DISCUSSION BRIEF
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Adaptation Without Borders

The Implications of Transboundary Climate Risks for India

This brief examines an important, emerging subject for India that warrants urgent research and policy attention: transboundary climate risks.

Transboundary climate risks (TCRs) arise when the impacts of climate change in one country or jurisdiction generate a threat to the economy, society or ecosystems of another. They also manifest when mitigation or adaptation actions in one place generate adverse effects in another. They occur because of the interdependencies between countries. These are most obvious and apparent when countries share a biophysical system, such as a river basin; climate impacts or adaptation actions happening upstream can have cascading consequences downstream. But countries face risks through more abstract but no less important routes, for example if climate change or reactions to it disrupts food imports, trade in commodities, the supply of remittances, the value of foreign direct investments, or flows of migrants and refugees.

This discussion brief examines India's current and future exposure to transboundary and cascading climate risks. It aims to synthesize the state of knowledge, using the relatively new and limited but growing evidence base for what has been termed "next generation" climate risks. It draws on new data analysis conducted specifically for the brief, a rapid literature review, interviews with key stakeholders, and a science-policy dialogue that brought together policymakers, experts and practitioners from across the country to discuss the subject. Held in Delhi in 2023, the dialogue also explored the implications and opportunities for India from establishing a regional institutional mechanism to strengthen cooperation on adaptation across the span of the Hindu Kush Himalaya.

The brief concludes with four recommendations to help India examine the transboundary climate risks it faces and to make the country more resilient to these and other climate risks. The authors argue that there is an urgent need for research to examine the potential threats to India's economy, investments and people – and to better understand the socio-economic implications at all levels, from the micro scale (effects on the most vulnerable households) to the macro scale (threats to India's economic growth aspirations). The authors argue that stronger adaptation planning is essential to build the resilience of communities in India to present and future risks.

Risks to India from transboundary climate impacts

Climate risks are inherently transboundary in nature. The Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) highlights how climate risks are becoming increasingly complex – occurring simultaneously and interacting with climate and non-climatic risks – leading such risks to compound and cascade across sectors and regions (B.5, IPCC, 2023). The report goes on to explain their international dimensions:

> "Weather and climate extremes are causing economic and societal impacts across national boundaries through supply-chains, markets, and natural resource flows, with increasing transboundary risks projected across the water, energy and food sectors" (B.5.3, IPCC, 2023).

Transboundary climate risks are still an emerging research topic. Though explicit evidence of their propagation via specific pathways remains scant in the literature, enough evidence exists to suggest how and where potential risks could manifest. For a concrete example, see Box 1.

Methodology

To better understand the transboundary climate risks that India faces today and could face under future warming scenarios we analysed data and risk levels for

Box 1. The Bangkok floods of 2011 – a case of cascading impacts on interconnected global supply chains

Climate change and rising global temperatures are increasing the occurrence and severity of extreme weather events, especially in terms of precipitation. Across the global, nations are experiencing months of rainfall in a matter of hours or days, resulting in deadly flooding (WMO, 2023). In 2011, Thailand experienced historically devastating floods for 158 days. More than 800 people were killed, with an estimated 13.6 million people affected (Promchote et al., 2016). The floods damaged seven industrial manufacturing parks, disrupting complex and interconnected global supply chains, and resulting in losses in the automobile and electronic industries (Carter et al., 2021). For example, Japan's manufacturing production index fell by 2.4% for the fourth quarter of 2011 due in large part to the knock-on effects of these flood-related disruptions. Other effects reverberating throughout the global economy (UN-ESCAP, 2012). The Bangkok floods generated a transboundary climate impact on global industrial supply chains, with cascading effects on interconnected industries in Japan and across Asia.

four indicators for which data were available. The indicators and their relative risks – assessed using the 2018 Transnational Climate Impacts Index (Hedlund et al. 2018) – are as follows:[1]

1. **Human mobility:** the risks posed by climate change impacts in neighbouring countries and beyond that are likely to affect migration from changing migration and displacement flows to and from India.[2]

   Risk level: high. Transnational Climate Impacts Index score: 9 out of 10.

2. **Remittances:** the risks posed by climate change impacts in neighbouring countries and beyond that are likely to reduce remittance flows to India.[3]

   Risk level: relatively high. Transnational Climate Impacts Index score: 7 out of 10.

3. **Foreign direct investment (FDI):** the risks posed by climate change impacts in neighbouring countries and beyond that undermine the value of FDI (inflows and outflows) for India.[4]

   Risk level: high. Transnational Climate Impacts Index score: 8 out of 10.

