) to look at exposure to EU internal impacts. The second section reviews a small number of studies on the EU's exposure to external impacts. It also draws on some original analysis by the authors to augment this picture. The third section describes the evidence gap that exists regarding the role of climate impacts in Europe on the rest of the world.

3.1. EU_i – European internal aspect

The European Environment Agency, in its report on climate change, impacts and vulnerability in Europe 2016 (EEA, 2017) identifies six priority internal transboundary systems that will be impacted by climate change, thus creating cross-border climate change impacts. Below is a brief summary of Section 6.5 of that report (Castellari et al., 2017), which is entitled "Vulnerability to climate change in European macro-regions".

The EEA define macro-regions as "a transnational region crossing administrative boundaries with common biogeographical characteristics, thus exhibiting particular climate change impacts and vulnerabilities". The report only focuses on regions for which comprehensive climate change vulnerability and impact assessment are available. In reality there will be a number of other transboundary macro-regions within the EU that will be affected by climate change.

In the **European Arctic**, which encompasses Denmark (including Greenland[2] and the Faroe Islands), Finland and Sweden (as well as Iceland and Norway, which are not part of the EU) climate change will be a significant stressor on biodiversity affecting the livelihoods of indigenous populations, which are already threatened by habitat loss and species decline. Climate change may lead to enhanced competition between countries to access non-renewable resources in the Arctic, adding pressure on the natural environment and indigenous people. The EEA report does not look into the potential effects of new shipping routes through the Arctic and the implications of this on the EU.

In the **Baltic Sea region**, which encompasses Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden (as well as Russia, which is not part of the EU) various impacts on water quality and marine life are expected from increased run-off in the inflowing river basins, as well as increased damages from storm surges and effects on water temperature. Thus climate change impacts are shared across this transboundary ecosystem, as are responsibilities and opportunities from coordinated adaptation.

In the **Pyrenees mountain region**, which encompasses France and Spain (as well as Andorra, which is not an EU member), climate change impacts on water resources and forests could affect populations on both sides of the border, for example given the enhanced risk of forest fires, which may cross administrative boundaries and impact air quality on each side. Impacts are also expected on tourism (from changing snowfall period) and infrastructure and settlements (from increased slope instability).

[2] Greenland is technically part of the Overseas Countries and Territories of the EU, having left the Union in 1985, but its citizens are EU citizens on account of Greenland being part of the Kingdom of Denmark.

In the **Alps mountain region**, which encompasses Austria, France, Germany, Italy and Slovenia (as well as Liechtenstein, Monaco and Switzerland, which are not EU members), increased hazards are expected, such as landslides, flooding, permafrost degradation and slope destabilisation, threatening settlements and energy and transport infrastructure. Climate change impacts and adaptation will have effects on different sides of Alpine borders, especially those concerning biodiversity, forests and tourism.

The **Carpathian mountain region**, which encompasses the Czech Republic, Slovakia, Poland, Hungary and Romania (as well as Serbia, which is an EU candidate country, and Ukraine, which is not an EU member), will be affected by similar impacts, threatening Europe's largest populations of brown bears, wolves, lynx, European bison and rare bird species, as well as forests, wetlands, agriculture and tourism.

The **Mediterranean region**, which encompasses Croatia, Cyprus, France, Greece, Italy, Malta, Slovenia and Spain (as well as Albania, Bosnia and Herzegovina and Montenegro, which have formal relations with the EU, and coastal states of the Middle East and North Africa region, which are members of the European Neighbourhood) has been identified as one of the main "climate change hotspots" for Europe. It is projected to be increasingly affected by severe impacts on several sectors, including water resources, agriculture, forestry, biodiversity, tourism and energy, as well as common risks related to changes in the Mediterranean Sea ecosystem itself. Although not covered in the EEA report, as a border region between Africa, the Middle East and Europe, successful adaptation throughout the Mediterranean is also key to broader European security, as well as to political and trade stability between the EU and its most immediate and strategic neighbours.

The EEA report also summarises climate change vulnerabilities in the EU overseas entities, which includes nine EU outermost regions and 25 overseas countries and territories, many of which are remote countries.

Despite fairly well-developed awareness about climate change vulnerability and impacts in European macro-regions, potential cross-border effects are not described in detail in the existing scientific literature. This means the true need for coordinated cross-border cooperation and even EU-level adaptation is perhaps under-appreciated, despite the summary of adaptation in macro-regions provided in Section 6.5 of the EEA report. Indeed, the EEA report recognises as one of the key knowledge gaps the lack of robust, integrated impact, vulnerability and adaptation assessments *across geographical and governance scales* (EEA, 2017:322).

Transnational cooperation on adaptation has occurred within Europe in the water management sector, for example via International River Basin Management Plans under the Water Framework Directive[3]. This is also starting to occur for coastal area management (EEA, 2017:55). However, for other sectors and issues, the level of awareness about cross-border "shared climate risks" and adaptation needs is low. Judging from the EEA report, specific knowledge gaps relating to the internal aspects of cross-border climate change impacts might include:

- **Food security** risks stemming from poor harvests within the EU single market;
- **Cascading risks** from climate change impacts on **critical infrastructure** in the EU;

[3] See DG ENV website on WFD: http://ec.europa.eu/environment/water/participation/map_mc/map.htm

- **Financial risks** stemming from exposure of individual member states via their investments in other EU markets, for example as a result of failed adaptation in some of the EU's most vulnerable countries;
- The social and political opportunities and risks associated with increased **human mobility** between member states as a result of negative climate change impacts within the EU;
- The cross-border impacts of climate change on transboundary ecosystems and other "macro-regions" that are currently under-studied (i.e. not covered in the EEA report).

Interviews conducted in the preparation of this report with representatives of several DGs in Brussels[4] revealed a high level of concern for broader European climate resilience about the variable level of preparedness across EU member states. One interviewee offered the view that adaptation is taken seriously by a group of member states – especially those in Western Europe – who have continuously assessed climate risk and integrated adaptation planning over several years. This impression was contrasted with a very different view among other member states, where adaptation information has struggled to make much impact on national strategy. The interviewee reflected that the consequences of "uneven" adaptation across the EU were potentially very severe, given the potential for cross-border impacts, raising new questions about the appropriate role of the EU itself in facilitating adaptation at the national level[5] and in preparing for what we here term *EU internal* climate change impacts.

3.2. EUx – European external aspect

Existing studies

In 2012 DG CLIMA commissioned a report to assess the *Spillover effects in the EU of the adverse effects of climate change in the rest of the world, in particular the EU's Neighbourhood countries* (Amec, 2013). This report identified some of the priority impacts for the EU and in many cases specified which member states were likely to be most affected. Table 4 provides a summary of the priority spillover impacts identified in that report.

The report concludes:

- "*The challenge for the EU remains to use the tools at its disposal to support adaptation in neighbouring countries, both through humanitarian aid and cooperation and also other industrial and economic policies aimed at securing important supply chains in the face of a changing global climate.*"
- *"Policy responses at the EU, Member State and regional levels have in general not directly taken spillover effects of global climate change into account."*
- *"No matter what the EU does to prepare for climate change within its own borders it remains vulnerable to climate change impacts in neighbourhood countries."*

[4] Interviews were held with various DGs ENER, ENV, CLIMA, DEVCO, RTD, the European Parliament and the European External Action Service between 20-23 February 2017 and subsequently via telephone. Questions focused on the level of preparedness for cross-border climate change impacts, chiefly among EU external functions but also including some internal functions.

[5] i.e. via Objective 1 of the EU Adaptation Strategy – *promoting action by member states* (EC, 2013).

Table 4: Summary of priority spillover effects for the EU (based on Amec, 2013).

Theme	Description
Energy security	e.g. permafrost disrupting oil and gas pipelines from Russia, as well as water-related disruptions to energy production and extraction activities in third countries
Food security	Especially price volatility, but also spillover effects from food insecurity in other countries, including the European Neighbourhood
Tourism	Positive and negative effects in European countries as a result of changing tourism patterns
Raw materials	Climate impacts on mining and supply of critical materials (e.g. from Asia and North America) for European value-added manufacturing, especially information and renewable energy technologies
Water resources	53 transboundary rivers in Europe are shared with neighbouring countries. Water intensive imports to the EU could be disrupted by climate-related droughts in producer countries.
External assistance	Increase in demand for EU humanitarian assistance, particularly in North Africa
Technology, knowledge and expertise	Opportunities for EU exports to address adaptation challenges in other countries, reducing the EU's exposure to spillover effects
Migration and human flows	Noting significant uncertainty, there is the potential for climate change to increase the number of migrants, with unknown consequences for the EU

More recently, an economic modelling assessment of potential impacts on the EU of climate change in the rest of the world was conducted as part of the GAP PESETA project (JRC, 2015). According to this analysis, which used a computable general equilibrium model called CAGE to assess how changes outside Europe would economically impact the EU, the effects are likely to be small. The key climate impact categories identified by the analysis were agriculture and labour productivity; agriculture shocks might lead to welfare losses of about $5 billion, whereas losses from decreased labour productivity outside Europe could be around $3 billion. Additionally, indirect losses from climate impacts on coastal infrastructure outside Europe might lead to between $0.5 billion and $2 billion worth of losses inside the EU, depending on the scenario of sea level rise used, according to JRC (2015). The most significant sources of cross-border impacts for the EU were identified as China and Brazil. There are certain limitations of studies that employ equilibrium modelling techniques to this question, including their poor treatment of shocks and higher-end climate change impacts (see Watkiss et al., 2015 and Deliverable D5.2 - Lamperti et al., 2016), which might also explain the low cost estimates in the results. However, studies such as this provide insights that are otherwise not available on the economic cross-border impacts of climate change.

A third source of information on the external aspect of cross-border impacts for the EU is offered by the EEA report on climate change, impacts and vulnerability in Europe 2016 (Lung et al., 2017), which highlights the importance of climate change outside the EU on European vulnerability. This is the first time the EEA report has placed such emphasis on the cross-border dimensions of climate change. It concludes that European vulnerability to cross-border impacts is expected to increase in the coming decades. Based on current evidence, the EEA identify the following priority vulnerabilities for Europe from climate change outside Europe (based on Chapter 6.4 of the EEA report: Lung et al., 2017):

- Economic effects through climate-caused global price volatilities;
- Disruption to transport networks such as ports;
- Changes in the Arctic environment, including new shipping routes;
- Vulnerability hotspots in Mediterranean countries to agricultural commodity trade shocks;
- Vulnerability hotspots in small, open and highly developed European economies to non-agricultural commodity trade shocks;
- Increased "strategic importance" of North Africa (particularly the Sahel and Maghreb) and Middle East in terms of climate-induced human migration flows and geopolitical and security considerations.

New analysis

An additional basis for assessing Europe's susceptibility is offered by the global Transnational Climate Impacts (TCI) Index, developed by the Stockholm Environment Institute to assess country-level exposure (Benzie et al., 2016). The TCI Index features nine indicators of exposure, which were identified according to the climate risk pathways described in Section 2: biophysical, trade, finance, people, as well as the global context.

Mainstream climate change indices, such as the Notre Dame Global Adaptation Index[6] (ND-GaIN) score industrialised countries as having low vulnerability to climate impacts, giving the impression that adaptation challenges will be low and manageable (see Figure 5). The TCI Index consider the characteristics of countries that are likely to expose them to climate-related changes in international flows of resources, finance, people and goods (see Figure 4 – details on methodology and data are provided in Benzie et al., 2016[7]).

Table 5 compares the top 30 countries in both the ND-GaIN and TCI Index. Whereas none of the top 30 countries in the NG-GaIN are in Europe, 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 in the TCI Index top 30, reflecting the high dependency of small industrialised countries on neighbours and global systems.

Figure 6 shows a scatter plot of countries' scores in both ND-GaIN and the TCI Index. It shows that the spread of results in the TCI Index among EU countries (y-axis) is almost as broad as across the rest of the world, even though they are tightly bunched at the low end of the ND-GaIN (x-axis).

[6] http://index.gain.org/

[7] The original analysis in this report is based on data openly available at: https://www.sei-international.org/publications?pid=2972

Table 5: Comparison between top 30 scoring countries in the ND-GaIN and TCI Index, identified by region.

ND-GaIN Country Index			
Rank	Country	Score	Region
1	Somalia	0.62	SSA
2	Burundi	0.59	SSA
3	Sierra Leone	0.59	SSA
4	Afghanistan	0.58	MENA
5	Central African Republic	0.58	SSA
6	Togo	0.58	SSA
7	Liberia	0.57	SSA
8	Dem. Rep. of the Congo	0.57	SSA
9	Ethiopia	0.55	SSA
10	Guinea	0.55	SSA
11	Mali	0.54	SSA
12	Chad	0.54	SSA
13	Solomon Islands	0.54	SIDS
14	Madagascar	0.54	SIDS
15	Haiti	0.54	SIDS
16	United Rep. of Tanzania	0.54	SSA
17	Guinea-Bissau	0.54	SSA
18	Timor-Leste	0.53	SIDS
19	Burkina Faso	0.53	SSA
20	Kenya	0.53	SSA
21	Niger	0.53	SSA
22	Yemen	0.53	MENA
23	Sudan	0.53	SSA
24	Uganda	0.52	SSA
25	Rwanda	0.52	SSA
26	Benin	0.52	SSA
27	Angola	0.52	SSA
28	Mozambique	0.51	SSA
29	Cote d'Ivoire	0.50	SSA
30	Nigeria	0.50	SSA

TCI Index			
Rank	Country	Score	Region
1	Jordan	8.11	MENA
2	Lebanon	7.86	MENA
3	Kuwait	7.57	MENA
4	United Arab Emirates	7.43	MENA
5	Sudan	7.14	SSA
6	Netherlands	7.11	Eur
=7	Mauritania	7.00	SSA
=7	Belgium	7.00	Eur
=7	Luxembourg	7.00	Eur
10	Malaysia	6.89	SE Asia
11	Egypt	6.78	MENA
12	Gambia	6.75	SSA
13	Togo	6.63	SSA
=14	Tajikistan	6.56	CE & C
=14	Swaziland	6.56	SSA
16	Liberia	6.44	SSA
=17	Portugal	6.33	Eur
=17	Kenya	6.33	SSA
=19	Maldives	6.29	SIDS
=19	Montenegro	6.29	Eur
21	Malta	6.25	Eur
=22	Armenia	6.22	CE & C
=22	Thailand	6.22	SE Asia
24	Latvia	6.13	Eur
25	Fiji	6.11	SIDS
=26	Azerbaijan	6.00	CE & C
=26	Jamaica	6.00	SIDS
=26	Mauritius	6.00	SIDS
=26	Austria	6.00	Eur
=26	Lithuania	6.00	Eur

Legend		% Top 30	
		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 Caucuses	0%	10%
Asia	South East Asia	0%	6.7%

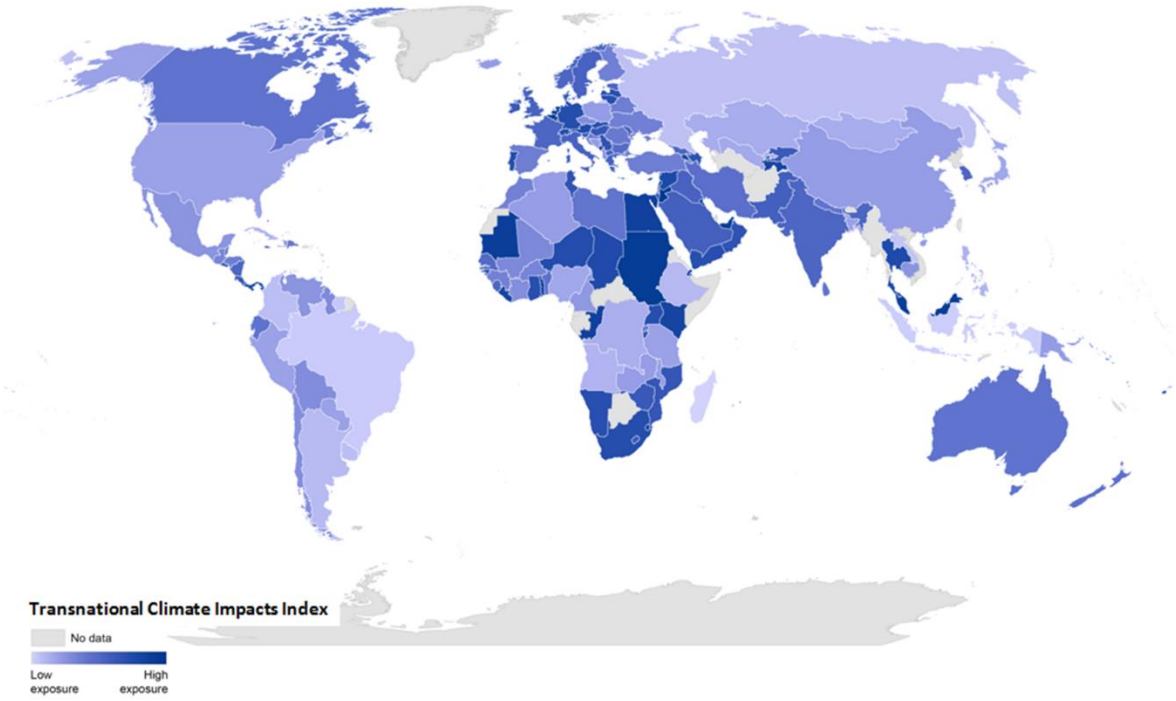

Figure 4: Exposure map for the Transnational Climate Impacts Index (Benzie et al., 2016).

