HSBC Global Research

Climate Change
Global

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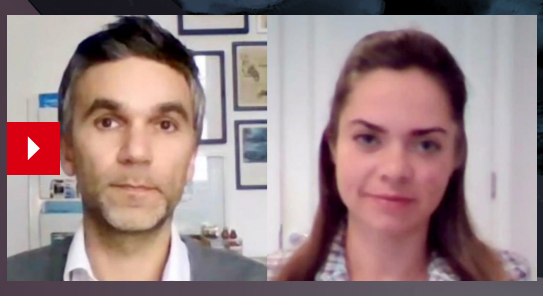
Fragile Planet 2021

Scoring climate risks: who is the most resilient?

The pandemic has shown the world's fragility… but also its capacity to fight back

Similar urgency is needed to tackle climate change, which poses an even bigger long-term risk to the planet

We rank 77 countries on their ability to shift from fossil fuels, adapt to climate change and profit from cleantech, adding 12 indicators to this year's analysis



Play interview with Ashim Paun and Lucy Acton

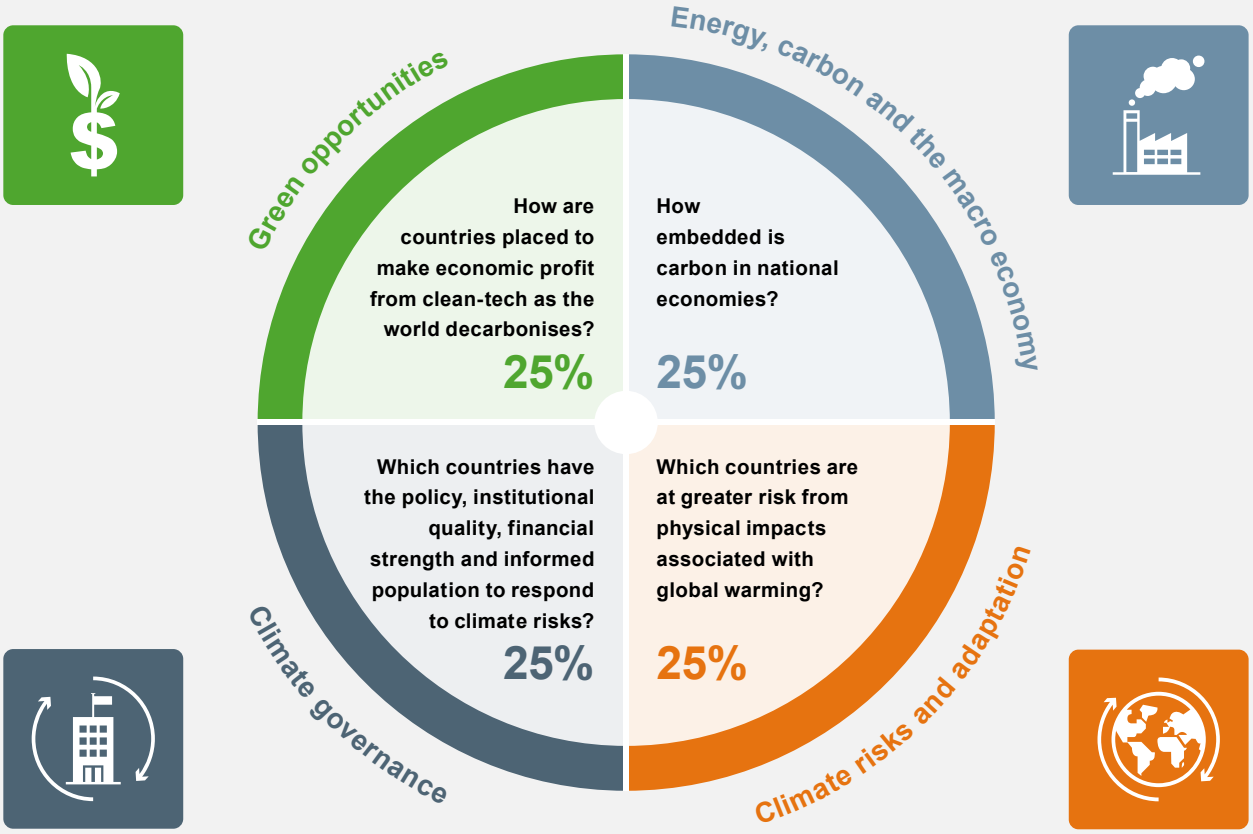
Figure 1.