4. **Trade:** the risks posed by climate change impacts in neighbouring countries and beyond that threaten India's imports of food and commodities, including major food crops, iron and steel, and non-ferrous metals.[5]

   Risk levels: very low to very high. Transnational Climate Impacts Index scores: 1 out of 10 for imported cereals (because of India's very low dependence on imports of cereals), but 10 out of 10 on embedded water risk (because of India's very high dependence on key commodities grown in highly water-stressed areas of the world).

The projected climate change impacts we study for the first three indicators (human mobility, remittances and FDI flows), as well for trade in non-ferrous metals, iron and steel, and sugar, are those that are likely to arise from *extreme climate events*: such as heatwaves, floods and droughts. For trade in the major food crops (wheat, soy, rice and maize), we assess the projected impacts of slow onset warming on the production of these crops. (See Annex 1 for a granular description of our methodology.)

Transboundary climate risks to human mobility

Migration as a climate adaptation response is becoming increasingly perceptible. It is projected that there could be more than 1 billion climate migrants in the world by 2050 (Ranjan et al., 2023). South Asia is already experiencing an increasing number of migrants due to climate change, disasters and environmental degradation (Ranjan et al., 2023). Akhtar and Shah (2023) argue that existing livelihood vulnerabilities will be further exacerbated by climate change in the coming years, leading to even more movement – including across borders.

India is the world's leading source of international migration; at the same time, it is also one the world's leading destinations for immigration (Singh, 2022). Climate change interacts with other drivers of human mobility – such as conflict – in complex ways, inflating migration flows through existing corridors. For example, major cyclones, such as Nargis in 2008 and Amphan in 2020, have devastated Myanmar, destroyed infrastructure and land and likely contributed to distress migration (Kaveri et al., 2023). As a result of this and other factors, more than 1 million Rohingya Muslims have left Myanmar and relocated to other South Asian countries, including India, in recent years (Kaveri et al., 2023). In Afghanistan, which is among the leading countries for migration to India, an estimated 371,000 people were forced to relocate in 2018 following years of continuous droughts (Akhtar and Shah, 2023).

Increasing numbers of people choosing or being forced to migrate could present a transboundary climate risk to hosting communities if poorly managed – placing additional strains on local resources and resulting in increased environmental degradation and disruptions to local development (Verme, 2023). If well managed, the same dynamics could present an opportunity, both for migrants and their destination countries. Table 1 shows data on India's major partner countries for migration, and those falling in the top 75th percentile of all partner countries likely to face increases in climate events (hot, wet, and/or dry).

Indian woman carrying wheat.
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Table 1. India's migration inflows and outflows

Major partner countries for migration inflows to India (number of people, 2012–2022):	Major partner countries for migration outflows from India (number of people, 2012–2022)
• Myanmar (76 321) • Afghanistan (27 820) • Yemen (1 462) • Somalia (1 439) • Nigeria (1 312)	• US (84 655) • Austria (23 869) • Canada (20 862) • UK (17 253) • Australia (14 589)
Above countries that are also in top 75th percentile of all partner countries projected to experience a change in extreme climate events (SSP3-7.0*, mean of 2081–2100, compared to baseline 1995–2014): • Yemen (hot events) *Note: India itself is in the top 75th percentile for dry events.*	Above countries that are also in top 75th percentile of all partner countries projected to experience a change in extreme climate events (SSP3-7.0*, mean of 2081–2100, compared to baseline 1995–2014): • Austria and the UK (wet events) • Australia (dry events)

* We chose a "high" emission scenario as defined by the IPCC (2021): the SSP3–7.0 scenario, representing 2.8 to 4.6 °C increase in global surface temperature. This scenario is selected as extreme climate events are sensitive to regional socio-economic and mitigation pathways. See annex 1 for further information.

Source: UN High Commissioner for Refugees (UNHCR)

India's migration outflows exceed its inflows. Among in-migration country partners, two (Myanmar and Afghanistan) are neighbouring countries and three are farther away, in Africa and Middle East (Yemen, Somalia and Nigeria). All out-migration country partners are located in Europe, North America and Oceania.

Risk: The data indicate that India could face a transboundary climate risk from rising numbers of in-migrants from future hot events in Yemen, and reduced numbers of emigrants leaving the country (as compared to the past) given future wet events in Europe (Austria and the UK) and dry events in Australia. Of course, Indian emigrants in these locations could also face direct climate risks from these extreme events.

Transboundary climate risks to remittance flows

Remittances are often seen as a potential opportunity for climate adaptation (Bendandi & Pauw, 2016). Receiving communities can use remittances to supplement their incomes and to adapt in ways that they would not be possible without these cross-border flows of capital. However, climate change can also impact migrant workers in their host economies. Extreme weather events such as cyclones, sandstorms, floods, heatwaves and droughts can prevent migrant workers from earning a living, and therefore reduce or eliminate the flow of remittances they are able to send back home.