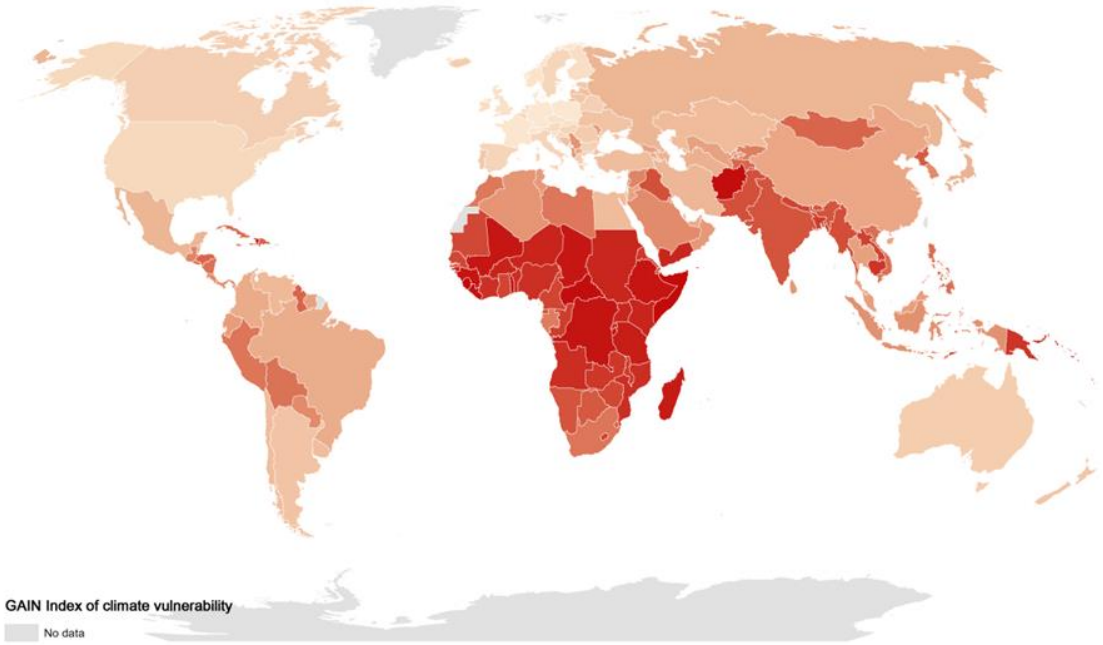

Figure 5: The ND-GaIN Country Index of vulnerability to (direct) climate impacts. Note: Map produced by the authors, with new colour-coding, using data downloaded from the ND-GaIN website.

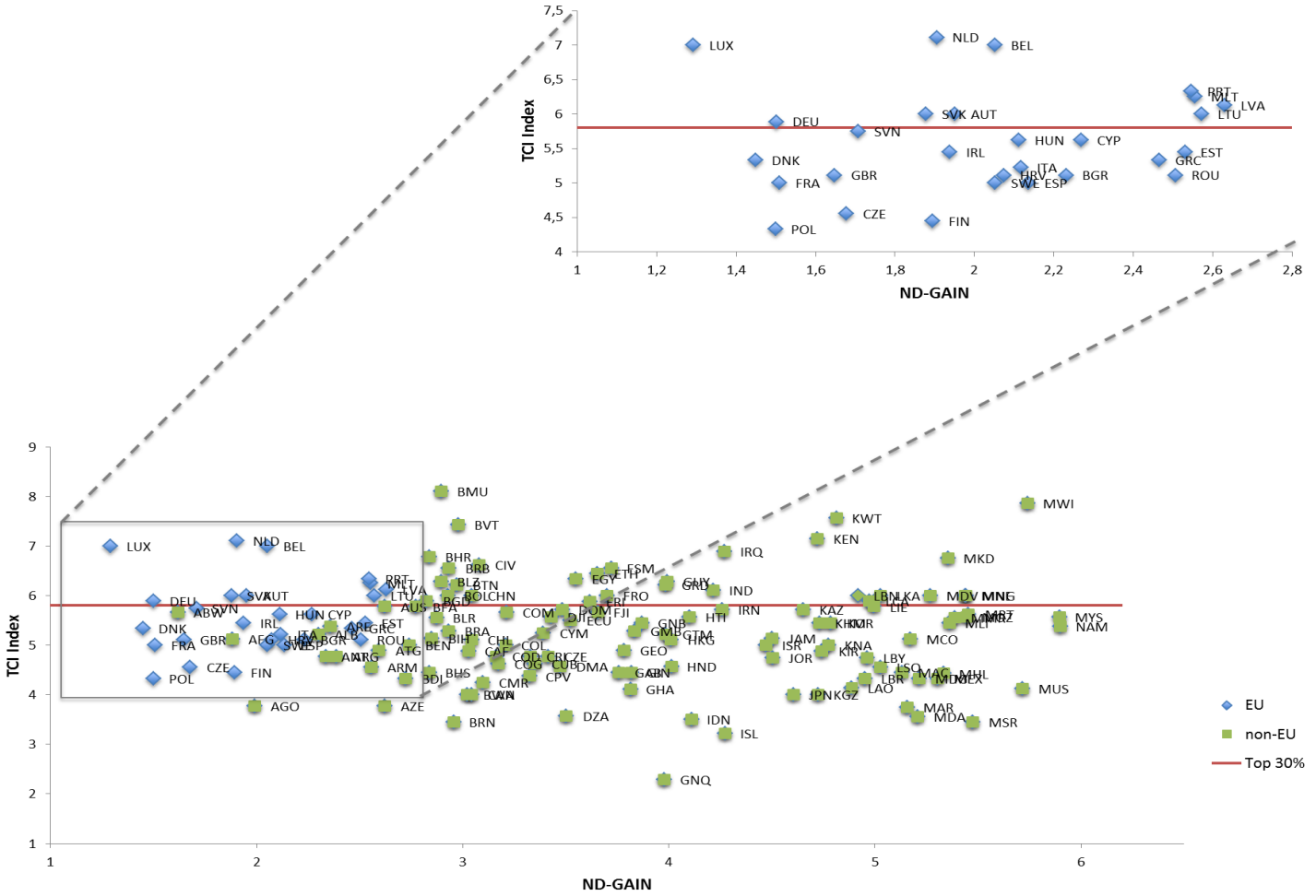

Figure 6: Scatter plot graph showing ND-GaIN vs TCI Index results per country (EU countries are shown in blue; the rest of the world is shown in green). The section containing EU countries is shown zoomed-in. Country codes: POL – Poland, FIN – Finland, CZE – Czech Republic, ESP – Spain, FRA – France, SWE – Sweden, BGR – Bulgaria, GBR – United Kingdom, HRV – Croatia, ROU – Romania, ITA – Italy, DNK – Denmark, GRC – Greece, EST – Estonia, IRL – Republic of Ireland, CYP – Cyrpus, HUN – Hungary, SVN – Slovenia, DEU – Germany, AUT – Austria, LTU – Lithuania, SVK – Slovakia, LVA – Latvia, MLT – Malta, PRT – Portugal, BEL – Belgium, LUX – Luxemburg, NLD – The Netherlands.

Below we look at the scores for EU countries on specific indicators that were used in the TCI Index. It is worth noting that the Index was developed with a global scope and it therefore selected indicators that had general relevance globally, and for which data were globally available (see Benzie et al., 2016, pp7-12). An indicator-based assessment specifically for Europe would be able to select indicators that were exclusively relevant to the European context and to benefit from better data availability for EU countries.

#	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

Figure 7: Nine country-level indicators of exposure to transnational climate impacts, using the SEI pathway framework (Benzie et al., 2016).

Compared to the rest of the world, no EU country scores in the highest categories for finance pathway indicators (Bilateral climate-weighted FDI or Remittance flows), and only a small number of EU countries score in the top categories for two of the trade pathway indicators (Malta, Belgium and the Netherlands for cereal import dependency; Greece and Germany for embedded water risk).

The EU scores relatively highly on transboundary water dependency, meaning a number of EU countries depend on upstream flows for a significant share of their domestic water resources (see Figure 8).

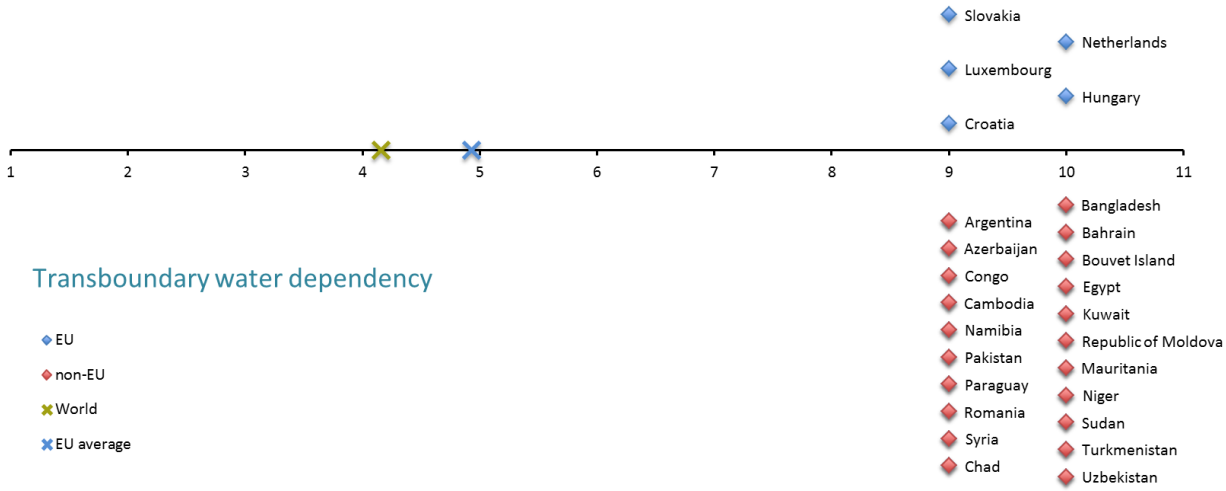

Figure 8: Top scoring countries – EU vs non-EU – Transboundary water dependency.

EU countries are among the top countries worldwide on globalisation and trade openness. **Figure 9** shows the number of EU countries (in blue) that score in the top two categories of the globalisation indicator (indicator 9). The blue "X" marks the EU average (c.9.5), which is considerably higher than the world average (c.5.5).

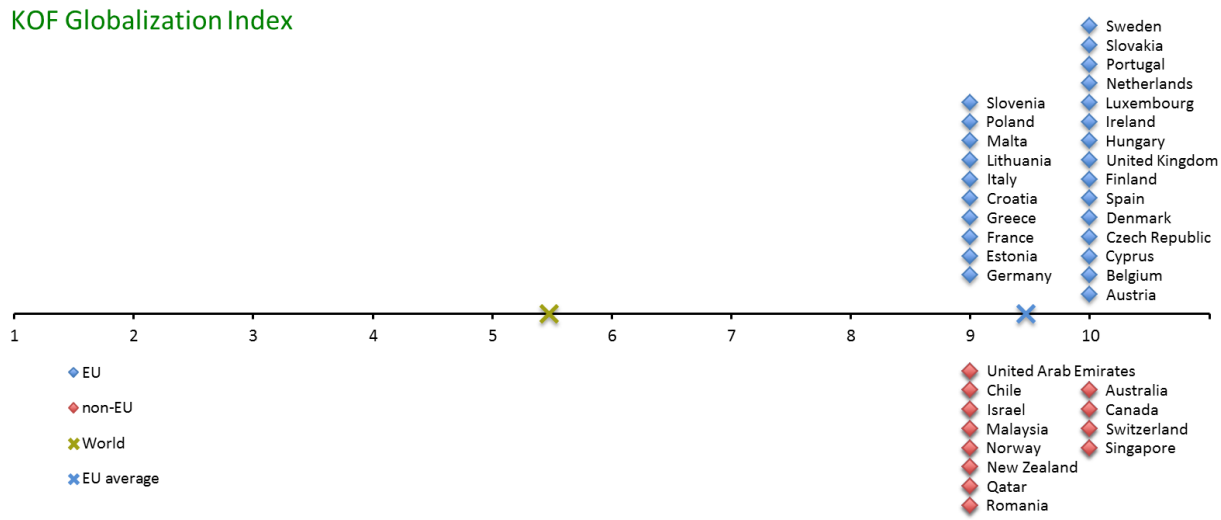

Figure 9: Top scoring countries – EU vs non-EU – KOF Globalisation Index.

Figure 10 shows the same information for indicator 6 on trade openness. Here, the EU average is also noticeably higher than the world average. Whilst trade openness is not just a feature of industrialised countries, several EU members, especially the smaller countries, score highly on this indicator, suggesting that they may be exposed to climate-related shocks and disruptions via international trade. **Error! Reference source not found.** shows the same results on a world map, highlighting that it is ften small countries, many of whom are EU members, whose economies are most dependent on trade.

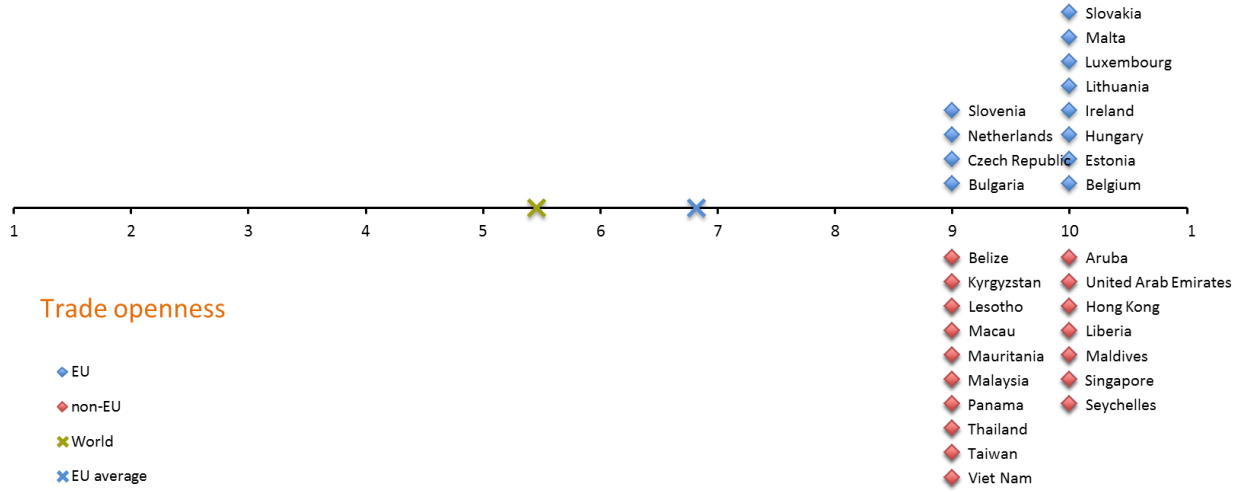

Figure 10: Top scoring countries – EU vs non-EU – trade openness.

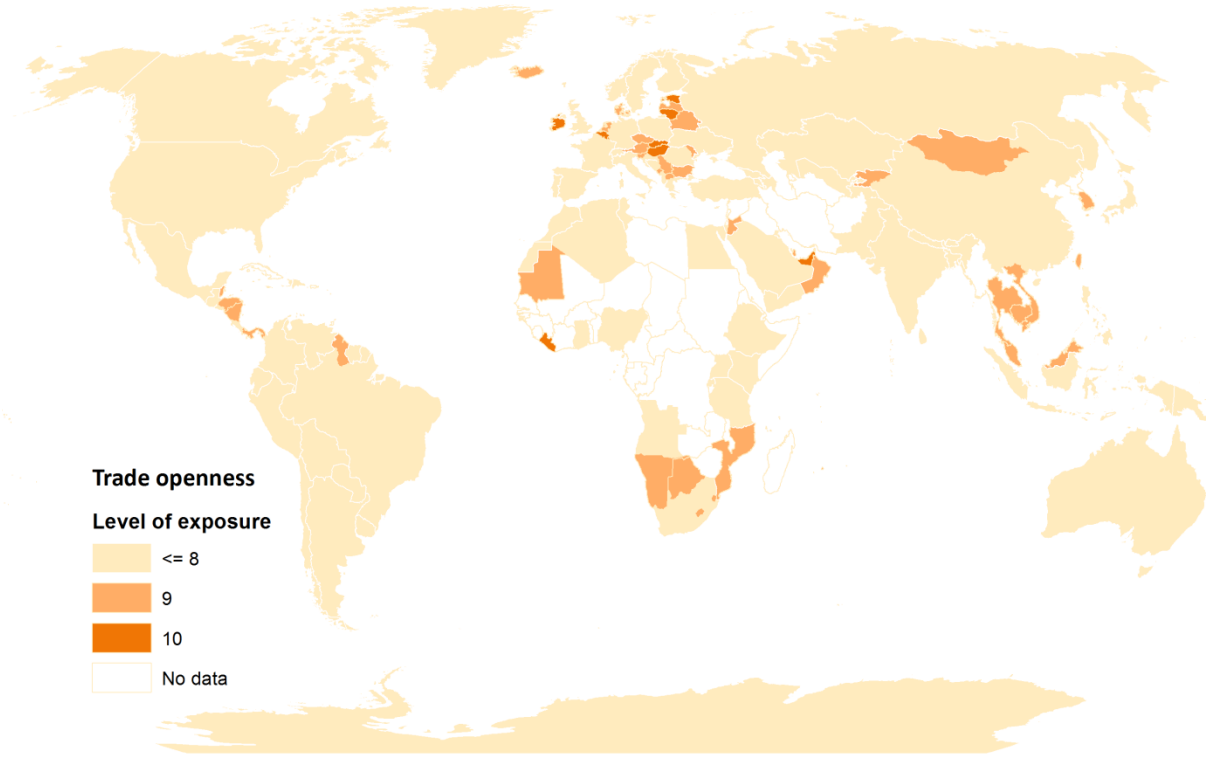

Figure 11: Global map of top scoring countries on Indicator 6 (trade openness) from the TCI Index.