Scoring climate risks

Which countries are most resilient in the face of rising climate risks – our methodology

Green opportunities	Weight
Climate revenues	7%
Industrial potential to produce cleantech	7%
Key minerals	7%
Corporate climate policies	2%
Technological innovation	2%

Energy, carbon and the macro economy	Weight
Economic carbon intensity	12.5%
Economic diversification and fossil fuel dependence	12.5%



Climate governance	Weight
Climate finance	5%
Institutional quality	5%
Enabled population	5%
Decarbonisation policy	5%
Health risk preparedness	5%

Climate risks and adaptation	Weight
Temperature	3.57%
Water scarcity	3.57%
Air pollution	3.57%
Food systems	3.57%
Ecosystem services	3.57%
Sea level risks	3.57%
Extreme weather events	3.57%

Source: HSBC

Contents

Figure 2.

From resilience to vulnerability

Greater resilience

Sweden

- Low emissions per GDP (2nd best)
- Overall second on Climate Risks and Adaption quartile
- Highest level of corporate climate policies, given size of the economy

France

- Lowest dependence on fossils for energy; corresponding highest use of alternative energy
- High raking on the Gender Parity Index
- Second best for Green Opportunities

Finland

- Top ranked for Climate Risks and Adaptation
- Very low exposure (currently) to extreme weather events
- Second to Norway on overall Climate Governance

Germany

- Strong ranking for Climate Governance quartile (4th), with strong policy framework
- Health risk preparedness – third highest number of hospital beds per capita
- Innovative industrial base – with high patent issuance in transition-relevant sectors

USA

- Emissions have dropped relatively quickly, on a per capita basis
- US companies earn most climate revenues, and these continue to rise fast, with high patent registration
- Suffered most extreme weather events in the past decade, with fast-growing number of people affected

More vulnerable

Nigeria

- Second most vulnerable in two quartiles: Climate Risks and Adaption, and Climate Governance
- Lowest exposure to Green Opportunities
- Only 38% of forested area remaining since 1990 levels

Bangladesh

- Very low resilience via Green Opportunities and Climate Governance
- Highest number of deaths per capita associated with extreme weather events between 2011-2020
- One of the lowest ranked countries for corruption and regulatory quality

Côte d'Ivoire

- Second worst on deaths attributable to air pollution
- Third lowest share of the population enrolled in tertiary education
- Lowest emissions per capita of the sample set

Tanzania

- Highest emissions per unit of GDP despite coming eighth on emissions per capita
- Vulnerable on health risk preparedness, including lowest ranked 0.5 surgical specialists per 100,000 population
- Minimal potential to exploit green opportunities at present

Tunisia

- Transition risk: Bottom decile for high fossil fuel pre-tax subsidies, third largest increase between 2013-2017
- No recorded public companies earning money from climate revenues currently
- Low rankings on governance metrics: regulatory quality, financial indicators, media independence, government effectiveness

Source: HSBC

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Executive Summary

Fragile Planet 2021

The COVID-19 global pandemic has, in our view, demonstrated humankind's *fragility*. But it has also shown our potential for *resilience*, as system supports have been rapidly deployed to protect life and society. Yet we face an even bigger, systemic risk in climate change. Now we need a similar level of urgency and determination to protect populations from the dangers of global warming. In this report, using an enhanced set of indicators this time, we again analyse which countries are more resilient, and which more vulnerable, to a broad set of climate risks.

With annual emissions still rising[1], so is the temperature, up around 1.2°C since the mid-19th century. As global warming increases, so do the associated impacts. These include Arctic ice melt and rising sea levels, ocean acidification, disruption to hydrological cycles, desertification and higher risks from extreme weather events.

Off-track for Paris

Currently, we are *not* on track to meet the maximum warming targets of the Paris Agreement[2]. The last climate negotiations, COP25, held in December 2019 left several important matters unresolved. COP26, in Glasgow in late 2021, is seen as an important COP[3] because it is to focus on raising (post-2020) ambition levels around decarbonisation and other climate priorities. (*The Climate in 2021*, 5 January 2021).

Global pandemic has shown fragility…and resilience

After centuries of attempting mastery over nature, COVID-19 has served as a reminder of how exposed society is to our treatment of and interaction with ecosystems, biodiversity and natural systems, as a virus that was passed from animals has wreaked profound negative socio-economic impacts. Nevertheless, the response has shown that there is enough institutional strength and financial firepower to deploy huge resources globally and rapidly.

We do think we can see evidence that the world is becoming increasingly focussed on climate change. Yet some countries look better placed on this than others. And so, as we did last year in *Fragile Planet 2020 – Scoring climate risks: who is most resilient*, we ask a question:

- ***Which countries are more resilient in the face of rising climate risks?***

1 2020 is a slight anomaly, down c.7%, due to the collapse in economic activity associated with the pandemic, but emissions in many countries are already bouncing back
2 According to the UN Environment Programme's (UNEP) *2020 Emissions Gap Report*, the world is "absolutely not" on track with either current policies, unconditional or conditional climate pledges.
3 The UK has outlined five issues that will be a focus of action at COP26: 1. Adaptation and Resilience 2. Nature or nature-based solutions 3. Energy transition 4. Clean road transport 5. Climate finance

More countries

This is the fifth in our series of Fragile Planet reports[4]. This time, we have once again expanded the list of developed, emerging and frontier market economies we study, from 67 to a set of 77[5].