In 2022, India received the highest share of remittances worldwide – and by quite some margin, valued at more than USD 111 billion – becoming the first country to reach and then surpass the USD 100 billion mark (McAuliffe & Triandafyllidou, 2022). A large proportion of Indians living in Arabian Gulf countries have gone there to seek employment in the oil industry. Remittances from the "oil boom" are a valuable source of income for India, particularly in high migrant-sending states such as Kerala (Calabrese, 2020). But the Arabian Gulf is also experiencing severe impacts of climate change with increased ambient temperature and significant decreases in precipitation. These changes are likely to have negative impacts on many sectors and societal systems, such as water and sanitation, food security, public health systems and renewable energy (Al-Maamary et al., 2017). As many Indian migrants in the region are working in manual labour jobs, they will be some of the first to feel the impacts of climate change, either directly – as part of carrying out their work (which is often in unprotected spaces outside) – or indirectly – as employment opportunities are disrupted (cancelled construction projects, for example). Dasgupta et al. (2021) note that, "warming directly affects labour supply (working hours) by changing the allocation of time to labour beyond certain thresholds, especially in working conditions that are highly exposed to the climate."

If these dynamics reduce or restrict remittance flows, they could generate a potentially significant transboundary climate threat to the Indian economy overall because remittances significantly support national GDP and households rely on this source of income. Table 2 shows data on India's major partner countries for remittances, and those falling in the top 75th percentile of all partner countries likely to face increases in climate events (hot, wet, and/or dry).

India's remittance inflows exceeded its outflows in the sample year (2021). Most remittance inflows are from

Cargo ship at Vishakhapatnam, Andhra Pradesh, India.
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Table 2. India's remittance inflows and outflows

Major partner countries for remittance inflows to India (million USD in year 2021):	Major partner countries for remittance outflows from India (million USD in year 2021):
• United Arab Emirates (19 821) • US (15 808) • Saudi Arabia (13 052) • Oman (6 413) • Kuwait (6 356)	• Bangladesh (5 747) • Nepal (1 583) • China (454) • Sri Lanka (436) • US (76)
Above countries that are also in top 75th percentile of all partner countries projected to experience a change in extreme climate events (SSP3-7.0*, mean of 2081–2100, compared to baseline 1995–2014):	Above countries that are also in top 75th percentile of all partner countries projected to experience a change in extreme climate events (SSP3-7.0*, mean of 2081–2100, compared to baseline 1995–2014):
• United Arab Emirates and Oman (hot events)	• Sri Lanka (dry events)

* We chose a "high" emission scenario as defined by the IPCC (2021): the SSP3–7.0 scenario, representing 2.8 to 4.6 °C increase in global surface temperature. This scenario is selected as extreme climate events are sensitive to regional socio-economic and mitigation pathways. See annex 1 for further information.

Source: Global Partnership on Migration and Development (KNOMAD)

the countries in the Middle East, while remittance outflows are more diverse – three countries are within the Hindu Kush Himalaya and South Asia regions and one is remote (in North America). In the case of extreme events in countries with which India has a high level of interdependence (such as the United Arab Emirates and Oman), India could see a decrease in remittance inflows that may constitute a transboundary climate risk to its economy. This may be further exacerbated by the economic costs of climate change domestically (as India experiences a rise in dry events, for example, that increase its dependence on remittances from abroad). India may also see an increased demand for remittances to Sri Lanka (in the case of dry events).

Transboundary climate risks to foreign direct investments

Transboundary climate risks to India can be transmitted via cross-border flows of finance in two principal ways. First, India's investments in assets and economies abroad may be jeopardized if they are negatively impacted by climate change. In addition, the impacts of climate change on other parts of the world may lead to decisions to divert or reduce the availability of foreign direct investments in India, with consequences for India's economic growth and development. Such decisions could negatively affect India in many ways, posing risks to its infrastructure, electronics-system manufacturing, information technology,

Table 3. India's FDI inflows and outflows

Major partner countries for FDI inflows to India (million USD, mean of 2008–2012):	Major partner countries for FDI outflows from India (million USD, mean of 2008–2012):
• US (3 727) • Japan (3 349) • UK (3 336) • Singapore (2 406) • Germany (2 291)	• Mauritius (1 888) • Singapore (1 635) • The Netherlands (754) • US (724) • United Arab Emirates (424)
Above countries that are also in top 75th percentile of all partner countries projected to experience a change in extreme climate events (SSP3-7.0*, mean of 2081–2100, compared to baseline 1995–2014):	Above countries that are also in top 75th percentile of all partner countries projected to experience a change in extreme climate events (SSP3-7.0*, mean of 2081–2100, compared to baseline 1995–2014):
• UK and Germany (wet events)	• Mauritius (hot and dry events) • United Arab Emirates (hot events) • The Netherlands (wet events)

* We chose a "high" emission scenario as defined by the IPCC (2021): the SSP3–7.0 scenario, representing 2.8 to 4.6 °C increase in global surface temperature. This scenario is selected as extreme climate events are sensitive to regional socio-economic and mitigation pathways. See annex 1 for further information.