Another interesting feature of the results for EU countries in the Index relates to the people pathway. Despite scoring highly on openness to asylum, where the EU average is above the world average, and Sweden, Germany, Austria and Malta score highly, migration levels into EU countries from the most climate-vulnerable countries in the world are extremely low (see **Figure 12** and **Figure 13**)[8]. In other words, the vast majority of current migrants from countries that are considered to be highly vulnerable to climate change – most of which are developing or least developed countries – migrate to other developing or least developed countries, not to the EU. An implication of this result is that policy to address "climate-related migration" might be more appropriately focused on enhancing capacity to manage migration flows in developing countries rather than preparing for – or even attempting to prevent – migration into the EU.

[8] The data used for this indicator are from 2010, from the World Bank's Global Bilateral Migration Database (see Benzie et al., 2016, p20 for more details).

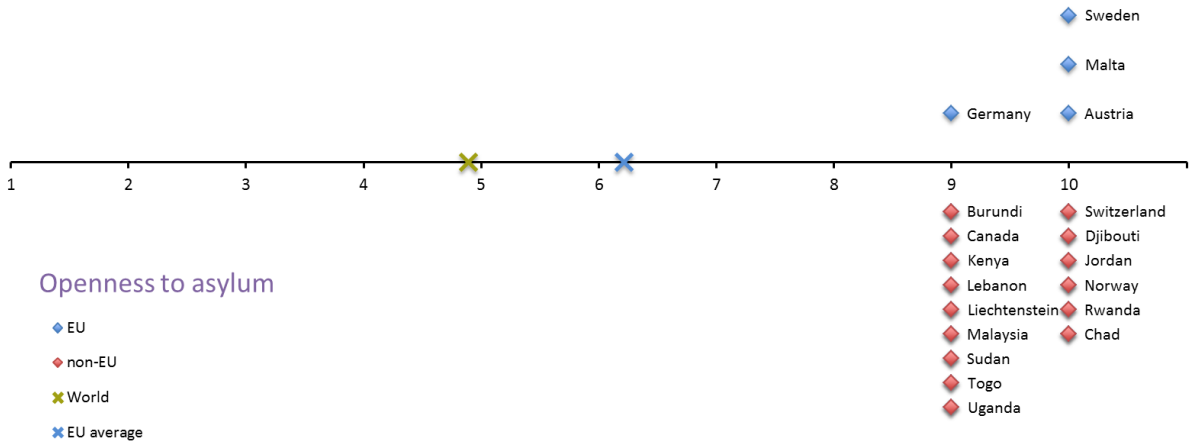

Figure 12: Top scoring countries – EU vs non-EU – openness to asylum.

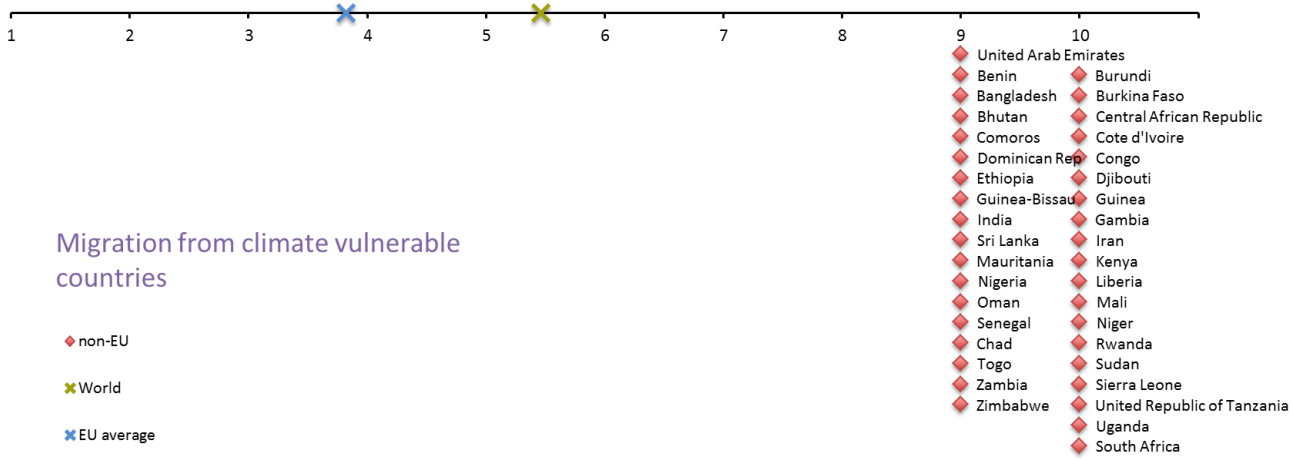

Figure 13: Top scoring countries – EU vs non-EU – migration from climate vulnerable countries.

Summary

By combining the scores in the TCI Index for all EU member states, we present a profile of the EU's exposure to cross-border impacts using the nine indicators of the TCI Index (**Figure 14**). The EU scores low on bilateral climate-weighted foreign direct investment, because significant proportions of FDI from EU member states is invested in relatively low-risk countries, including much of it within the EU itself. The EU also has low dependency on remittances, making an overall low exposure to cross-border impacts via finance pathway indicators, in comparison to the rest of the world. Certain aspects of the EU increase its exposure to potential changes in the flow of people across national borders, although the migration links between EU countries and the most vulnerable parts of the world are less than for many developing countries. Certain aspects of the EU trade profile and its extremely high overall level of engagement in the global economy mean that events outside the EU could have profound impacts on EU welfare as a result of cross-border impacts.

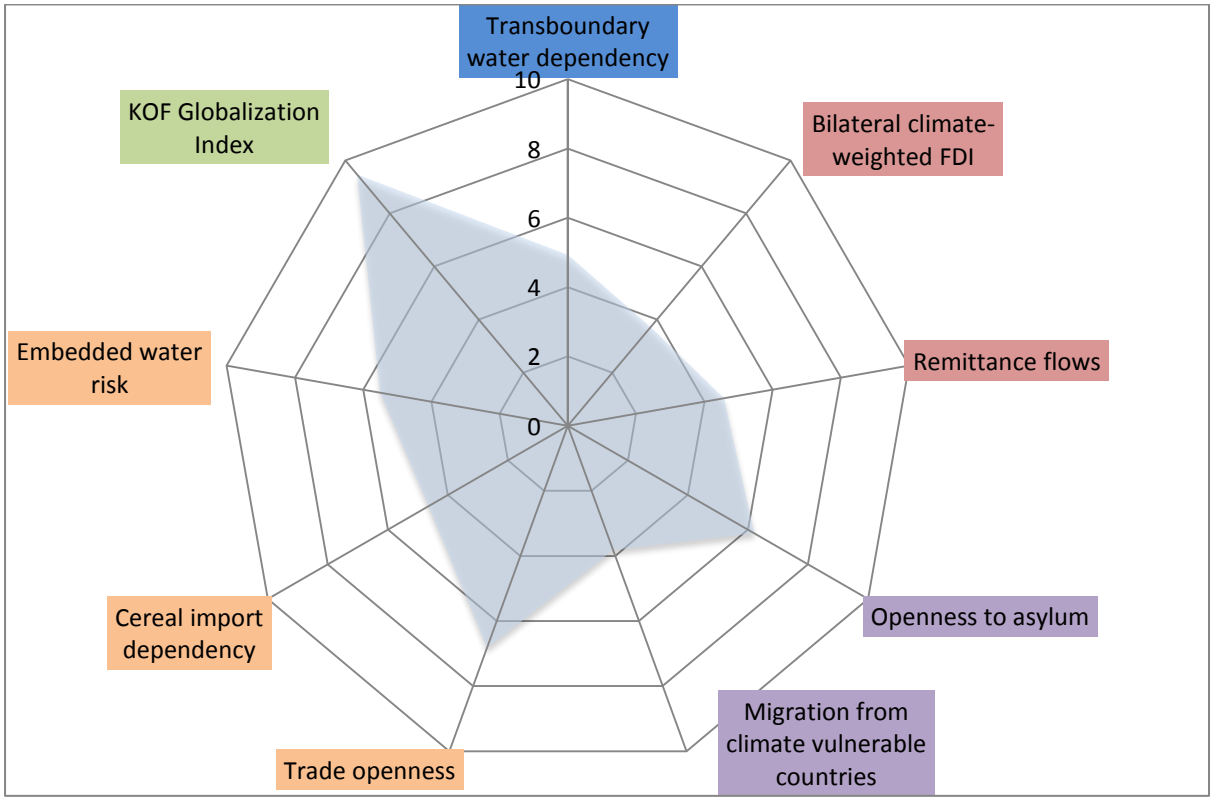

Figure 14: EU profile – exposure to cross-border climate change impacts using data from the TCI Index (Benzie et al., 2016).

Despite the usefulness of the TCI Index in developing an initial idea of the pattern of EU exposure in relation to the rest of the world, a more bespoke and detailed indicator-based assessment of European exposure would help to inform future adaptation planning at the EU scale. Caution must be exercised though when using crude, indicator-based approaches, given the enormous potential for, assumptions, distortions and data limitations to influence results.

3.3. EU impacts on the rest of the world

In order to facilitate adaptation to cross-border impacts, it would be ideal if all countries assessed the impacts in their own territories that could have potential impacts on other countries (SEI, 2017). This logic also applies to the EU, which, for the reasons described above, is integrated into the global economy and therefore likely to impact other countries through its own successful or failed adaptation. However, knowledge about the potential effects of EU adaptation on third countries is currently lacking. In future, a dedicated section of the EU Adaptation Strategy could raise this question and begin to identify the various positive and negative consequences of EU adaptation for the rest of the world.

3.4. Cross-border spillover narratives for the IMPRESSIONS case studies

Below we present a cross-border climate change impact exposure profile for the four countries that feature in case studies within the IMPRESSIONS project. These profiles help to set out the boundary conditions for more detail analysis of cross-border climate risk exposure at the national or sub-

national case study level in the future. Taken together with Section 3.2, which described potential exposures to cross-border impacts for Europe, these profiles imply a set of spillover narratives for the IMPRESSIONS case studies.

The spider diagrams show the indicator scores for four countries (coloured line), which is compared to the EU average (shaded in grey).

Iberian case study: Portugal and Spain

A comparison between the profiles of both countries in this case study reveals the very different risk exposure faced by downstream (Portugal; Figure 15)) as opposed to upstream countries (Spain; Figure 16), with Portugal scoring high on the transboundary water dependency indicator, and Spain very low.

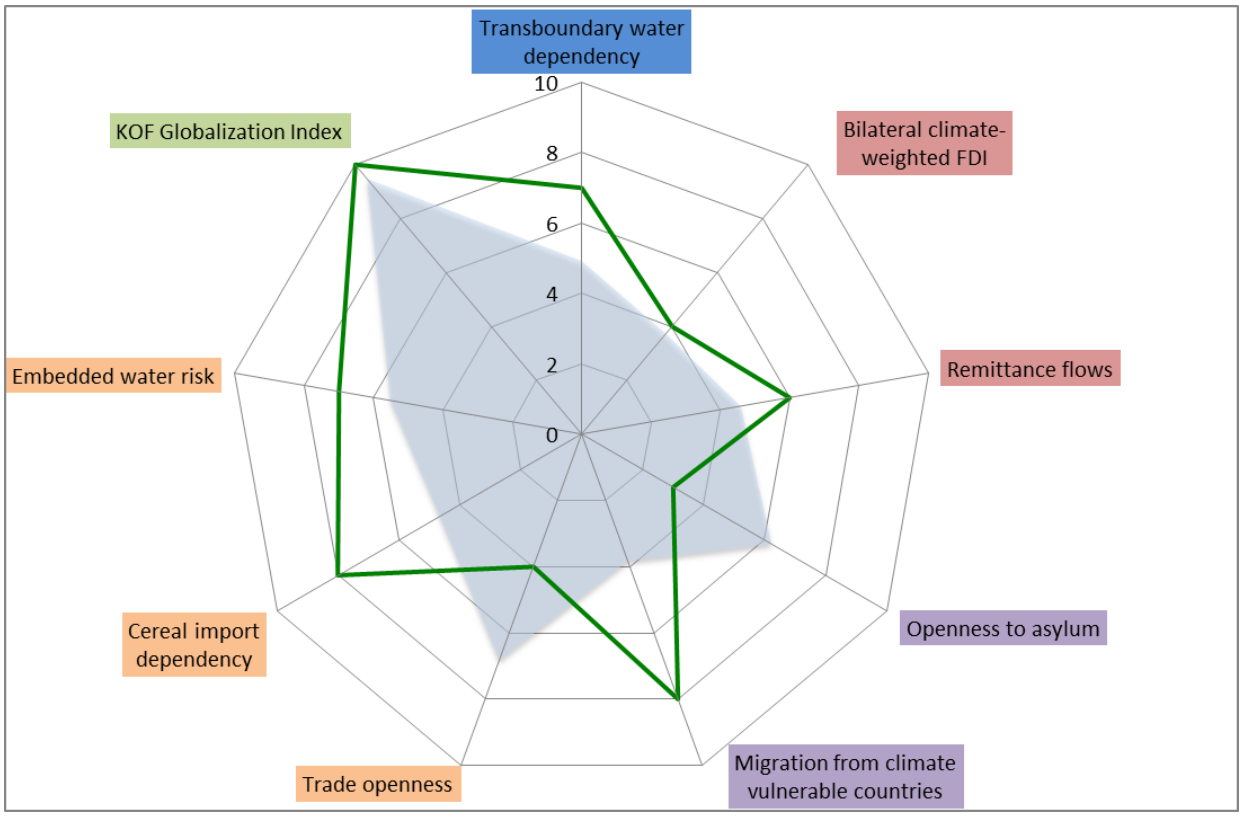

Figure 15: Portugal – cross-border climate change impacts exposure profile, based on nine indicators from the TCI Index (Benzie et al., 2016).

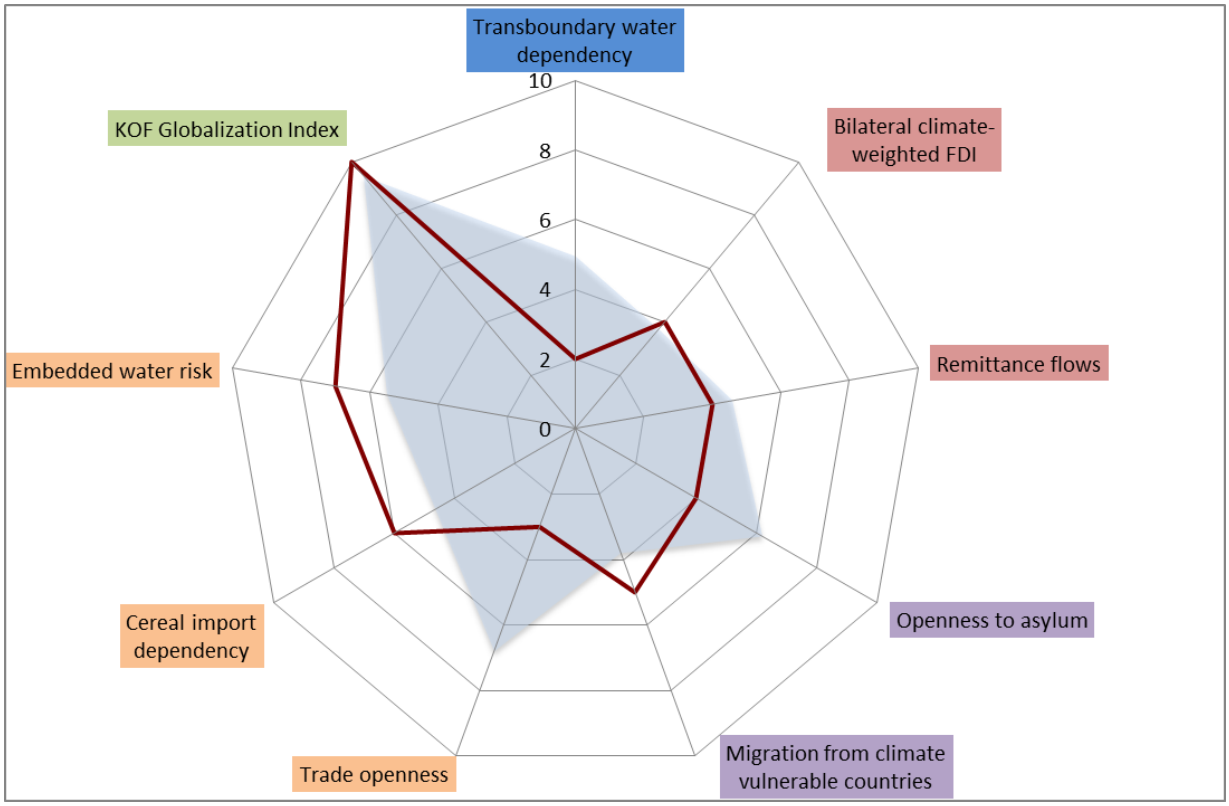

Figure 16: Spain - cross-border climate change impacts exposure profile, based on nine indicators from the TCI Index (Benzie et al., 2016).

Portugal scores higher than the European average on most indicators – indeed it is ranked the joint-17th most exposed country globally in the TCI Index. It is unusual for a EU member state in receiving a high proportion of migrants from climate vulnerable countries, despite lower than average openness to asylum (the normal pattern in the EU is opposite). Portugal is also highly dependent on cereal imports, highly integrated into the global market and imports a significant amount of embedded water from water-stressed parts of the world (indicator 8).

Spain has a "typically European" exposure profile, suggesting potential risk exposure via investments in climate-vulnerable countries (FDI indicator) and above average migration from climate vulnerable countries: both, perhaps, reflections of Spain's situation on the southern flank of the EU in the Mediterranean region.

Transboundary water resources and governance is already a core focus of the Iberian case study. These indicator-based profiles suggest that strategies in the Iberian Peninsula to adapt to climate change should also consider the potential implications of cross-border impacts on **food security**, **migration** and **trade-related** risks.

Scotland case study: UK

The IMPRESSIONS case study focuses on Scotland, not the UK, but the TCI Index treats the UK as a single country, without distinguishing data for the devolved administrations such as Scotland. We therefore present results for the UK here (Figure 17).