The report is organised into four sections, each seeking to answer a single question, which together feed into the main question above. The four section-related questions are as follows:

- ***How embedded is carbon in national economies?***
- ***Which countries are at greater risk from physical impacts associated with global warming?***
- ***Which countries have the policy, institutional quality, financial strength and informed population to respond to climate risks?***
- ***How are countries placed to make economic profit from cleantech as the world decarbonises?***

New indicators

We have enhanced the set of indicators we use to explore these questions. We newly include datapoints allowing us to explore dynamics around fossil fuel subsidies, regulatory quality, gender equality, health risk preparedness, biodiversity loss and sea level-rise. Plus, we include an expanded list of commodity reserves and production data, up from six to 16 and now including platinum, rare earths, vanadium and others. (On page 21 of this report, HSBC economist, Paul Bloxham, provides comments on commodity implications of the transition). This takes us to a total of 49 indicators – of which 12 are new – explored via 92 datapoints for each country in this analysis (see Figure 3 for a complete list – all new indicators are in italics).

> **“ The pandemic response shows there exists institutional strength and financial firepower to deploy huge resources in the face of a systemic challenge**

Podium places go to European nations…but relevant risks can lie in individual datapoints

The 5 best-placed countries – the most resilient - are dominated by wealthy, European nations. **Sweden** ranks first, followed by **France**, **Finland** and **Germany**. The **US** is in fifth place. The most vulnerable countries are dominated by those in warmer latitudes, in descending order – **Nigeria ranks as most vulnerable**, **Bangladesh**, **Cote d'Ivoire**, **Tanzania** and then **Tunisia**. However, while the final rankings (Figure 2) are interesting, we believe digging into the detail is more illuminating; i.e., the value in this report can be found in specific areas of risk and individual indicators. To illustrate, focusing on these apparent winners and losers masks important findings, for instance that:

- **Switzerland, Sweden** and **Norway** head the list of countries with low emissions per unit of GDP. The highest include **Tanzania** and **Vietnam**.
- Energy subsidies distort the energy market by creating an uneven playing field - **Egypt** gives out the most significant amount, at around 6.3% of GDP, followed by **Saudi Arabia** and **Kuwait**
- **Qatar** and **Bahrain** experienced the highest average annual temperatures at 28.4˚C and 28.3˚C. Over the two decades to 2016 **Romania** has warmed the fastest, up 0.92˚C, rapid warming over a 20-year timeframe, with other countries in the region - **Serbia**, **Russia**, **Hungary** and **Bulgaria** - also experiencing high temperature increases.

4 Earlier editions: *Fragile Planet: Scoring climate risks around the world*, March 2018, *Fragile Planet – Commodities: From climate risks to agriculture*, July 2018, *Fragile Planet - The politics and economics of the low-carbon transition*, April 2019, *Fragile Planet 2020*, 20 January 2020.
5 Countries included in our framework that weren't included in Fragile Planet 2020 are: Botswana, Bulgaria, Côte d'Ivoire, Cyprus, Ghana, Iceland, Latvia, Malta, North Macedonia, Slovakia, Tanzania.

- **Kuwait** has the lowest water-availability per capita, followed by the **United Arab Emirates**. DMs with the lowest per capita availabilities are Singapore and Israel.
- **Pakistan** registers the highest readings of urban particulate matter (PM10 – air pollutant harmful to human health), followed by **Egypt** and **Bahrain**
- 22 countries have lost forest cover between 1990 and 2016, notably **Nigeria** with only 38% of the forested area that the country had in 1990 now remaining
- Many countries face sea-level risks. **The Netherlands** has 56% of land area below 5m of elevation, with 59% of the total population living in these areas. **Bahrain**, **Vietnam** and **Denmark** are also exposed in terms of land area and population living there
- The number of people affected by extreme weather events across the **US** continues to rise. In the first decade of this century, 67 people per 1,000 of the population were affected. This rose by 303%, to 270 people, between 2011 and 2020.
- Climate change can present significant health risks to populations, and a specialist surgical workforce can signify response capacity. **Greece** ranks highest, with an average of 164 surgical specialists per 100,000 of the population, followed by **Italy** and then the **United Kingdom**. At the other end of the scale, African countries rank as most vulnerable on this metric; **Tanzania** has only 0.5 surgical specialists per 100,000, with **Nigeria** and **Kenya** only marginally higher.
- The **US** and **China** are earning substantial climate solutions revenues already, while **Italy** has the industrial diversity to suggest it has the capacity to do so in future.
- **Switzerland** and **Korea** have the highest number of patents registered in sectors relevant to climate change-related products and services, relative to population. However, in absolute numbers, **Japan** and the **US** top the table.