Source: UN Trade and Development (UNCTAD)

automotive industry, pharmaceutical sector, service industry, railways and airlines, textiles and aerospace industry, and other sectors supported by FDI.

Evidence of climate change impacts on FDI is limited; however, some studies do show a correlation. Drabo (2021) – drawing on a sample of low- and middle-income countries from 1995 to 2018 – suggests that FDI, overseas development assistance (ODA), and remittances are susceptible to climate shocks, particularly in developing countries. Barua et al. (2020) also find that increases in temperature correlate with decreases in FDI. These studies indicate potential risks to India's inflows and outflows of FDI that warrant further investigation – particularly considering India's dependence on such investments for its economic growth aspirations. Table 3 shows data on India's major partner countries for FDI, and those falling in the top 75th percentile of all partner countries likely to face increases in climate events (hot, wet, and/or dry).

Total FDI inflows exceeded outflows during the sample period. Foreign direct investments to and from India are reciprocated between two partners: the US and Singapore, even though FDI inflows from the US quite substantially exceed India's outflows to the country. Of India's partners for FDI inflows, the UK and Germany face projected increases in wet events. India should consider the consequences of this on the stability of investments both in and from these countries. India's return on investments *may* also be at risk in Mauritius from concurrent or sequential hot and dry events, in the United Arab Emirates from hot events, and in the Netherlands from wet events.

Transboundary climate risks to trade

The Bangkok case study (Box 1 above) illustrates how global supply chains have become increasingly interconnected and complex, transmitting climate risk between importing and exporting countries. In a landmark study, Adams et al. (2021) find that transboundary climate risks to global food security are "critical and mounting", revealing how these risks are distributed via international trade in six key commodities that link producers and consumers thousands of kilometres apart. The report finds that traditional approaches to managing trade risk, such as substitution and diversification, are unlikely to be effective given accelerating climate change impacts on every continent. It articulates the high potential for increasingly tense geopolitical dynamics, as countries strive to maintain their current market shares in an increasingly uncertain world. It also illustrates the material risk posed to food security by climate change in countries at all levels of development, making adaptation to transboundary climate risk a matter of public policy the world over.

For example, consider the transboundary climate risks that may arise from India's potential dependence on imports of wheat from other countries. In recent years,

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India's wheat production has suffered because of rising temperatures, which reduced domestic supply (Dhar, 2024). Thus, India is expected to begin importing this staple crop (Bhardwaj and Jadhav, 2024). However, one of India's main trading partners for wheat is Australia, where wheat production has also been negatively impacted by climate change. Rising temperatures are causing an accelerated maturation of wheat crops in Australia, adversely impacting its yields (Williams, 2024), which have declined by an estimated 27% since 1990 (Hughes, et al. 2021).

India also depends on food imports from climate-vulnerable countries such as Indonesia, Malaysia, Brazil and parts of Africa. As these suppliers face the impacts of climate change, the availability of essential raw materials such as palm oil and sugar is likely to diminish or become more volatile, threatening India's food supply chains and potentially leading to limitations on volumes of imports and/or rising prices (Sun et al., 2023). Research suggests that by 2060, palm oil supplies from Malaysia and Indonesia may decline by 5.3% and 4.9%, respectively, exacerbating food price volatility and economic challenges for countries that rely on these imports, as is the case for India (Sun et al., 2024). Sun et al. (2024) argue that these kind of spillover effects have "important consequences in terms of global food security, energy supply, and the supply of various mineral products".