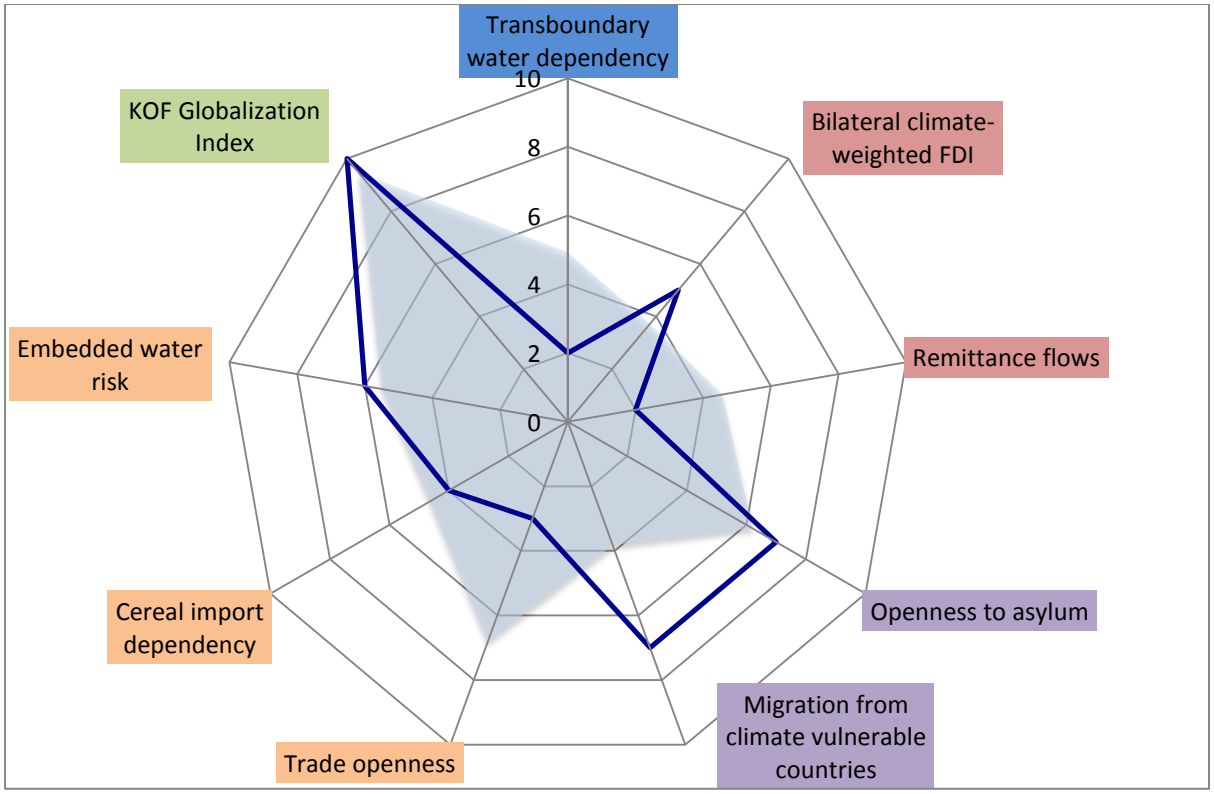

Figure 17: United Kingdom - cross-border climate change impacts exposure profile, based on nine indicators from the TCI Index (Benzie et al., 2016).

The UK's exposure profile, like Spain's, is fairly typical of the EU, suggesting high levels of integration into the global economy. One explanation for the low score on "trade openness" might be due to the way in which the indicator measures the financial sector, which is very significant to the UK economy. Trade openness is the sum of a country's imports and exports as a share of GDP (see Benzie et al., 2016, p22). Financial services – including banking, insurance and investment management – are not usually treated as exports in trade data. However, the UK financial services sector is directly linked to investments around the world and as such is a sector highly sensitive to changes in risks overseas. The nuance of this aspect of the UK's economic profile is not well reflected in the TCI Index; if it were, the profile for trade-related risks may be significantly higher. The UK scores above average for the climate exposure of its FDI portfolio, and is also the destination for a high level of migrants from climate-vulnerable countries. As an island, transboundary water dependency is insignificant for the UK, although there is a low level of inter-dependence between Scotland and England in the transboundary Solway Tweed river basin.

This indicator-based profile suggests that strategies in Scotland to adapt to climate change should consider the potential implications of cross-border impacts on **migration**, **financial risks** and the **global economy**.

Hungarian case study

Hungary has a more unusual cross-border risk profile when compared to fellow EU member states (Figure 18). It has low levels of exposure on the people pathway, although this assessment is based on data that does not include the most recent dynamics of the Refugee Crisis in Europe; it could still very much be the case that, irrespective of Hungarian migration policy, changes in the flow of people into Europe directly affect municipalities in Hungary. It also scores very low on embedded water risk and cereal import dependence, and near the EU average for finance pathway indicators.

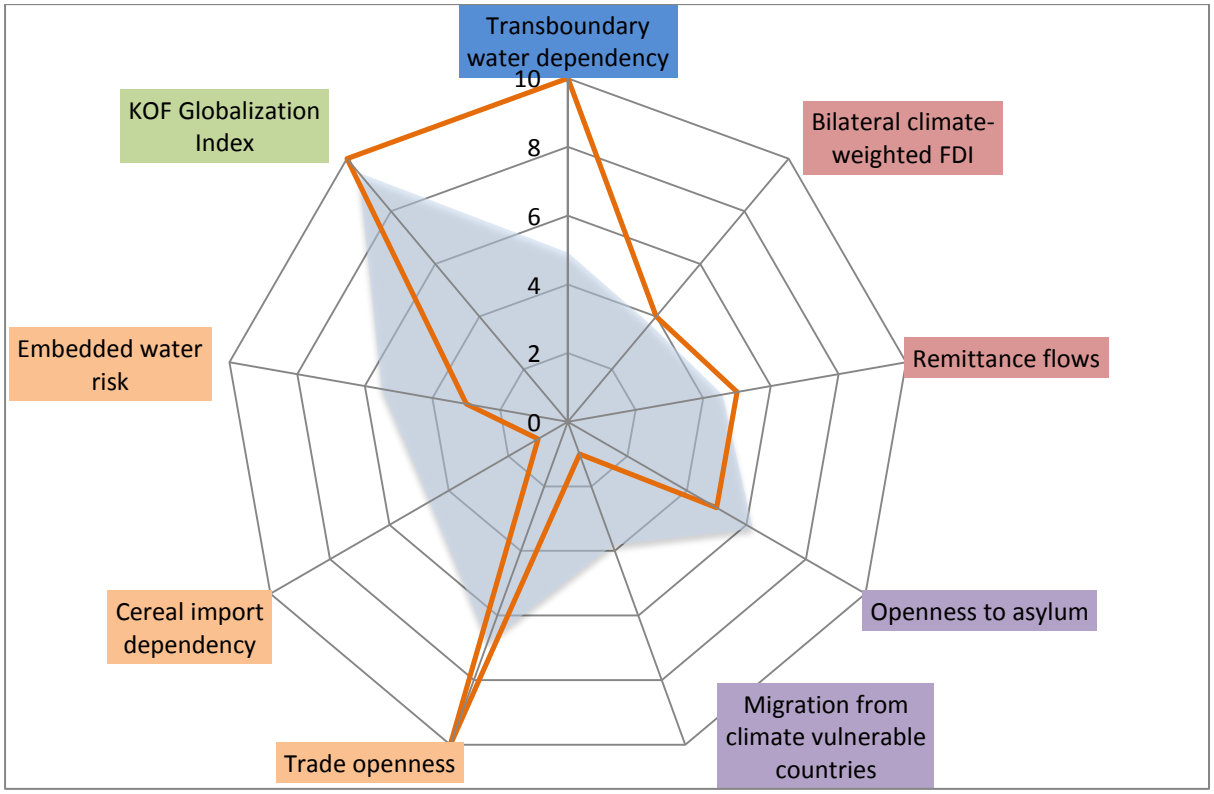

Figure 18: Hungary - cross-border climate change impacts exposure profile, based on nine indicators from the TCI Index (Benzie et al., 2016).

Hungary does score very high on exposure to changes in transboundary water availability and trade openness / globalisation. Thus, as a relatively small country within Europe, Hungary will be highly dependent on other countries – and on its ability to cooperate with other countries via the EU and other international mechanisms – to successfully reduce the risks from cross-border climate change impacts.

This indicator-based profile suggests that strategies at the municipal level in Hungary to adapt to climate change should consider the potential implications of cross-border impacts on transboundary water resources and international trade. Despite the low indicator score, changes to migration patterns may also directly affect Hungary under future climate scenarios.

Box 2: EUx case study – high-end scenarios and cross-border impacts in Central Asia

As part of the IMPRESSIONS project, one of five case studies has been dedicated to the topic of cross-border impacts. Specifically, the research team proposed to assess how climate change impacts outside the EU may require adaptation within the EU's external functions. After a period of consultation with various EU stakeholders, the case study focused on Central Asia and cross-border dynamics between this region, Russia and China. A participatory process was then undertaken to develop and extend scenarios in the region that take account of cross-border impacts and responses from the five Central Asian states, Russia and China.

Objective

The objective of this case study is to re-think EU strategies towards Central Asia in light of high-end climate and socio-economic scenarios, taking into consideration geopolitical dynamics with Russia and China.

Motivation

Central Asia is a strategically important region given its endowment of natural resources and location in the heart of Eurasia, situated between geopolitical powers, including Russia, China, Iran, India, Turkey, Europe and others. Historically it has been a bridge between East and West, home to the Silk Roads that became major conduits of trade and ideas that fuelled the development of civilisations throughout Eurasia. Since suddenly gaining independence after the collapse of the Soviet Union, the five independent republics of Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan and Tajikistan have faced similar challenges, though they have embarked on different paths of development, and struggled to reconnect with the world.

The natural environment in Central Asia is rich but fragile. Governments in the region have been surprisingly stable since independence, but significant uncertainties cloud the near- and long-term development of the region. Relatively little is known about the consequences of climate change from a regional perspective. The coverage of Central Asia for downscaled regional climate information and impact assessments is poor. The implication of climate change impacts across borders within and beyond the region has hardly been studied. Climate change threatens the livelihoods of people living in the region; it could also play a critical factor in geopolitical developments.

Russia maintains significant influence in Central Asian republics; China has become an ever more present player in the region. It is not possible to assess future risks and opportunities in Central Asia without considering the role of at least these two powerful external actors.

Meanwhile, the EU has struggled to achieve significant influence in Central Asia, despite the strategic relevance of the five independent countries to both European and global security and stability. This begs the question: How can the EU's strategy of supporting democracy, human rights, sustainable development and open trade in Central Asia be made more robust to future socio-economic and climate changes in the coming decades? Is there a need to re-think the objectives or

means of implementation for EU strategies regarding Central Asia? How can the EU adapt to climate change impacts in other countries that might cross borders and affect the EU "at home"?

Based on the main vulnerabilities in Central Asia, five key climate change adaptation challenges were identified.

1. Building trust and establishing effective governance of trans-boundary waters;
2. Achieving food security in the face of resource and environmental pressures;
3. Balancing and benefiting from external interest in the region's primary resources, including oil and gas and other commodities;
4. Preventing mass population movements;
5. Maintaining regional security, building cooperation and avoiding conflict.

Highlights

- Stakeholders from Central Asia see a very wide range of potential scenarios emerging in the future. In most, external actors are likely to play a major role.
- Global scenarios can be applied to explore "parallel" futures in different parts of the world simultaneously to support adaptation to cross-border climate change impacts.
- Achieving a new regional transboundary water sharing agreement would be a positive "tipping point", unlocking huge potential for adaptation and mitigation.
- Central Asia provides a test for future EU-Russia and EU-China cooperation; mutually beneficial opportunities exist, but new methods of engagement may be required.

See the IMPRESSIONS website for further details on the EUx case study:
http://infohub.devtest.science/page/central_asia

4. Current state of adaptation planning for cross-border impacts

This section looks at what is currently being done to address cross-border impacts in Europe.

4.1. Current EU approaches

The EU Adaptation Strategy recognises the importance of cross-border climate change impacts. This includes recognition of both EU internal aspects (e.g. using the proposed LIFE instrument, "*Priority will be given to adaptation flagship projects that address key cross-sectoral, trans-regional and/ or cross-border issues*") and external aspects (e.g. "*The strategy takes account of global climate change impacts, such as disruptions to supply chains or impaired access to raw materials, energy and food supplies, and their repercussions on the EU.*") (EC, 2013, p5).

The EU Adaptation Strategy is currently being evaluated in preparation for the launch of a new strategy in 2018. Cross-border or "spillover" effects is one of the thematic areas that the evaluation process is considering as the Commission tries to adopt a tighter and more focused approach on where the EU can "add value" to adaptation in Europe via the new strategy. For the reasons discussed above, the EU-internal aspects of cross-border impacts provide a clear rationale for EU action, providing a strong

opportunity for the evaluation process to enhance focus on these issues. However, external aspects could also be addressed in the EU Adaptation Strategy. Potential issues to address in the revised strategy include:

- The EU's role internationally in facilitating effective adaptation among the EU's global partners.
- Options for improved monitoring and evaluation of member state adaptation planning and implementation, in order to enhance overall EU climate resilience by reducing risks from EU-internal cross-border impacts (e.g. specific focus on the consideration given to spillover effects in a member state "score card" assessment – one idea that has been proposed).
- Identifying key knowledge gaps that currently hold back decision-making on adaptation to cross-border impacts at the EU and member state level.
- Potential priority cross-border impacts for consideration include:
    - Migration – due in large part to the swell of political awareness and interest in EU migration policy in wake of the refugee crisis of recent years;
    - Security – again, following increased instability in the EU neighbourhood and the potential for climate change to play a dynamic role in future insecurity at individual, community and state levels;
    - Trade – recognising the difficulty that previous adaptation strategies have encountered (at member state as well as EU level) in meaningfully engaging trade ministries in adaptation planning;
    - Common Agriculture Policy reform – focusing on food security within the EU under a changing climate;
    - Financial markets and climate resilience – currently a topic that receives little attention in adaptation research or planning.

The EU Adaptation Strategy is, however, only an EU Communication – it is not legislation; the EU is limited in the extent to which it can oblige member states to adapt, or to influence or steer adaptation implementation at member state level. A focus for the EU in addressing cross-border impacts is therefore to mainstream such considerations in existing instruments, for example:

The EU Civil Protection Mechanism gives a stronger competence to the European Commission to address events that can have effects across borders. It includes a national obligation to undertake national risk assessments that consider the potential for cross-border effects. The Mechanism applies to all 28 EU member states as well as a number of affiliated non-EU countries, but it can be – and has been – called upon to respond to crises by any country of the world[9]. A central theme at the heart of the EU Civil Protection Mechanism is that "disasters know no borders", making it a potentially useful and highly relevant instrument with which to build EU-wide resilience to climate change (as well as other) extreme events. A mid-term evaluation of the Mechanism is currently ongoing, opening up the opportunity for it to be modified and applied to address climate-relevant emergencies inside and beyond the EU's borders.

[9] DG ECHO website: http://ec.europa.eu/echo/what/civil-protection/mechanism_en

EU Disaster Risk Reduction programmes can also be used to prevent and adapt to cross-border impacts, including those from climate change. For example, the EU has already invested over €325 million in DRR globally via the Disaster Preparedness ECHO programme (DIPECHO).

EU Cohesion and Structural Funds have attempted to mainstream climate change adaptation over recent years and dedicate significant EU investments to projects and programmes that hold potential to address cross-border climate change impacts via regional approaches, especially in parts of the EU that are especially vulnerable to climate change impacts.

An overarching mechanism with which the EU can seek to reduce the risks of external cross-border climate change impacts is the **2016 EU Global Strategy: *Shared Vision, Common Actions*** (EU, 2016). A key message in the Strategy is that "The external cannot be separated from the internal"; "Fragility beyond our borders threatens our vital interests" (EU, 2016). Given this and the explicit recognition of climate change as one of the global challenges facing the EU, cross-border impacts could be said to be at the heart of EU foreign policy.

The Global Strategy recognises the EU's significant diplomatic reach and numerous networks of influence as key instruments of EU security strategy. It includes the goals of "Pre-emptive Peace", the use of a "multidimensional approach" to conflict prevention and resolution – employing all available policies and instruments – and a willingness to invest in stabilisation in regions beyond the EU, including by making better use of development cooperation and more coherent external policies overall.

The notion of pre-emptive peace, which is discussed specifically in the context of climate change (e.g. EU, 2016, p29), implies an enhanced role for EU-funded or facilitated climate change adaptation in other countries as a strategy for preventing instability that might negatively affect the domestic interests of the EU and its citizens.

One of the five key priorities for external action in the Strategy is "State and Societal Resilience to our East and South":

> *"It is in the interests of our citizens to invest in the resilience of states and societies to the east stretching into Central Asia, and to the south down to Central Africa …But resilience is also a priority in other countries within and beyond the {European Neighbourhood}. The EU will support different paths to resilience, targeting the most acute cases of governmental, economic, societal and climate/energy fragility, as well as develop more effective migration policies for Europe and its partners." (EU, 2016, p9)*

The UN system in general, and the Paris Agreement on Climate Change in particular, feature as bedrocks of the EU approach to implementing foreign policy.

Under the United Nations Framework Convention on Climate Change (UNFCCC), including the Paris Agreement, the EU is required to submit regular assessments of its own climate vulnerabilities and adaptation plans (e.g. Adaptation Communications), and as such also has access to the equivalent reports from all other Parties. This provides one source of information on climate risks that may originate beyond the EU's borders. The UNFCCC process also provides mechanisms for enhancing adaptation in other countries, for example, through the provision of international adaptation finance,

technology transfer and capacity building in other countries: roles that the EU has traditionally supported in both negotiations and in practice. The five-year review of ambition under the Paris Agreement, which will include adaptation, and the forum provided by the ongoing UNFCCC negotiations, also provide the EU with an opportunity to monitor and further encourage the implementation of adaptation in other countries, including in ways that benefit the EU by reducing the risk of cross-border impacts (see SEI, 2017).