The impacts of climate change can disrupt not only manufacturing hubs (as Box 1 illustrated) but also mining operations that are the source of many supply chains. The UN Environment Programme reports that intensified storms and floods are the top drivers of financial impacts on global mining (UNEP, 2024). Transboundary climate risks increase as the impacts threaten specific, global supply chain nodes or "choke points", such as ports and other shared infrastructure. India's international trade plays a critical role in its economic growth, foreign exchange earnings, and population's employment. Its industrial sector, encompassing manufacturing, construction and mining, constitutes 27.6% of GDP. *Understanding how this sector is exposed and vulnerable to transboundary climate risks should be a top government priority.*

Tables 4 and 5 show data on India's major partner countries for trade (imports and exports). It also lists countries in the top 75th percentile of all partner countries likely

Table 4. India's imports and exports of non-ferrous metals, iron and steel, and sugar

Commodity	Major partner countries for imports (million USD, 2017)	Major partner countries for exports (million USD, 2017)	Countries also in top 75th percentile of all partner countries projected to experience a change in extreme climate events (SSP3-7.0*, mean of 2081–2100, compared to baseline 1995–2014):
Non-ferrous metals (India net importer)	• Switzerland (21 684) • United Arab Emirates (5 865) • US (3 396) • Ghana (2966)	• United Arab Emirates (4 772) • China (3506) • Korea (1158) • Malaysia (843)	• Switzerland (wet events) (import) • Malaysia (dry events) (export) • United Arab Emirates (hot events) (import and export)
Iron and Steel (India net exporter)	• China (2 638) • Korea (2 289) • Japan (1 338) • US (494)	• US (1 198) • Italy (1 179) • Nepal (1 088) • United Arab Emirates (1 037)	• United Arab Emirates (hot events) (export)
Sugar (India net importer)	• Brazil (2 216) • Pakistan (17) • United Arab Emirates (13) • US (4)	• Sudan (243) • United Arab Emirates (102) • Kenya (70) • Ethiopia (59)	• Kenya (wet events) (export) • Sudan, Kenya and United Arab Emirates (hot events) (export)

* We chose the "high" emission scenario as defined by the IPCC (2021): the SSP3–7.0 scenario, representing 2.8 to 4.6 °C increase in global surface temperature. This scenario is selected as extreme climate events are sensitive to regional socio-economic and mitigation pathways. See annex 1 for further information.

Table 5. India's imports and exports of major food crops

Commodity	Major partner countries for imports (million USD, 2017)	Major partner countries for exports (million USD, 2017)	Countries also in top 75th percentile of all partner countries projected to experience slow onset warming leading to a reduction in crop production (RCP8.5*, mean of 2070–2099, compared to baseline 1983–2013):
Wheat (India net importer)	• Australia (623) • Ukraine (425) • Russia (105) • Bulgaria (46)	• Nepal (57) • Afghanistan (8) • United Arab Emirates (3) • UK (1)	• Nepal and Afghanistan (export) • Australia (import)
Soy (India net exporter)	• Sudan (25) • China (22) • Benin (19) • Ethiopia (19)	• Indonesia (264) • US (166) • Russia (69) • Malaysia (64)	• Russia (export)
Rice (India net exporter)	• India is virtually self-reliant for its rice demand.	• Nepal (43) • Philippines (27) • Bangladesh (4) • Vietnam (3)	• Nepal (export)
Maize (India net exporter)	• Argentina (38) • Ukraine (14) • US (7) • Uruguay (6)	• Nepal (133) • Sri Lanka (22) • Bangladesh (15) • Pakistan (11)	• Nepal (export)

* For studying impacts of slow onset warming on crop yields, we chose the "very high" emission scenario RCP 8.5 and long-term projections (the mean of the period 2070–2099), representing 2.6 to 4.8 °C increase in global surface temperature (IPCC, 2013). The scenario RCP 8.5 is selected for studying slow onset impacts due to its focus on long-term warming, which has been proven to have severe effects on crop production (Zhao et al., 2017). See annex 1 for further information.

Source: Global Trade Analysis Project (GTAP)

to face a) increases in climate events (hot, wet, and/or dry) for non-ferrous metals, iron and steel, and sugar; and b) reductions in yields for wheat, soy, rice and maize due to slow onset warming.

Tables 4 and 5 show that India could face challenges to its supply of wheat from negative impacts on yields from increasing slow onset warming in Australia. In turn, demand for India's rice, wheat and maize exports could increase if Nepal faces negative impacts on its domestic production of those crops. The role that climate change may play in the stability of India's exports (from the impacts of extreme events on exports of non-ferrous metals, iron and steel; and from the impacts of slow onset changes on staple crops) is less clear. Demand could diminish if importers are forced to divert resources to cope with escalating impacts, but demand could rise if domestic production in importer countries is curtailed. Whether these dynamics represent risks to and/or opportunities for India's trade, commerce and industry merits further research. However, India's imports of non-ferrous metals from Switzerland and the United Arab Emirates may be less stable in the future from an increase in wet events and hot events respectively.

The policy landscape on adaptation to transboundary climate risks in India

India has a comprehensive landscape of policies, plans and funds that could support the stronger governance and management of transboundary climate risks in the future.

National Action Plan on Climate Change (NAPCC): Launched by the Prime Minister of India in 2008, the plan outlines India's strategy for adapting to climate change and enhancing the ecological sustainability of its development path (NAPCC 2008). It encompasses eight strategic missions, four of which are relevant to managing transboundary climate risks. These are 1) the National Water Mission (NWM) (particularly regarding risks that are generated through biophysical systems), 2) the National Mission for Sustainable Agriculture (NMSA), 3) the National Mission on Strategic Knowledge for Climate Change (NMSKCC), and 4) the National Mission for Sustaining the Himalayan Ecosystem (NMSHE).

A key principle that guides the overarching national plan is an emphasis on international cooperation for research and development, and the sharing and transfer of technologies. Two missions also focus on strengthening cooperation and collaboration – through strategic alliances on science and technology (NMSKCC) (DSTa 2010), and through research and development projects (NMSHE) (DSTb 2010). In line with the national plan, all the states in India have prepared state-level action plans. India's National Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) flags a number of actions that pertain

"India has a comprehensive landscape of policies, plans and funds that could support the stronger governance and management of transboundary climate risks in the future."

to the management of transboundary climate risks under three of these missions (NWM, NMSA and NMSHE), including through the establishment of a national adaptation fund.[6]

National Disaster Management Plan (2019): India is active in global efforts on disaster risk management that could support the reduction of transboundary climate risks. The UN Disaster Management Team in India comprises UN agencies such as the Food and Agriculture Organization, International Labour Organization, World Food Programme and Office of the High Commissioner for Refugees. India is a participating country in the Global Facility for Disaster Reduction and Recovery (GFDRR) and a founding member of the Asian Disaster Reduction Center. It also has cooperation agreements with several countries on disaster risk management that facilitate the exchange of ideas and expertise (NDMA, 2019). India's national plan builds coherence across the three international agreements – on the Sustainable Development Goals, Sendai Framework for Disaster Risk Reduction and the Paris Agreement – and the Prime Minister's Ten Point Agenda for Disaster Risk Reduction. The tenth point of the Ten Point Agenda refers to bringing about greater cohesion in international responses to disasters.[7]

River water agreements:[8]

- India-Nepal: The Mahakali Treaty has the Pancheshwar Multipurpose Project as its centrepiece, aimed at energy production and augmentation of irrigation in India and Nepal, especially during dry seasons. It also aims to provide flood moderation/control benefits to both India and Nepal.[9]
- India-China: A Memorandum of Understanding (MoU) supports flood control and disaster mitigation in downstream areas of India related to the Brahmaputra and Indus rivers, through the sharing of hydrological flow data during monsoon season.[10]
- India-Bhutan: The Comprehensive Scheme for Establishment of Hydro-meteorological and Flood Forecasting Network on rivers Common to India and Bhutan is in operation. It consists of 32 hydro-meteorological stations located in Bhutan, maintained by the Royal Government of Bhutan with funding from India. The data received from these stations are utilized in India for formulating flood forecasts.[11]

> "In India there is a need to raise awareness of transboundary climate risks with multiple government ministries, agencies and departments."

Regional cooperation:

- The South Asian Association for Regional Cooperation (SAARC) Action Plan on Climate Change: The plan calls for regional cooperation through knowledge transfer on adaptation to climate change and extreme events such as floods, glacial lake outbursts, heat waves and drought (SAARC 2008).
- Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC): The initiative (spanning India, Bhutan, Bangladesh, Myanmar, Thailand, Nepal and Sri Lanka) established a Centre for Weather and Climate to share changing weather and climate information across the BIMSTEC countries[12].

Relevant sectoral policies:

- India's international trade policies and regulations: The Foreign Trade Policy (FTP 2023) of the Directorate General of Foreign Trade under the Ministry of Trade and Commerce aims to promote economic growth, boost exports and create a favourable business environment. It also aims to facilitate cross-border trade and (more specifically) promote the export of perishable agricultural commodities.[13] In addition, the Government of India's Agriculture Export Policy (2018) aimed to double exports in five years.
- India's governance of foreign direct investments and remittances: The Foreign Exchange Management Act, 1999 (FEMA) and Consolidated Foreign Direct Investment Policy, 2020 (issued by the Department of Promotion of Industry and Internal Trade (DPIIT)) govern matters related to FDI and remittances. They are both amended periodically.

India-UN Development Partnership Fund: This fund aims to support climate- and disaster-vulnerable states and communities internationally. Therefore, it could help manage transboundary climate risks to India at their source and assist other countries in managing the direct and transboundary climate risks they face. Through this fund, India has supported seven Pacific Island countries to create early warning systems and has helped countries in Africa and the Caribbean on resilience-building and adaptation more broadly (MOEFCC 2021).