4.2. Current national approaches

A few European countries have conducted national assessments of cross-border climate change impacts and risks. In this section we summarise the approach and key findings of four prominent examples: Switzerland, Finland, the United Kingdom (UK) and the Netherlands. It is worth noting that the vast majority of effort in these assessments is on the relevance of global climate change for the countries in question (i.e. what this report refers to as the "external aspect"); there is very little assessment of transboundary climate change impacts from neighbouring EU countries (i.e. the "EU internal aspect").

Switzerland

One of the earliest national studies of cross-border impacts of climate change was conducted for Switzerland (INFRAS, 2007), in recognition of its small, largely open economy and its strong dependence on international trade. A multi-country input-output model was used in conjunction with economic projections from a global equilibrium model and damage potential estimates from parallel studies to assess the exposure of the Swiss economy to changes in the flow of goods due to climate change impacts (both direct flows and via third countries) by 2050. The study concluded that climate impacts internationally were almost as important for Swiss exports as impacts at home and were likely to increase in importance. Moreover, the financial services sector is likely to suffer a loss of market and purchasing power due to climate change, though the insurance industry may benefit from increased demand from reinsurance services. A survey of experts was also conducted, which concluded that the international influences of climate change on the Swiss economy as a whole will be greater than impacts within Switzerland. The effects on trade flows and capital markets are most important, followed by impacts on migration and resource flows.

Finland

Another study for Finland, in the same year as the Swiss report, reviewed economic sectors of national importance that were considered to be most sensitive to international impacts of climate change, with special attention paid to regions and countries with connections to Finland through trade, investments, tourism or as development co-operation partners (Kankaanpää and Carter, 2007). Some of the focal topics included impacts on agriculture and forestry (and related bioenergy crops) through world prices and demand, shifting patterns of tourism, energy import dependencies, commercial, transport and environmental implications for Finland of Arctic sea ice decline and the need to assess priorities for adaptation planning in development co-operation partner countries.

In a follow-up study a systematic approach was adopted to review potential cross-border impacts on the following ten sectors or activities of relevance to Finland: primary and manufacturing industries, energy, transport, business and finance, tourism, population, human health, biodiversity, foreign

policy and development co-operation (Hildén et al., 2016 – Figure 19). Potential impacts were then assessed qualitatively by sector/activity for each of the six pathways shown in Table 1 (column FIN). Three classes of potential impact were identified based on the available literature: mainly beneficial, mixed or neutral, and mainly adverse (colour coding in **Figure 19**).

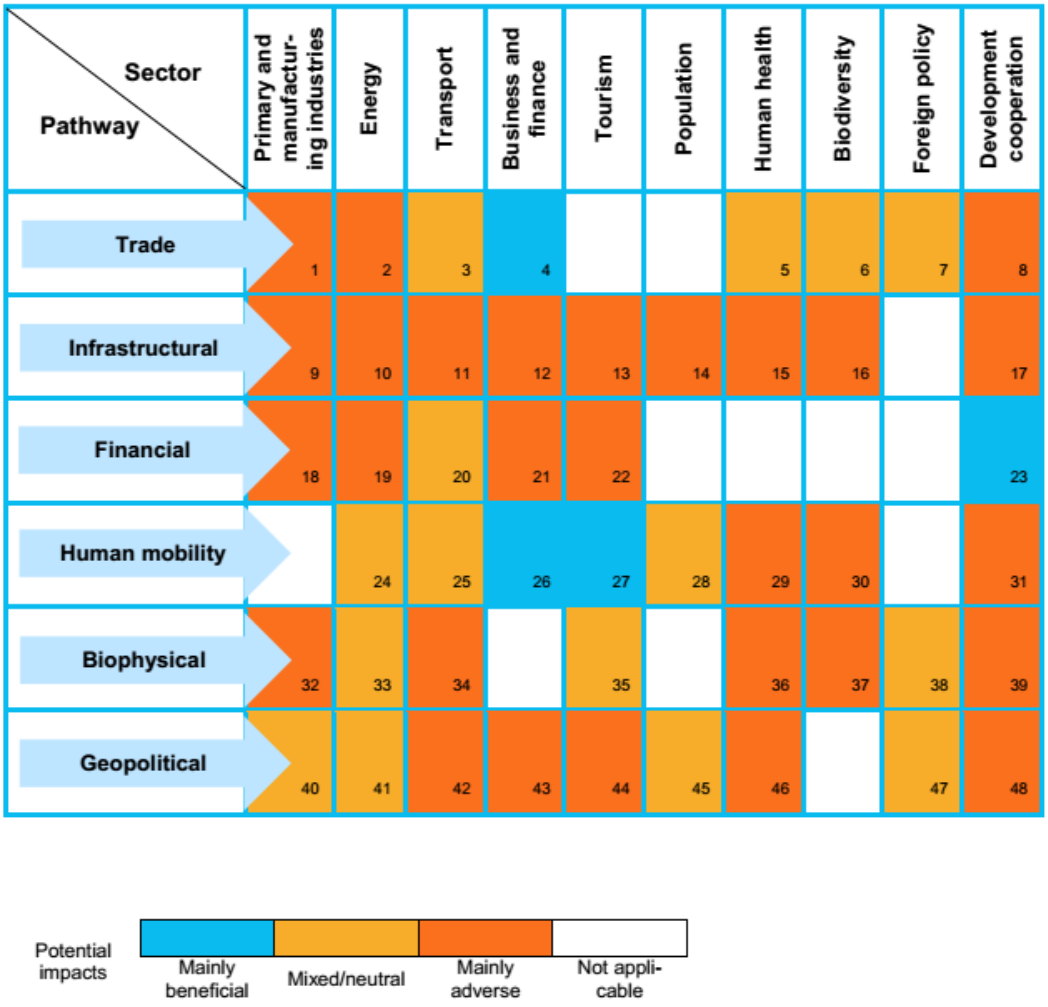

Figure 19: Matrix of potential cross-border impacts of climate change affecting Finland for different sectors through six pathways. Numbers refer to explanatory descriptions (not shown) for the relevant cell. Source: Hildén et al. (2016).

United Kingdom

The United Kingdom undertook a series of foresight studies under the banner of the International Dimensions of Climate Change project (Foresight, 2011), which identified a diversity of risks to the UK from climate change impacts overseas, including diplomacy and foreign policy, security, resources and commodities, finance and trade, human health and social values, and hence the need for a broad approach to possible responses. Results from the project were also published in a special issue of Climate Policy. More specifically, five key threats and challenges of climate change and sea level rise were identified (Sentance and Betts, 2012; Nicholls and Kebebe, 2012; Lewis and Witham, 2012b):

(i) shifts in the UK's international role and global influence with respect to geopolitical factors affected by changes in climate (e.g. access to resources, stability of infrastructure and security).
(ii) failure of the business and finance sector (including insurance) if insufficient attention is paid to the changing balance of risks for overseas assets.
(iii) adverse economic impacts affecting overseas resources and infrastructure, including disruption to vital infrastructure serving global markets, manufacturing of commodities, supply chains, energy supplies, extraction of raw materials and communications networks.
(iv) impacts on human health arising from climate change, affecting citizens travelling overseas, visitors coming to the UK and provision of health care overseas.
(v) increasing international instability, due to climate-induced extreme events that exacerbate stresses on water availability and other infrastructure in regions that are already vulnerable.

A number of potential opportunities afforded by climate change were also highlighted:

(i) opportunities to influence the global stage, by playing a leading political role in responding to climate change through mitigation and adaptation policies at home and abroad.
(ii) business and financial opportunities for key sectors engaged in developing mitigation and adaptation technologies with global or targeted regional application (for example, expertise in managing coastal hazards).
(iii) opportunities to influence behavioural change at home by raising awareness of the potential implications of impacts occurring abroad.

The studies also explicitly recognise that future impacts are highly conditional on the magnitude of climate and socio-economic changes as well as the success or failure of responses (Nicholls and Kebede, 2012). Policy responses through mitigation and adaptation are themselves closely associated with the directions in which global and regional governance mechanisms evolve as well as the legal frameworks developed for implementing these (e.g. de Larragán, 2012).

After the Foresight reports, a supplementary assessment was commissioned to explore the international threats and opportunities of climate change for the UK (PwC, 2013). This assessment filled the gap that was left in the first nation-wide climate change risk assessment (CCRA), which focused exclusively on direct climate change impacts within the UK (Wilby, 2012). The second UK CCRA has now been published, which contains a chapter on "International Dimensions" (Challinor et al., 2016). This chapter discusses three key dimensions of opportunity and risk: those associated with the global food system; migration and displacement; and geopolitical issues. The report cites the need for new forms of cooperation across UK government departments to address cross-border climate change impacts, as well as the need to act abroad (e.g. by supporting adaptation in other countries) as a way to reduce the UK's risk exposure.

Despite the relatively strong evidence base and high awareness that resulted from the Foresight, PwC and CCRA02 assessments, the coverage of cross-border impacts in the UK National Adaptation Programme[10] is largely limited to the role of business in managing international supply chains.

[10] Available at: https://www.gov.uk/government/publications/adapting-to-climate-change-national-adaptation-programme.

The Netherlands

A study of the consequences for the Netherlands of climate change abroad concluded that the main risks arise from weather extremes such as cyclones, extreme precipitation events, heatwaves and drought, but that gradual changes would also have impacts over the longer term, such as the decline of Arctic sea ice, shifting agroclimatic zones and migration of fish stocks (Vonk et al., 2015). The study distinguishes between implications for the Netherlands of impacts in other European countries and impacts further afield. In Europe it highlights three types of cross-border impacts: on water levels and flooding, on infectious diseases and on the power grid and information and communication technology (ICT) networks. Of these, the first two are already being addressed by the government, but the third was regarded as the biggest challenge for climate change adaptation, requiring close co-operation with other countries. Globally, the main repercussions are likely to be felt through impacts of climate extremes on commodity prices and on disruption to supply chains, as well as a need to cope with possible political instability resulting from these events or from conflicts over access to natural resources brought about by a changing climate (e.g. in the Arctic or relating to access to fresh water). Finally, like in the UK study, the report stresses the importance of effective global assistance for adapting to climate change, both through technical means and by strengthening institutional capacity, especially in developing countries. There are also potential opportunities to be gained by the private and public sectors for deployment of Dutch expertise abroad, such as in integrated water management (Vonk et al., 2015).

Summary

The studies by European countries referenced above show that awareness of the existence of cross-border effects has been in place for a decade and that a variety of assessment techniques have been adopted including economic modelling (e.g. Switzerland), systematic research review (e.g. Finland) and more system-first, or country-profile based assessments (e.g. UK and the Netherlands). Whilst these studies begin to shed light on the nature and breadth of the risks posed by cross-border impacts, the uptake of these issues in national adaptation agendas is somewhat low, currently.

4.3. Emerging views from the national level in Europe

In order to augment the view of national level approaches that can be ascertained from published reports, and in order to get an up-to-date view of current thinking about cross-border impacts at the member state level in Europe, we undertook a survey of climate change adaptation professionals.

The objective of this expert survey was to collect information about the understanding, coverage and levels of activity around cross-border impacts (or transnational climate impacts). Many of the experts we contacted are working as UNFCCC National Focal Points in government or in similar roles in Europe. These individuals are arguably best placed to foresee emerging opportunities and challenges related to transnational climate impacts, and to understand the information needs for policy. We contacted them to find out: Are there examples of such indirect impacts in their countries? Do they see this as a priority? Do they have sufficient data and support at their disposal?

Annex I gives a detailed account of the expert selection, survey methodology, survey questions and analysis of the results. Here we summarise a selection of the key findings.

Survey coverage

Respondents were identified through the EU projects CIRCLE and CIRCLE2, the Climate Change Impacts, Vulnerability and Adaptation National Reference Centres (NRC), listed experts in European Environment Agency member countries, the EPA Interest Group "Climate & Adaptation" and the European Environment Information and Observation NETwork (Eionet). Approximately 130 people were sent the survey by email. Ten individuals from across Europe provided very detailed responses. The countries represented in the sample are Austria, Sweden, Germany, Romania, Spain, Denmark, Finland and France, plus responses from the European level, eight of whom "occasionally" consider cross-border impacts in their work, the remaining two of whom recognise the issue and are beginning to include it in their work.

Whilst the response ration was very low, especially from eastern and southern Europe, Annex I offers some reflections on the reasons for this, which include the heavy workload of adaptation focal points and the "new" nature of the topic, as well as the low evidence base that currently exists. Both factors make it difficult for respondents from countries that have not yet initiated action on this topic to respond: none of the survey respondents answered that they do not consider cross-border issues, for example. We therefore suspect that a number of the countries that did not respond may not have begun to look into the issue[11]. This assumption is circumstantially supported by our literature review of national approaches to cross-border impacts, as well as by interviews conducted during the preparation of this report with the EEA and DG CLIMA Adaptation Team. Nevertheless, the survey does not provide a large enough sample from which to draw firm conclusions about the state of adaptation to cross-border impacts in the EU. It does, however, provide a small sample of quite detailed insights on the topic.

Awareness and key issues

Two of the most prevalent cross-border climate change impacts identified in the survey were: (i) the supply of agricultural products due to climate change-induced crop failures; and (ii) floods in transboundary river basins. Others mentioned included transboundary air pollution, climate-induced migration from the EU neighbourhood, increased price of imports and supply chain disruption and energy security (due to climate impacts on sources of imported energy). Many of these impacts were based on past experience of climate related cross-border impacts.

Status of national level assessments

A minority of countries has completed national level assessments, but some level of activity is underway in all of the countries who responded to this question (nine), as show in **Figure 20**.

[11] One known exception is the UK, which is arguably one of the countries that has previously looked most deeply into this topic, but which did not have capacity to respond to our survey.

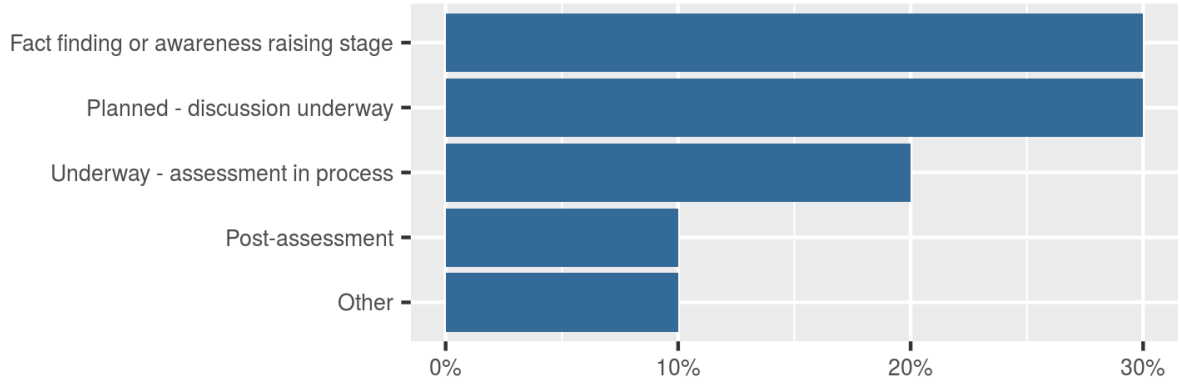

Figure 20: National level assessments of cross-border impacts – the current state of play.

As shown in Figure 21, 50% of the respondents stated that these assessments are being led through a national process, or initiated and/or led by specific departments or functions of government; 40% responded that these are led through a European process (e.g. a European funded project, implementation of an EU Directive, etc.); 20% of such assessments have been led by a regional process (e.g. Interreg project or other non-EU regional cooperation between countries); 20% are also led through a local process.

One respondent stated that such an assessment has been led through the business sector which has been influential at the national level, and one other stated that these can be led from multiple levels. For example, the National Adaptation Strategy of Austria includes recommendations for action within the activity field "economy". These strategic adaptation options address transnational climate risks, but a systematic assessment of these impacts is to a large extent is still missing. This intersection of different processes at different levels indicates the institutional complexity that is sometimes involved in national level assessments, especially for adaptation.

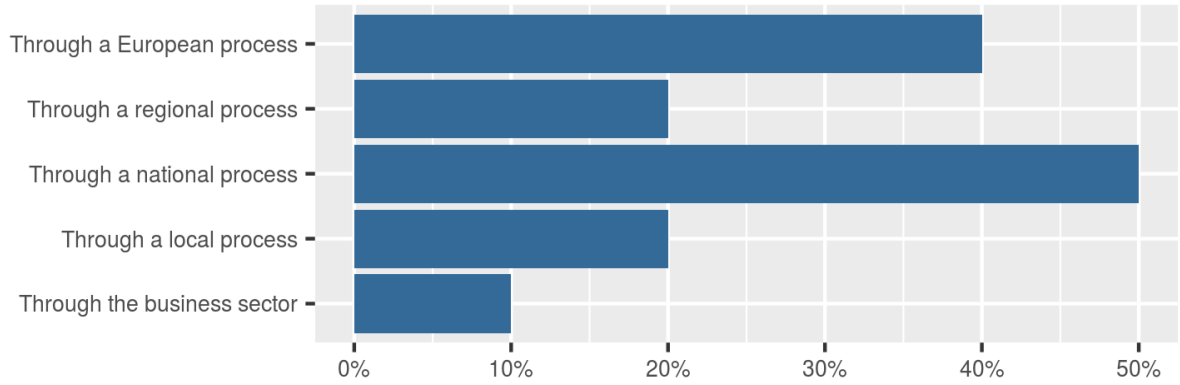

Figure 21: Leadership of national level assessments of cross-border impacts – responses to a multiple choice answer.

Drivers to consider cross-border impacts

Almost all respondents cited the refugee crisis and/or growing awareness of possible links between climate change and migration as a factor that is likely to encourage governments to consider cross-border impacts. Other notable drivers include future extreme events that might disrupt international supply chains and therefore welfare in Europe, and growing security concerns – especially in the Middle East. Half also noted the role of the private sector in driving awareness at the national level about cross-border impacts, given the international scale of many businesses operations. Around a third of respondents highlighted institutional factors that might drive future assessments, including revised adaptation guidance, requirements and incentives via adaptation finance and the role of research and policy discussions.

Barriers

Respondents cited a range of reasons that are perceived to be holding back action to address cross-border climate change impacts (see Figure 22 below). A majority suggested that adaptation to cross-border impacts is beyond their institutional remit and that there is insufficient evidence describing the significance of cross-border impacts at the national level.

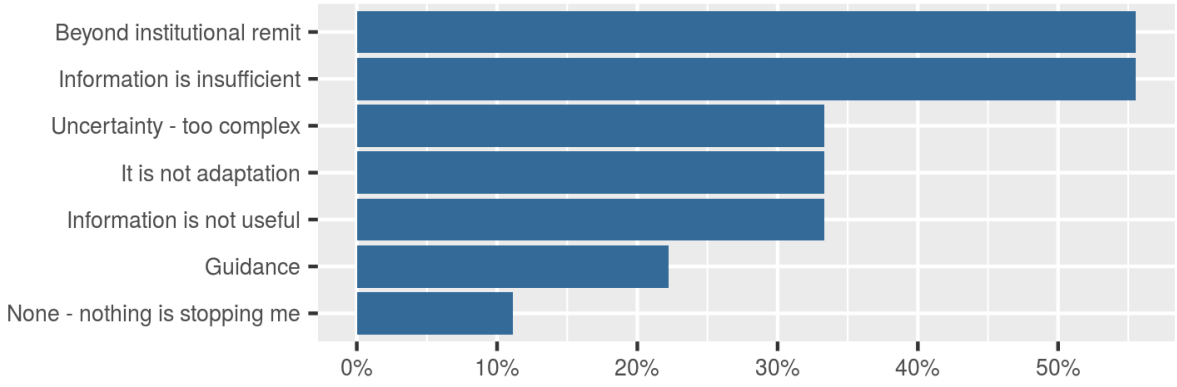

Figure 22: Barriers to considering cross-border impacts at the national level – survey responses.

Roles and responsibilities for managing cross-border impacts

Interestingly, all respondents see an enhanced role for the EU in addressing cross-border climate change impacts. National Focal Points who answered this part of the survey (n=9) think that management of transnational climate impacts, is primarily the responsibility of the European Union (100%) , followed by National Governments (88.9%), the UN Framework Convention on Climate Change (44.4%), private sector actors (44.4%), other non-governmental actors (22.2%), and finally, other (33.3%).

Specific suggestions for the EU role in managing cross-border climate change impacts include:

- Support to adaptation initiatives in “source” countries, meaning those external countries where risks originate (e.g. funding, knowledge sharing, etc.).

- Support systematic risk assessments and joint response strategies in EU member states (e.g. through research funding, transnational cooperation programmes, etc.).
- Raise awareness, gather evidence and communicate facts, provide examples of work undertaken.
- Be responsible in foreign trade (exports beyond the EU) and in coordinating efforts to secure resource demands by member states.
- Bringing relevant actors together: raise awareness, start a bottom-up approach/avoid a top-down approach, and a supranational entity will have to take the lead.
- EU should have a common response to transnational impacts across its borders.
- Further research is needed in order to identify areas where new policies or changes to existing policies might be needed.

Other issues covered

The survey also asked respondents to identify key knowledge gaps and preferred information sources, as well as to make suggestions for new initiatives and to identify the key socio-economic variables that might influence future exposure to cross-border impacts in Europe. See Annex I for more information.

Conclusions from the survey

We emphasise five key points out of the many issues that this survey has brought into focus in the context of cross-border climate change impacts.

1. Most respondents are aware of some potential future impacts in their respective countries. However, impacts are generally hard to predict and are under-investigated.
2. Population growth, increased inequality and migration are seen as among the top future socio-economic developments that are likely to increase the significance of cross-border climate change impacts.
3. Informational and institutional barriers are perceived as most important, but also uncertainty, as well as more specific guidance on whether responses to these types of impacts should be considered as 'adaptation'.
4. The most meaningful terms for describing this phenomenon were 'transboundary', 'international', 'spillover' and 'indirect'. It was also suggested that a broader encompassing term might be preferable that could be used for all types of audiences.
5. Whilst respondents cited a general level of awareness in their countries, they also indicated that management of cross-border climate change impacts is primarily the responsibility of the EU followed by national governments.

4.4. Current private sector approaches

The sections above have noted indirectly that the private sector is likely to play a major role in identifying, assessing and managing – indeed "owning" – many of the risks associated with cross-border climate change impacts. This view is supported by previous assessments of adaptation needs and responsibilities, including at the EU level (e.g. McCallum et al., 2013). This is because of the myriad roles played by private entities in export and import industries, risk management, insurance, investment and supply chain logistics. It is therefore extremely important to explicitly consider the

division of roles and responsibilities between the state and private sectors in adaptation within this context.

Currently, little is known about the level of climate risk exposure among private sector organisations in Europe, and about the plans that private actors have to manage and adapt to those risks, including the consequences of private sector adaptation decisions on other sectors of society (e.g. communities, the environment).

One of the major sources of such information is provided by the CDP (previously known as the Carbon Disclosure Project), a non-governmental organisation that elicits climate risk disclosure information from private organisations (and also public, including cities) on the behalf of institutional investors. Over the last 15 years, the CDP has collected information on corporate climate risks, which includes disclosure of "physical" risks (i.e. climate impacts and adaptation needs), in addition to regulatory risks, (e.g. from ambitious climate change mitigation regulations). Data from over 1,000 companies on climate change is published in a regular Global Report and housed in a database. The CDP also publish a series of Supply Chain reports, which look at several issues, including the risks facing companies from climate impacts along their international supply chains (i.e. cross-border impacts). As such, the CDP offers insights into the range of risks facing companies and their planned adaptation activities that is otherwise difficult to access. However, many companies restrict information about commercially sensitive risks and look to gain reputational advantages through their reporting, questioning the reliability of the data.

Governments have experimented with various ways to initiate and track adaptation in the private sector (Benzie & Wallgren, 2014). For example, an experiment in obligatory climate risk disclosure was undertaken by the UK government as part of its implementation of the Adaptation Report Power, under the Climate Change Act 2008, which gave it powers to request climate risk assessments and adaptation plans from private companies that were undertaking "statutory functions" on behalf of the government, for example operating critical energy or transport infrastructure. This yielded useful information for government, but little detail on international (cross-border) impacts (see Cranfield, 2012).

Despite the importance of private sector actors as owners and assessors of cross-border climate change impacts, there remains little usable information or transparency upon which governments or the EU could seek to base adaptation strategies.

5. Discussion and Conclusion

This report has suggested that the EU is linked via flows of resources, goods, capital and people to all other regions of the world. As such, global climate change matters for the EU; the EU is likely to be exposed to cross-border climate change impacts that originally occur in other countries.

There are various ways to conceptualise this reality. Research on the topic is in its infancy and there is as yet no widely accepted terminology with which to describe this international dimension of climate risk. We offered a way of seeing cross-border impacts as being transmitted via various pathways, though the number and type of pathways is perhaps a matter of individual preference; more

meaningful applications of these ideas are needed to compare and analyse the utility of different approaches.

Based on existing evidence, the EU is likely to be exposed to external aspects of cross-border impacts as a result of: its trade ties and dependencies, especially its reliance on resources (including food) and materials, as well as component parts via international supply chains from outside the EU; economic ties with other countries and with the global economic system as a whole; its strategic, geo-political and security relationships and interdependence with other countries; and given its proximity to regions and countries that are less likely than the EU to be able to adapt to adverse climate impacts, raising the possibility of significant spillover effects. This aspect appears to have gained traction within various sections of the EU.

The EU member states will also need to meet the challenge of adapting, preferably in a coordinated fashion, potentially facilitated by EU institutions, to the internal aspect of cross-border impacts within Europe. Early actions in this respect are already underway, for example in European macro-regions.

As a responsible global actor, the EU should also identify, assess and track the potential cross-border effects of climate change impacts within Europe, as well as the secondary effects of adaptation actions taken by the EU and its member states on other, "third party" countries. No significant initiatives of this type appear to be in existence, yet.

Awareness of these issues is on the rise. The time is therefore ripe for a more concerted, coordinated and deliberate attempt by the EU to direct its considerable experience with adaptation towards the challenge of adapting to cross-border climate change impacts. EU member states have shown that it is possible and worthwhile to embark on this journey. There is, however, no blue print on what "good practice" adaptation – or even vulnerability or impact assessment – looks like, in this case. A range of scientific as well as policy challenges lies ahead. But there are also opportunities, not least for the EU itself. The EU is a rare but well-placed supra-national actor, with a unique remit and capacity to manage transnational issues and identify mutually beneficial solutions for its member states.

Big questions remains about the ability of national governments to proactively take ownership of supra-national, transnational risks (Persson & Benzie, 2016). It is also beyond the EU to control all aspects of this policy agenda. Not only does a large proportion of the workload fall to member states, but the EU will be subject to risks that result from action (or inaction) on the part of third party governments and other actors, including multinational companies, beyond its jurisdiction. Recent developments in global politics, including a possible trend towards more protectionism and isolationism, do not bode well for international cooperation to address cross-border climate change risks. However, on both the scientific and policy sides, there are opportunities for the EU to drive this agenda forward in the coming years, including in the next cycle of the EU Adaptation Strategy.

5.1. Policy challenges – potential EU Responses

In this section we speculate about potential responses to cross-border climate change impacts at the EU level. We focus on what potentially could be done that isn't currently being done. We draw on the recommendations of the national assessments cited above, findings from the adaptation focal point survey conducted for this report and our interviews with decision-makers within the EU. We identify potential responses according to the three aspects of cross-border impacts highlighted above, namely

EU internal, **EU external** and **EU impacts on the rest of the world**. This distinction is considered a helpful way to begin assigning responsibilities for adapting to cross-border impacts across different functions of the EU.

EU external (EUx)

Cross-border impacts imply a set of challenges, but also opportunities for the external functions of the European Union. Perhaps the most directly affected EU functions are likely to be the European External Action Service (EEAS) and Directorates General for Energy (DG ENER), Humanitarian Aid and Civil Protection (DG ECHO), International Cooperation and Development (DG DEVCO/ EuropeAid) and Climate Action (CLIMA).

In general, a thorough assessment of the EU's exposure to the external aspect of cross-border climate change impacts would help to set priorities between these core external functions of the EU institutions. Such an assessment could build on recent, preliminary studies (mentioned above), but undertake a much more detailed and thorough assessment of the EU's key global interdependencies, the climate risks that are implied by these interdependencies, the prospects for successful adaptation in other countries and places with which the EU is linked and the options available to EU actors to reduce cross-border risks in overseas territories through various types of adaptation.

The EEAS should continue to support the Commission in its delivery of "Climate Diplomacy" globally, seizing on positive momentum generated by the Paris Agreement to ensure its implementation. A greater focus on the strategic nature of climate risk to EU interests relies on improving the knowledge base and intelligence that describes how, when and from where the EU is at risk from cross-border impacts.

DG ENER should assess the strategic risks to EU energy supplies from climate change, including under higher end scenarios, and support other DGs to implement programmes that build climate resilience. This may require more systemic views of adaptation, for example, making investments in societal resilience in regions that deliver critical energy supplies to the EU (including critical materials for renewable energy production), rather than merely looking to enhance the physical resilience of supply infrastructure.

The capacity of DG ECHO should be increased in anticipation of a much greater demand for emergency relief support and resilience building in fragile parts of the world as a result of climate change, including those where there are significant risks of spillover effects into the EU.

The capacity of DG DEVCO should also be increased to ensure that successful mainstreaming of adaptation in development cooperation occurs in all the regions of the world where it is active. Greater consideration should be given to regional (transboundary) programmes and projects in forthcoming cycles of the Development Cooperation Instrument, so that recipient countries are themselves better prepared to adapt to cross-border impacts.

DG CLIMA should encourage other countries to take seriously the threats posed by cross-border climate change impacts, including via its engagement at the UNFCCC and the implementation of the Paris Agreement. Mechanisms for supporting more regional, transboundary and even transnational approaches to climate change adaptation should be explored, including via multilateral climate

finance institutions such as the Adaptation Fund and the Green Climate Fund, as well as the bilateral adaptation finance programmes of EU member states.

DG TRADE should consider the risks associated with climate shocks and long-term climatic changes to the EU's trade portfolio, including critical supply chains for EU industry and European food security (in combination with other DGs).

EU internal (EUi)

The EU could act as a climate risk disclosure clearinghouse for its member states, in a similar way to the role of the CDP in private sector climate risk disclosure. For example, Climate-ADAPT[12] could be used as a site where national assessments *and their potential consequences for neighbouring or other members states* could be collected and referenced by the Commission and member states when assessing and adapting to internal cross-border impacts in the EU.

European Regional Development Funds should continue to foster regional cooperation on projects relevant to climate change adaptation, including via Interreg Europe. The focus should not only be on sharing good practice between agencies in different parts of Europe, but on actual cooperation to address shared climate risks, whether these are transboundary or regional in scope, or more abstract and connecting constituencies from different parts of the EU.

Climate risks on food security in Europe resulting from climate change on production and supply chains within the single market should be assessed by the Commission.

EU impacts on the rest of the world ($EU_{\rightarrow ROW}$)

Currently, no EU actor tracks the consequences of EU adaptation or climate change impacts within the EU on other countries. Nevertheless, the existence of cross-border impacts implies that all regions of the world are likely to be the source of climate change risks that affect third parties. It is therefore in the common good to provide relevant information on the potential for cross-border impacts as part of a two-way exchange with other countries or regions.

The EU Adaptation Strategy would be a suitable place to provide an initial assessment of both the positive and potentially negative consequences of EU adaptation for other countries, in line with the logic of a policy impact assessment, or similar.

5.2. Scientific challenges

Analysis of cross-border climate change impacts is inherently complex. Assessments must take account of potential changes in at least two different locations, and often multiple locations. For example, in the case of assessing climate-related migration, climate change impacts, vulnerabilities and adaptation options need to be identified in source, transit and recipient countries.

Cross-spatial analysis of climate change impacts raises many of the same methodological challenges as cross-sectoral analysis (as well as new ones), namely the challenge of dealing with "complex interdependencies" (see Harrison et al., 2015; Harrison et al., 2016). There is the same scope for

[12] http://climate-adapt.eea.europa.eu/

uncertainties to be magnified when combining assessments from different places or sectors. There is also a similar challenge in how to account for these uncertainties in ways that remain transparent and meaningful to the stakeholders who will ultimately use the results to inform decisions. Considering cross-border impacts under high-end scenarios adds an extra layer of uncertainty and complexity to this challenge.

Nevertheless, scientific challenges can be confronted, especially where new interdisciplinary teams can be established to reveal new insights into the scale and nature of cross-border climate change impacts. Below we highlight some key challenges.

Balance

An important balance must be struck between full "360°" assessments of cross-border impacts and pathway-specific or case study assessments. Full 360° assessments are needed to scope out the full range of potential risks facing a decision-maker, such as a national government. Deeper analyses are also needed to inform sector- or department-specific decisions, but it is important not to focus solely on what can be measured or modelled. Some of the national assessments reviewed in Section 4.2 were severely limited by available evidence and current modelling applications. It is important that future EU assessments do not ignore the most complex, most highly uncertain risks just because the analytical challenge is daunting.

Another important, related balance to strike is between quantitative and qualitative assessments. Whilst many decision-makers prefer quantitative assessments, high levels of uncertainty and poor data availability for some cross-border impacts (see below), mean that combinations and comparisons between quantitative and qualitative assessments may be necessary.

Economic modelling

Some of the most robust studies of cross-border effects have been provided by computable general equilibrium (CGE) models, which can analyse potential changes in trade between countries or world regions, for example when coupled to climate change impact models for specific sectors, such as agriculture to analyse changes in food trade. Such studies help to understand how gradual changes in climate and shifts in the most productive agricultural regions will affect prices, competitive advantage and terms of trade between countries worldwide (see for example Schenker 2013; Schenker and Stephan, 2014). However, there are important limitations of CGE analyses, including the way in which they represent climate damages and their limited capacity to model the effect of production and trade shocks (which in reality influence the way in which risks are distributed via trade, including from climate change – see Benzie & John, 2015). Alternative economic modelling approaches are needed to complement the global insights provided by CGE models (see Deliverable D5.2 – Lamperti et al., 2016).

Network analysis

Network analysis is an under-used discipline in climate change impacts, vulnerability and adaptation research. Recently it has been used to study global food systems, for example to understand bilateral trade and food security (Brooks et al, 2013), production shocks in wheat and rice networks (Puma et al, 2015) and shock propagation in global seafood trade (Gephart et al, 2016). Bren d'Amour et al.

(2016) analyse the effect of production shocks for major staple crops taking into account the vulnerability of consumer nodes within a network.

Network analysis could be applied to various aspects of cross-border climate change impact assessment, especially to explore the non-linear system dynamics that characterise many of the more complex risks, including those operating over teleconnected dimensions (as opposed to transboundary dimensions between neighbours). Agent-based modelling is also a promising avenue for research on this topic (Lamperti et al., 2016). Future EU assessments should consider embracing these and similar scientific methods to better understand exposure to cross-border impacts both within and beyond the EU.

Trade modelling

Assessing impacts and risks relating to climate change reveals many of the data limitations that scholars and decision-makers face when assessing trade dynamics. For example, it is common to be held back by the so-called "Rotterdam Effect": standard trade statistics record the "last port of call" for imports, which, in Europe, is often one of the major commercial ports. Thus, according to standard trade statistics, Sweden, for example, imports its bananas from Rotterdam in the Netherlands, despite the fact that they were produced – and possibly traded – elsewhere.