India hosted the third Voice of Global South Summit,[14] which addressed several agendas with relevance to transboundary climate risks. India's participation in collaborative initiatives (such as the International Solar Alliance and the Coalition of Disaster Resilient Infrastructure) have laid the foundations for the kinds of regional and international cooperation required to manage transboundary climate risks. However, while these policies, plans and funds are all relevant to the management of transboundary climate risks, they do so indirectly rather than through decisive, targeted measures.

In India there is a need to raise awareness of transboundary climate risks with multiple government ministries, agencies and departments; to mainstream and integrate response measures as policies and plans are updated; and to undertake a swift assessment of which transboundary climate risks require urgent adaptation, given their potential to undermine India's economic health and aspirations and the physical and social wellbeing of its citizens.

Recommendations

In October 2023, a science-policy dialogue in Delhi brought together policymakers, experts and practitioners from across India to discuss the country's exposure to transboundary and cascading climate risks. The dialogue also explored the implications and opportunities for India if it were to establish a regional institutional mechanism – spanning the Hindu Kush Himalaya – to strengthen cooperation on adaptation to manage them.

The following four recommendations are based on the content of the dialogue and inputs from stakeholder interviews. The recommendations also draw on actions in bilateral river water agreements, the Prime Minister's Ten Point Agenda for Disaster Risk Reduction, existing fora for regional cooperation (such as SAARC and BIMSTEC), and three international agreements (the Sustainable Development Goals, Sendai Framework for Disaster Risk Reduction and Paris Agreement).

Initiate and advance research and information sharing on transboundary risks

To enhance cooperative disaster risk management and adaptation planning in India and across the wider region, it is crucial to advance national and regional assessments of transboundary climate risks and to convene related knowledge-exchange events. These could be initiated by, and advanced through, existing regional university networks and initiatives, such as the India Universities and Institutions Network for Disaster Risk Reduction (IUIN-DRR). Establishing an international chapter of such networks, with a mandate to foster regional scientific collaboration and build the evidence base on transboundary climate risks, is a strong concrete proposal. Such initiatives should prioritize actionable research for decision-makers, alongside knowledge-sharing practices between sectors and disciplines.

Boost both governance capacity and policy support within India and with other key countries

Convening dialogues with policymakers on transboundary climate risks is essential – nationally, bilaterally (between jurisdictions that share and spread risks) and regionally (among the countries of the Hindu Kush Himalaya). At the national scale, encouraging exchanges between ministries, departments and agencies is critical to generate effective and coherent policy responses to transboundary climate risks. For example, equipping the Ministry of Commerce and Industries to integrate disaster risk reduction and adaptation into supply-chain and investment mapping is particularly important. A comprehensive mapping of opportunities for addressing transboundary climate risks across India's existing and anticipated bilateral and multilateral agreements should be undertaken as a next step, strengthening the governance of transboundary climate risks through identified mechanisms and policies. Identifying gaps and articulating key priorities for the better management of transboundary climate risks will be imperative. Sharing best practices across the region could help both the formulation and implementation of more effective policy frameworks.

Promote and leverage climate negotiations and coalition building

Science-based diplomacy on transboundary climate risks will be a necessary component of multilateral climate negotiations in the years ahead. India could benefit by taking steps to develop stronger regional cooperation and alliance in the UNFCCC negotiations – both by supporting and promoting regional interests related to transboundary climate risks and by helping develop common and consistent messaging on these issues. Leveraging such global developments and agreements could, in turn, bolster regional adaptation initiatives. Strengthening multilateral collaboration – through a partnership between the National Institute of Disaster Management (NIDM), Adaptation Without Borders, the SAARC Centre for Disaster Management, and ICIMOD – is one concrete proposal. But there is also a need to undertake more inclusive coalition-building on transboundary climate risks. Multi-stakeholder dialogues will be important to engage constituencies all levels (from grassroots community and local governance institutions to global players) and to communicate about key risks among all actors.

Strengthen capacities and increase finance to build resilience

Building resilience to transboundary climate risks will require new capacities and finance. Training programs, such as those run by the NIDM under the Indian Technical and Economic Cooperation programme (ITEC), should be utilised to equip and enable a range of institutions to better understand transboundary climate risks and generate resilience-building solutions. As recognized in the Prime Minister's Ten Point Agenda on Disaster Risk Reduction, India should also play a role in extending this support to other countries – not only in capacity building (facilitating resource sharing via the India Disaster Resource Network, for instance) but also in risk preparation and response (through joint or regional mock drills, for example). Climate finance providers must also be engaged in implementing responses to transboundary climate risks. Enhancing adaptation finance across the board – raising awareness of financing mechanisms and improving access – will be important in programming adaptation to both direct and transboundary climate risks. This will require a mix of multilateral, bilateral and private climate finance alongside ODA. Addressing gaps through innovative partnerships, involving the private sector, could support the scaling of finance from national to regional scales to more effectively manage transboundary and cascading climate risks.