Alternative trade statistics and modelling techniques are therefore needed to assess cross-border climate change impacts via the trade pathway. These include input-output methods and combinations of these methods with other climate-relevant data sets (see for example West and Croft, 2016; West et al, 2015).

Additionally, efforts to increase the transparency of supply chain data, in order to improve accuracy in tracking the links between consumers of traded commodities with the sites and conditions (including exposure to climate risk) where they were produced, offer significant potential (see Godar et al, 2015; Gardner et al, submitted; see also https://trase.earth/).

Scenario methods

One way to overcome the inter-spatial, cross-sectoral and high uncertainty around this issue is to employ scenario methods as a technique for exploring a range of possible future cross-border climate change impacts. For example, one concrete way forward would be to develop a matrix of European shared socioeconomic pathways (SSPs), coupled with climate change scenarios (see section 2.3) against the climate risk pathways identified in Section 2.1. For specific DGs or even sub-regions of the EU, a similar but bespoke exercise would also be appropriate.

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Annex I – National Focal Points Survey on Transnational Climate Change - Analysis

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1. Introduction

The objective of this expert survey was to collect information about the understanding, coverage and levels of activity around transnational climate impacts[13] (or indirect impacts). The experts contacted were Climate Change Adaptation (CCA) professionals, many of whom are working as UNFCCC National Focal Points in government or in similar roles in Europe. These individuals are arguably best placed to foresee emerging opportunities and challenges related to transnational climate impacts, and to understand the information needs for policy. We contacted them to find out: Are there examples of such indirect impacts in their countries? Do they see this as a priority? Do they have sufficient data and support at their disposal?

The IMPRESSIONS project uses 'transnational climate impacts' (TCI) to describe the impacts of climate change that "cross countries". They are defined as impacts that require a response in one place as the result of climate change or extreme weather events somewhere else. For example, droughts in far-off countries might affect agricultural production that disrupts international food supply chains, or slow onset changes in neighbouring countries may influence cross-border migration patterns or water availability from transboundary rivers.

Although this area is still relatively less well understood and under-researched, recently SEI have developed an Index of exposure to indirect impacts of climate change and a conceptual framework for assessing indirect impacts of climate change with four pathways - biophysical, trade, finance, people – plus an additional dimension that captures the global context in which climate change impacts and adaptation occur . A question was included in the survey about the framework, about what was missing from the framework, and what changes could be considered. The question was included as it relates to the topic of the survey.

It was clear from the initiation of the work that this might be a difficult group to get responses from because of their workload, plus their broad areas of responsibility, thereby making it difficult to target the correct individuals.

[13] The survey was conducted using the terminology preferred by the Stockholm Environment Institute team at the time of designing the survey: transnational climate impacts. For the sake of clarity, the term "cross-border impacts" has been used in the rest of this IMPRESSIONS report. See the section in the main report on terminology.

As a relatively new field for research and practice, it is also difficult to engage and motivate survey responses from individuals who are either not familiar with the issues covered, or have little or no information on the topic at their national scale with which to complete the survey.

We have directed this survey at focal points, researchers, practitioners and policy-makers working on adaptation at the national level in various EU Member States. Some of the questions follow on from questions posed in the 2014 European Environmental Agency (EEA) survey on National Adaptation Policy Processes in European Countries (REF).

Respondents were identified through the EU projects CIRCLE and CIRCLE2, the CCIVA National reference centres (NRC), experts in EEA member countries, the EPA Interest Group "Climate & Adaptation" (PBL, Netherlands), and through the European environment information and observation network (Eionet), which is a partnership network of the EEA and the countries through the head of the climate change impacts, vulnerability and adaptation of the EEA. Approximately 130 people were sent the survey by email. Ten individuals responded from across Europe, and in considerable detail.

The survey results will provide input to an EU-funded research project IMPRESSIONS, which aims to advance our understanding of the implications of high-end climate change, involving temperature increases above 2°C, and to help decision-makers apply such knowledge within integrated adaptation and mitigation strategies.

The survey covers terminology, national level initiatives, national and European Union responsibilities for adaptation planning, and finally barriers to addressing transnational impacts in this area of adaptation work. Results will be analysed and published as part of the IMPRESSIONS project, please visit http://impressions-project.eu/ for more information. The research team hope to use insights gained from the survey to improve the availability and usefulness of research on transnational climate impacts for decision-makers.

2. Profile of participants in the study

A total of ten respondents filled out the survey. The respondents were based from the following towns/cities: Vienna (Austria), Norrkoping (Sweden), Dessau (Germany), Bucharest (Romania), Madrid (Spain), Copenhagen (Denmark), Helsinki (Finland), and Paris (France). This spread shows that Northern and Central Europe are well represented, each with three countries, but only one country in Eastern Europe and one country in Southern Europe is included. Notably nobody from UK or from Italy, two of the most populous countries, took part.

40% of respondents fall in the 40-49 age range, 30% are comprised in the 30-39 years old range, 20% fall in the 50-59 years old range and the remaining 10% falls in the range of 60 years old and/or above. 60% of the respondents were male whilst the remaining 40% were female respondents.

We also asked respondents to select the type of sector of work which best describes their position. 80% of the respondents work in the government/civil service sector, whilst 10% (i.e. one individual) works in research and 10% work at the national environment agency (boundary organisation).

We asked about geographical focus of work. Possible responses were ordered across different geographical levels from 'International' to 'Local.' 40% work at the international level - including any

geographical area that impacts core work functions, 40% work at the international/regional level in specific countries or areas beyond the national border, 60% of the respondents work at the national level, and only 10% works at the local level - internal region or local area (Figure 1).

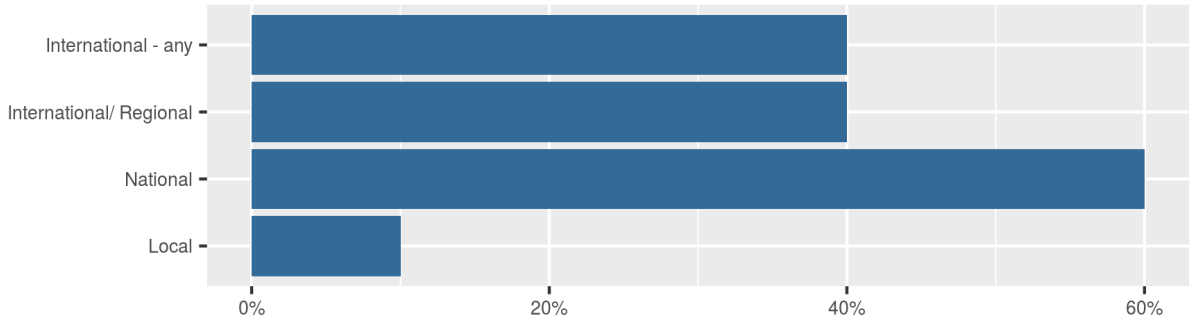

Figure 1: Responses to the multiple answer question about geographical focus of work as percentages.

Five respondents agreed to follow up interviews (analysis to be completed later).

3. Terminology around transnational climate change impacts

In the IMPRESSIONS project the term 'transnational climate change impacts' is used to mean 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. However, other terms are used to mean a similar thing, in different disciplines or sectors, which can cause confusion. Moreover, some terms can also have a double meaning. Therefore, a first question aimed to address what terms were thought to be confusing or meaningful to the Focal Points with regards to 'transnational climate change impacts' (Figure 2).

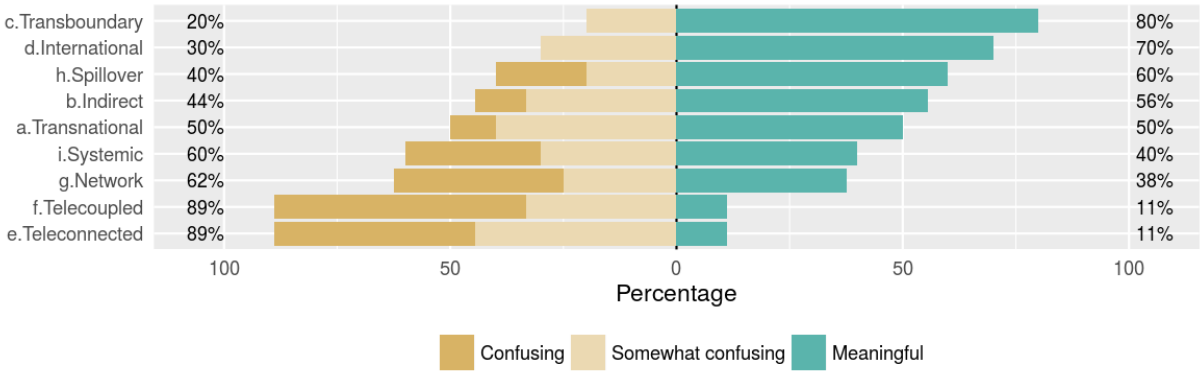

Figure 2: Responses to the question about whether different terms are meaningful or confusing.

Figure 2 shows the degree of meaningfulness and/or confusion of the nine terms proposed to refer to transnational climate impacts. Possible responses were ordered from 'Confusing' and 'Somewhat confusing' to 'Meaningful'. The left side of the graph shows the extent of confusion about of each term, whilst the right side shows what percentage of respondents thought the different terms were meaningful.

Along the y-axis, terms are ordered by which were most often thought to be meaningful.

Among the nine terms proposed, we can see from Figure 2, that respondents feel that the top terms that are **meaningful** are **'transboundary'** (80%), followed by '**international'** (70%), '**spillover'** (60%), and '**indirect'** (56%) when it comes to referring to 'transnational climate change impacts'. The most confusing terms considered by the ten respondents of this survey are **'teleconnected'**(89%), **'telecoupled'** (89%), **'network'** (62%), followed by **'systemic'** (60%). Interestingly, 'transnational' is considered both meaningful (50%) and confusing (50%).

3.1 Discussion of terminology

Participants were asked whether they consider definitions and terminology to be problematic. And, if so, in what ways. Some interesting comments resulted from this discussion. For example, the term 'transnational' is already used by transnational cooperation programmes under the ERDF funding scheme (Interreg/European Territorial Cooperation). On the other hand, one respondent argued that 'transboundary' seems to suggest impacts across directly adjoining borders, which is rather a specific case of the globally connected impact chains meant with 'transnational climate impacts'. Another respondent pointed out that the translation in other EU languages can lead to confusion in the interpretation of terms as the same thing might mean slightly different things or have another connotation in other languages (e.g. Swedish) so things may get lost in the translation. The term 'indirect' could suggest that the impact would not be big and not as important; hence there could be an issue in the order of priority when it comes to addressing these types of impacts based on the choice of term. Further clarification about the type of impacts these are concerned with would be more self-explanatory. For example, the use of 'economic effects/impacts' or 'food security impacts' would make these terms much more meaningful and less vague.

For some, the terms 'transnational' and 'transboundary' give the impression that relate to mainly physical climate change impacts that affect more than one country. Alternatively, a respondent argued that the Greek root 'tele' suggests some IT focus, despite that etymologically 'tele' means 'far off, afar, at or to a distance'.

As suggested by a few respondents, additional terms that could be regarded as useful could be 'interconnected' and 'cross-border impacts', which have not been considered in this survey.

Some respondents argue that a broader encompassing term (if any) that does not overlap with other terms (such as 'transnational' versus 'transboundary') should be used for all types of audiences (from academia, policy-makers, practitioners to the general public), although it is recognised that there should be sub-categories of impacts to describe and be able to distinguish different types or mechanisms that transfer impacts (e.g. physical, economic, political, etc.).

3.2 Definition of 'transnational climate impacts'

Participants were asked to write down their own definition of TCI and how they think it is interpreted at the national level. It was found that the interpretation was quite similar from one individual to another, although some nuances were identified between the different interpretations the respondents had. For example, some define it as *'effects that cross national borders'*, or *'climate change impacts in one place affect human systems (social, economic) in other parts of the world'*, *'impacts across borders; the same impacts in two or more countries or impact in one country and consequences of this impact in two or more countries'*, also described as *'cumulative impacts that are located across national borders'*, *'impacts that affect two or more countries simultaneously in the same areas of influence such as common river basins'*, and also defined as *'impacts of climate change that occur in a given geographical area, but cause effects at other locations in different countries via indirect or systemic impact chains'.* For a respondent that works at the EU level, it was necessary to distinguish two types of 'transnational climate impacts', one that refers to impacts of climate change outside Europe and that can have an effect on Europe, and one that has to do with impacts of climate change in one European country and that can have an effect on another European country.

It was also noted that effects that cross national borders does not necessarily give the overall picture of what is entailed/involved. For example, as expressed by one of the respondents, the first image that comes to mind with 'transnational impacts' is rather one of physical impacts that cross borders (i.e. flooding events, rivers, etc.), and not necessarily impacts such as migration, import of goods or food supply, which are also very important to consider and not immediately grasped with an encompassing term.

4. Awareness of transnational climate impacts, national initiatives and governance

This section covers the extent to which participants consider transnational climate impacts in their work at the national level, and the status of any initiatives or TCI assessments in the countries, with a specific focus on government level initiatives and leadership.

4.1 Awareness and consideration of transnational climate impacts

A total of 80% of the respondents say that they occasionally take into consideration transnational climate impacts in their work, whilst 20% recognised the issue and are beginning to include it in their work.

Participants were asked whether they were **aware of any future impacts on their countries** that would result from increased climate risk in other countries, and to name the 'source' country or countries and the nature of the transnational climate impact.

Most respondents are aware of some potential future impacts in their respective countries that could likely result from increased climate risks in other countries. However, the impacts are generally hard to predict as these type of impacts seem to be underexplored and under-investigated and there is no systemic analysis nor quantification/verification studies yet available on this. Most of the studies

provide rough estimates (e.g. trade statistics). Some of the 'transnational climate impact examples' mentioned by the respondents include:

- Transboundary pollution;
- The potential role of droughts and crop failure in war prone countries and transcontinental migration flows, e.g. from Syria, the Middle East, Africa, etc. to European countries;
- Increases in market prices of imported resources and (agricultural) produce due to climate change-induced crop failures;
- Flood risk in transboundary river basins e.g. between Germany (Bavaria) and Austria or extreme weather events induced disruptions in transboundary transport connections between neighbouring countries and Austria.
- Nuclear power plants in the surroundings of Austria with increased temperature, water scarcity, and increasing energy demands to cool the power plants might increase the risk for power plant failure;
- Heat waves in Eastern Europe/Russia impacting on crops;
- Floods in Thailand impacting on Information Technology (i.e. manufacture and supply of computer components such as hard drives).

These point to a few common issues that respondents thought were important. Two of the most prevalent concerns for impacts on EU countries due to increased climate risk in other countries were (1) supply of agricultural products due to climate change-induced crop failures, and (2) floods in transboundary river basins.

A further question enquired about the status of national level assessments of TCI (Figure 3).

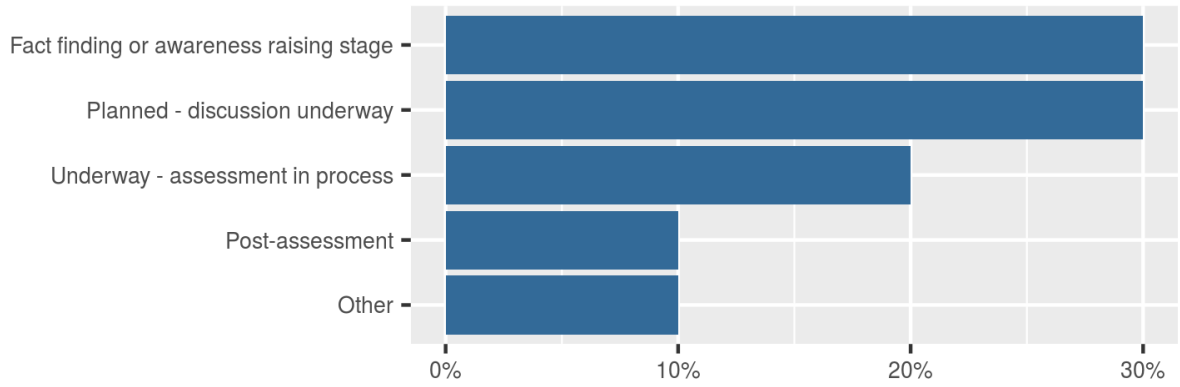

Figure 3: Current state of play - national level assessments of transnational climate impacts.

Participants were asked how they would best describe the current state of play regarding national level assessments of transnational climate impacts in their country. Nine responses were obtained (Figure 3). 30% of respondents stated that the assessments are fact finding or are on at awareness raising stage; so the issue has been acknowledged but there are no specific plans in place. Another 30% mentioned that assessments of this nature are planned and discussions are underway to

undertake such an assessment. A further 20% of respondents say that such assessments are underway in some countries. One respondent (10%) said that there is a post-assessment and adaptation responses are being considered in light of the findings of a national assessment and one other (10%) replied that Austria, for example, takes part in several Interreg projects and programmes where transnational issues are considered.

4.2 Leadership of national level assessments

The question about status of national level assessments was followed up with questions about the focus of leadership and important factors for conducting these assessments.

As shown in Figure 4, 50% of the respondents stated that these assessments are being led through a national process, or initiated and/or led by specific departments or functions of government. 40% of the respondents stated that these are led through a European process (e.g. a European funded project, implementation of an EU Directive, etc.), 20% stated that such assessments have been led by a regional process (e.g. Interreg project or other non-EU regional cooperation between countries), whilst 20% stated they are also led through a local process. One respondent (10%) stated that such an assessment has been led through the business sector which has been influential at the national level, and one other (10%) stated that these can be led from different levels, such as through a regional process (e.g. Interreg project or other non-EU regional cooperation between countries), through a national process - initiated and/or led by specific departments or functions of government; or through the business sector which has been influential at national level in Austria in particular. For example, the National Adaptation Strategy of Austria includes recommendations for action within the activity field "economy". These strategic adaptation options address transnational climate risks, but a systematic assessment of these impacts is to a large extent is still missing.

Therefore, from the responses obtained it seems that in certain cases these processes can be co-initiated at different levels; for example, from both the EU level and regional levels, from both the EU and the national level, etc. This intersection of different processes at different levels indicates the institutional complexity that is sometimes involved in national level assessments.

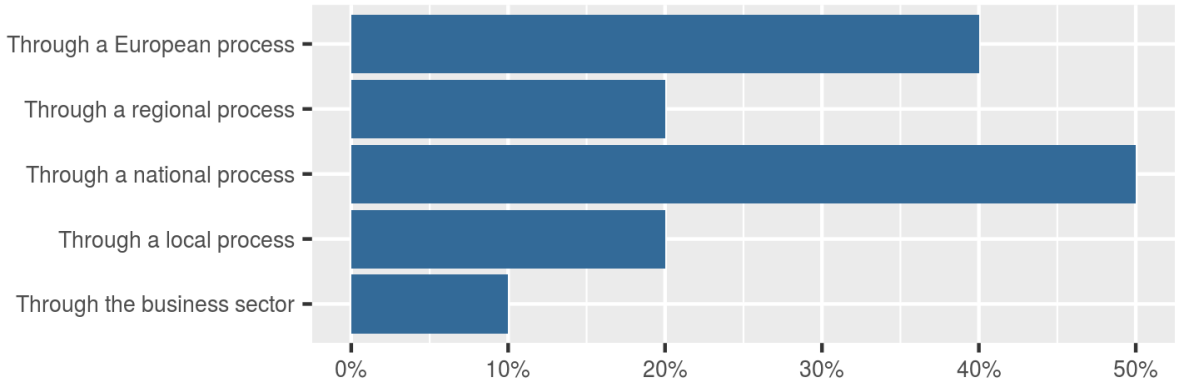

Figure 4: Responses to the multiple answer question about leadership of national level assessments.

The next question enquired about what factors respondents thought could encourage governments to consider transnational climate impacts (Figure 5). 90% of the respondents think that among the factors that are most likely to encourage governments to consider transnational climate impacts include the growing awareness about migration and possible links to climate change (e.g. resulting from ongoing debates around responses to the refugee crisis in Europe). 60% of the respondents consider that another factor that can likely encourage governments to consider transnational climate impacts could be the future events, such as a major trade shock or supply chain failure, or after witnessing the knock-on effects of a major extreme weather event outside Europe that affected European welfare. 60% thinks that another factor is the growing awareness about security threats and possible links to climate change (e.g. resulting from ongoing conflicts in the Middle East). 50% of respondents consider that the factor could be the perspectives of the business sector, which are often national or multinational and do consider such risks. 30% think it could be it could be encouraged through more explicit attention being given to these issues and solutions in adaptation guidance, requirements for adaptation finance and other institutionalised forms of adaptation. Finally, 30% state that the factor that could encourage governments is increased awareness about their significance, based on research and policy discussions.

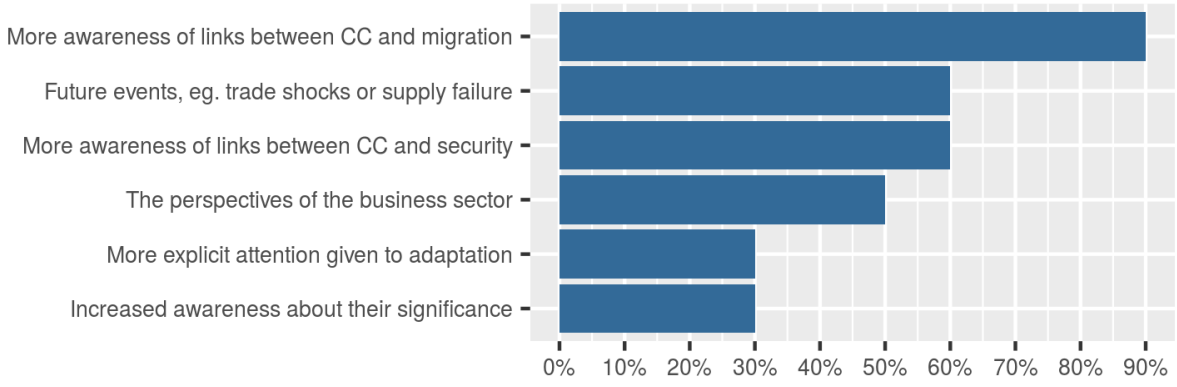

Figure 5: Responses to the multiple answer question about factors that might encourage governments to consider transnational climate impacts.

5. Roles and responsibilities for managing transnational climate impacts

National Focal Points who answered this part of the survey (n=9) think that management of transnational climate impacts, is primarily the responsibility of the European Union (100%) , followed by National Governments (88.9%), the UN Framework Convention on Climate Change (44.4%), private sector actors (44.4%), other non-governmental actors (22.2%), and finally, other (33.3%) (Figure 6).

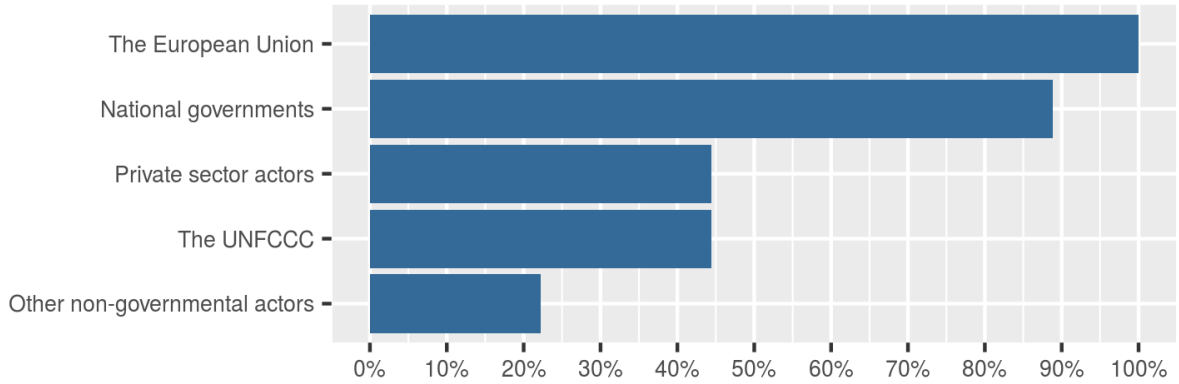

Figure 6: Responses to the multiple answer question on which actors should have primary responsibility for TCI.

The next question asked for more information specifically on what the role of European Commission (EC)[14] should be in managing transnational climate impacts. Respondents thought that the EC's responsibilities in managing transnational climate impacts should include:

- Support to adaptation initiatives in the source countries (e.g. funding, knowledge sharing, etc.).
- Support systematic risk assessments and joint response strategies in EU member states (e.g. through research funding, transnational cooperation programmes, etc.).
- Raising awareness, gather evidence and communication of facts, provide examples of work undertaken.
- Be responsible in foreign trade (out-EU) and in coordinating efforts to secure resource demands by Member States.
- Bringing relevant actors together: raise awareness, start a bottom-up approach/avoid a top-down approach, and a supranational entity will have to take the lead.
- EU should have a common response to transnational impacts across its borders.
- Further research is needed in order to identify areas where new policies or changes to existing policies might be needed.

6. Barriers to addressing transnational climate impacts

The main barriers, perceived by participants, to nations addressing transnational climate impacts are primarily information and institutional barriers, also uncertainty, and finally guidance on whether this type of impacts are considered 'adaptation' or not. Responses (n=9) are shown in Figure 7. In order of frequency, the perceived barriers are:

- **Institutional:** it is beyond the institutional remit of work/department focus (55.6%).

[14] Our understanding is that the Commission usually are responsible for assessment and research studies on impacts but the EU may in fact be more involved in supporting the management of these risks.

- **Information:** there is insufficient evidence describing the significance of in-country transnational climate impacts (55.6%).
- **Uncertainty:** it is too complex to assess the in-country level of risk (33.3%).
- **It is not 'adaptation':** the link to climate impacts is too vague; it does not constitute climate change adaptation (33.3%).
- **Information:** the information that is available is not useful/does not compare with the information we have on 'direct' climate impacts (33.3%).
- **Guidance:** it does not feature in the adaptation guidance that I follow (22.2%).
- **None:** nothing is stopping me (11.1%).

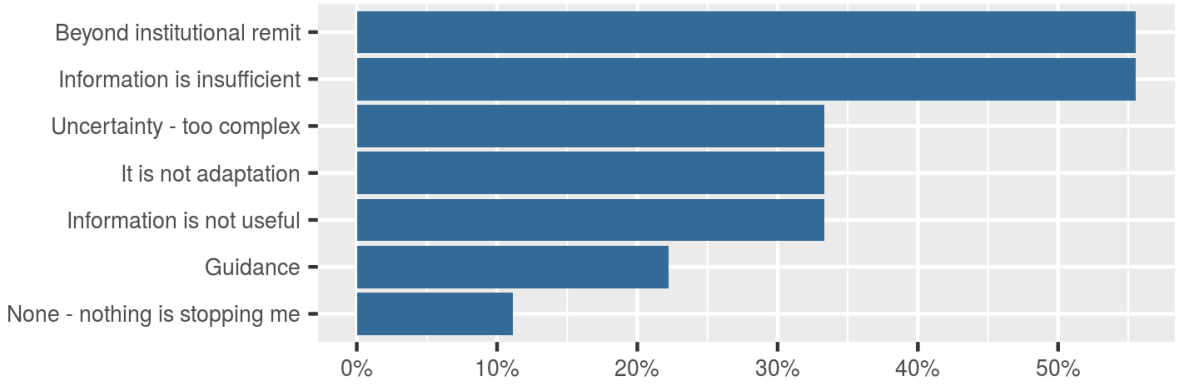

Figure 7: Responses to the multiple answer question about key barriers to transnational climate impacts.

7. Sources of information, promising methodologies and initiatives

The next set of questions focused on information gaps and needs - which was revealed as a key barrier in the previous question.

We asked respondents what were the **key information gaps** that need to be addressed. Examples given included: systemic cause-effect relationships, figures that show actual costs, comparisons of national vulnerability with vulnerability by transnational climate impacts, need for strategic collaboration for cases in which various types of impacts are difficult to seize, the type of transnational impacts that need new pro-active action, possible migration, water management, the process of indirect effects, including all relevant drivers at the various steps.

The **sources of information** that are most likely to be consulted when assessing transnational climate impacts include: an appropriate knowledge base linked to the country of focus or that is the most directly relevant to the country; information about other EU countries where clear parallels can be drawn; trade statistics and science based literature; national assessments (if available); discussion with key experts; reports on impacts; ClimateAdapt; Monitoring Mechanism Regulation (MMR); IPCC reports; academic and government reports; Working Group 6 on Adaptation under the Climate Change Committee; European Environment Agency (EEA) studies; project and program reports; and networks; etc.

We asked **which disciplines, fields or assessment methodologies seem to be more informative?** Answers from participants included: economic sciences, resilience research, descriptions of flow products, services and people, economics of trade, European and national statistics, and an assessment of costs of transboundary effects, interdisciplinary research, migration, water management, etc.

As shown in Figure 8, **initiatives that could help countries identify, assess and manage transnational climate impacts** include: European initiatives between Member States (90%), more research in general on the topic (70%), detailed studies of specific transnational risk (70%), international dialogue between countries (60%), awareness raising material for national level planners (60%), a mechanism for sharing information about key national climate risks that may create transnational climate impacts for others (50%), guidance on how to undertake such assessments (50%), pilot projects between countries (50%), comparisons of 'direct' versus transnational climate impacts (40%).

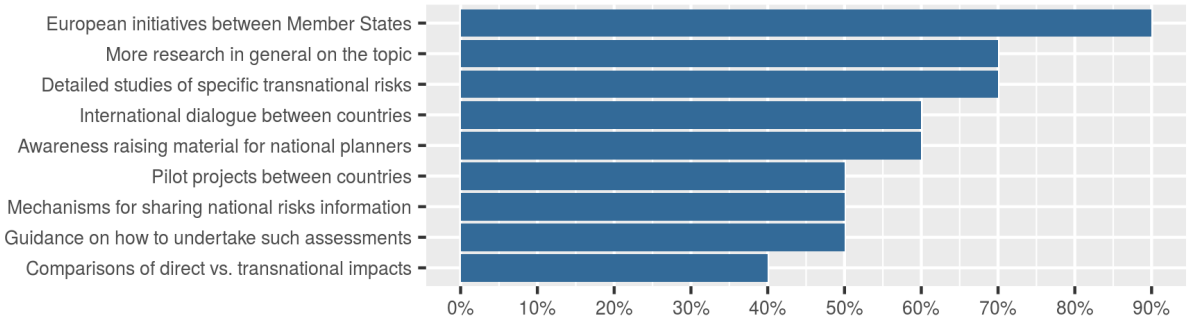

Figure 8: Responses to the multiple answer question about which initiatives are helpful.

Based on the survey responses, participants thought that the **leads in developing these initiatives** should be the European Commission together with national governments from Member States, and research funders.

8. Future socio-economic developments and transnational climate impacts

Based on the survey, the future socio-economic developments perceived as likely to increase the significance of transnational climate impacts are as follows (Figure 9): population growth (70%), increased inequality (60%), increased migration (50%), economic growth (40%), more globalisation/global integration (40%), increased conflict (40%), increased trade (30%), less regulation/bigger role played by multinational corporations (20%), decreased material consumption (10%), more localism (10%), more regionalisation (versus globalisation) (10%).

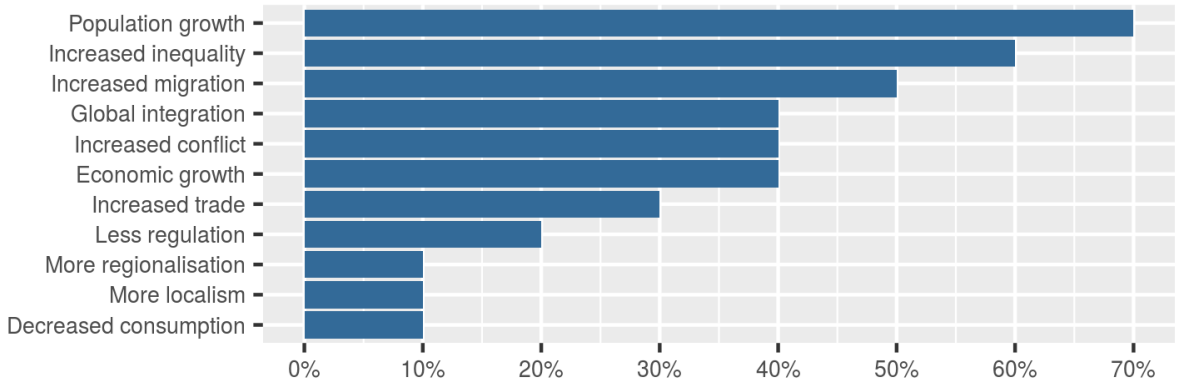

Figure 9: Which socio-economic developments are likely to increase the significance of transnational climate impacts?

9. Summary and Recommendations

In this section we emphasise **5 key points** out of the many issues that this survey has brought into focus in the context of transnational climate impacts.

- Most respondents are aware of some potential future impacts in their respective countries that could likely result from increased climate risks in other countries. However, the impacts are generally hard to predict, and are under-investigated; neither quantification or verification studies nor systemic analyses are yet available.
- Population growth, increased inequality and migration are seen as among the top future socio-economic developments that are likely to increase the significance of transnational climate impacts.
- The main barriers perceived are informational and institutional barriers, but also uncertainty, and guidance on whether responses to these types of impacts should be considered as 'adaptation'.
- The most meaningful terms were shown to be 'transboundary', 'international', 'spillover' and 'indirect'. Additional terms, which were not included in the survey, might be 'interconnected' and 'cross-border'. It was also suggested that a broader encompassing term might be preferable that could be used for all types of audiences.
- Participants thought there was some general awareness - plans or discussions are underway on national level assessments - which are commonly led through a national, an EU process or co-initiated at different levels. They also indicated that management of transnational climate impacts is primarily the responsibility of the EU followed by National governments.

With such a small sample size (n=10), these responses are not representative of the views of the community of UNFCCC National Focal Points and similar professionals in general. They do, however, give an insight into some of the thinking around these issues in many countries.

Recommendations for the SEI framework

One section of the survey collected views on the SEI conceptual framework for assessing indirect impacts of climate change.

One respondent noted that a useful distinction to take into account may be that of the EU level, where six distinctions when it comes to pathways are being made. For example, trade in agricultural commodities; trade in non-agricultural commodities; infrastructure and transport; geopolitical and security risks; human migration; and finance.

Additional insights from the responses suggest to include the export perspective for decision-makers (e.g. risk and chances), trade and network effects (e.g. substation options, dependencies, world markets, etc.), financial implications (e.g. insurance, direct investments), forest and biodiversity aspects.

A respondent also stated that this 'framework' does not seem to be a conceptual framework, rather it provides examples that illustrate some pathways for cross-border impacts, as a 'framework' it would need to account for the possibility of reduced as well as increased river flow. One participant mentioned that the comprehensive conceptual framework, being applied in the draft 2016 EEA CCIV report, should be considered.

Further research could involve consulting the draft section on 'Europe's vulnerability to climate change impacts outside Europe' from the 2016 EEA CCIV report. This, it was suggested by one respondent, would provide a comprehensive framework to build on. Additional EEA reports that were suggested to be consulted are the following: http://www.eea.europa.eu/publications/national-adaptation-policy-processes and http://www.eea.europa.eu/publications/national-adaptation-policy-processes/self-assessment-surveys-from-countries.

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This product has been developed to share initial findings that are pertinent to transnational climate impacts under high end climate change scenarios. The responses include opinions expressed by the respondents and therefore the author(s), and are not necessarily shared by the EC, the IMPRESSIONS team or other programme partners.