Annex 1: Methodology

Climate change variables for human mobility, remittances and FDI flows, as well as trade in non-ferrous metals, iron and steel, and sugar, are represented by projected changes in exposure to three types of climate extreme indices:[15] so-called hot events (Tx90p), wet events (R95p) and dry events (CDD). Ensembles of global climate model (GCM) simulations from Phase 6 of the Coupled Model Intercomparison Project (CMIP6) were used to compute changes in the exposure of countries to climate extremes from 2081 to 2100 as compared to the baseline from 1995 to 2014. The ensembles used were of fourteen (Tx90p) to fifteen (R95p, CDD) GCMs for one realization (r1i1p1f1), aggregated yearly. The projected changes were computed as the fractional change in values of the indices for the 2081–2100 period compared to the 1995–2014 period. We chose a "high" emission scenario, defined by the IPCC (2021) as the SSP3–7.0 scenario, representing a 2.8 to 4.6°C increase in global surface temperature. This scenario was selected as extreme events are sensitive to regional socio-economic and mitigation pathways. A country was considered highly exposed to an extreme event if the projected change fell in the top 75th percentile of all partner countries.

For trade in staple cereal crops (wheat, soy, rice and maize), climate data are represented by the projected impacts of slow onset warming on the production of these crops. Data on the impacts were sourced from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) (Jägermeyr et al., 2021). The project provided integrated analyses of GCM and impact models and, specifically, global gridded crop models. The ensemble data from Phase 3 of the Global Gridded Crop Model Intercomparison within ISIMIP were used. These data

include simulations from five climate models and twelve crop models, encompassing all the select crop types. Averages of relative changes projected by each climate-crop model combination were computed and compared to a reference period from 1983 to 2013. Emission scenario RCP 8.5 and long-term projections (the mean of the 2070–2099 period) were applied, representing a 2.6 to 4.8 °C increase in global surface temperature (IPCC, 2013). The scenario RCP 8.5 was selected for studying slow onset impacts due to its focus on long-term warming, which has been proven to have severe effects on crop production (Zhao et al., 2017).

Endnotes

1. The biophysical pathway of transboundary climate risk (through shared water resources, for example) is of critical importance to India, too, but this subject has been better researched and, as a result, is better understood. For an example of transboundary impacts through the biophysical pathway see the Kosi Flood (PDF) Institutional dysfunction and challenges in flood control: A case study of the Kosi flood 2008.
2. Data source: UNHCR refugee flows, 2022 (https://www.unhcr.org/refugee-statistics/insights/explainers/forcibly-displaced-flow-data.html). These data need to be treated as indicative and not exhaustive as the actual extent of migration flows could vary.
3. Data source: KNOMAD remittance flows, 2021 (https://www.knomad.org/data/remittances).
4. Data source: UNCTAD, mean over 2008–2012 (More recent data are not available because this database has been discontinued).
5. Data source: GTAP 11b, 2017 (https://www.gtap.agecon.purdue.edu/)
6. India's INDC: Towards Climate Justice, MOEFCC, Government of India (https://moef.gov.in/uploads/2018/04/revised-PPT-Press-Conference-INDC-v5.pdf)
7. https://ndma.gov.in/Reference_Material/PM_Ten_Agenda
8. We include here only countries lying upstream of India – Nepal, China and Bhutan – because such agreements affect water resource availability and flooding conditions in India. India has a moderate score (6/10) for its water dependency ratio (the proportion of water resources in a country that originates in transboundary upstream countries) on the Transnational Climate Impacts Index.
9. India-Nepal Cooperation, Department of Water Resources, River Development and Ganga Rejuvenation (https://jalshakti-dowr.gov.in/india-nepal-cooperation/)
10. India-China Cooperation, Department of Water Resources, River Development and Ganga Rejuvenation (https://jalshakti-dowr.gov.in/india-china-cooperation/)
11. India-Bhutan Cooperation, Department of Water Resources, River Development and Ganga Rejuvenation (https://jalshakti-dowr.gov.in/india-bhutan-cooperation/)
12. https://bimstec.org/bimstec-centre-for-weather-and-climate
13. https://www.dgft.gov.in/CP/?opt=ft-policy
14. https://www.mea.gov.in/bilateral-documents.htm?dtl/38186/Chairs+Summary+3rd+Voice+of+Global+South+-Summit+August+17+2024
15. As defined by the Expert Team on Climate Change Detection and Indices (ETCCDI) (https://www.wcrp-climate.org/etccdi).

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