A huge, global response is necessary to address climate risks

Decarbonisation requires technological innovation, economic support and policy formation and delivery. Similarly, the build-up of resilience to the negative impacts of warming will require a massive financial, technological and political response. Yet there are opportunities for countries which move quickly and prudently, to protect societies and even to enhance economic outlook.

> **We take a broad lens in analysing climate risks for 77 developed, emerging and frontier market countries, utilising 92 separate datapoints to explore 49 indicators**

While the pathway to delivering climate resilience is extremely challenging, we believe that catalysts continue to come and, for every disappointment in the rate of response and transition, other areas surprise positively. COP26 is a major opportunity to drive global climate ambition yet further forward. And we think the importance of the European Union implementing the intentions of its Green Deal is substantial, in driving scale and ambition. Furthermore, we expect China and the US to join the race to deliver an energy transition and climate resilience leadership. And indeed, all countries need to increase their ambition and deliver on their plans. It remains possible for countries to build social, economic and environmental resilience, but they must act rapidly and act radically.

Figure 3. Fragile Planet 2021: Metrics and indicators analysed to rank 77 DM, EM and FM countries

Risk area	Indicators		Source	Weights	*Level*	*Change*
Energy, carbon & the macro-economy				**25%**		
Economic carbon intensity				**12.50%**		
	Alternative energy	Share in primary energy use	World Bank		*2.08%*	*1.04%*
	GHG emissions	Per capita (ex. LULUCF)	CAIT (World Resources Institute), United Nations		*2.60%*	*1.30%*
		Per GDP (ex. LULUCF)	CAIT (World Resources Institute), World Bank		*2.60%*	*1.30%*
		From LULUCF per capita	CAIT (World Resources Institute), United Nations		*1.04%*	*0.52%*
Economic diversification & fossil fuel dependence				**12.50%**		
	Fossil fuels in the economy	Rents (% of GDP)	World Bank		*2.08%*	*1.04%*
	Fossil exports	HSBC exposure calculation	UNCTAD (United Nations)		*2.08%*	*1.04%*
	Low cost oil-and-gas	Reserves-to-breakeven ratio	Rystad Energy		*3.13%*	
	Energy subsidies	*% GDP*	*United Nations*		*2.08%*	*1.04%*
Climate risks and adaptation				**25%**		
Temperature				**3.57%**		
	Average temperature	ºC	World Bank Climate Change Knowledge Portal		*1.19%*	*2.38%*
Water scarcity				**3.57%**		
	Renewable water	Volume availability (m^3) per capita per year	Aquastat, United Nations		*0.60%*	*1.19%*
	Basic drinking water services	% population	Food and Agriculture Organisation		*1.79%*	
Air pollution				**3.57%**		
	Ambient air quality	Annual mean ug/m3 PM10 levels in cities	World Health Organisation		*1.79%*	
	Outdoor air pollution - fatalities	Attributable deaths (deaths/100,000 people)	World Health Organisation		*1.79%*	
Food systems				**3.57%**		
	Agriculture in the economy	Agricultural value add in GDP (%)	World Bank		*1.19%*	
	Food security	Cereal dependency ratio	Food and Agriculture Organisation		*1.19%*	
		Food production variability	Food and Agriculture Organisation		*1.19%*	
Ecosystem services				**3.57%**		
	Deforestation	Share of forest remaining	Food and Agriculture Organisation		*1.19%*	
	Biodiversity	*Threatened species per 100K population*	*International Union for Conservation of Nature*		*1.19%*	
		Threatened species per 000 sq km	*International Union for Conservation of Nature*		*1.19%*	
Sea level risks				**3.57%**		
	Land elevation	*% land area below 5m above sea level*	*World Bank*		*1.79%*	
		% population living below 5m above sea level	*World Bank*		*1.79%*	
Extreme weather events – storms, wildfires, droughts, floods, extreme temperatures				**3.57%**		
	Frequency of events	Total, normalised per sq. km.	EMDAT, World Bank		*0.60%*	*1.19%*
	Sensitivity - people affected	People affected per mn population	EMDAT, United Nations		*0.30%*	*0.30%*
	Sensitivity - fatalities	Fatalities per mn population	EMDAT, United Nations		*0.30%*	*0.30%*
	Sensitivity - damage costs	Disaster cost per 000USD of GDP	EMDAT, United Nations		*0.30%*	*0.30%*
Climate governance				**25%**		
Climate finance				**5.00%**		
	Wealth	GDP per capita, current USD	World Bank		*2.00%*	
	Borrowing potential	Debt to GDP ratio	International Monetary Fund		*1.20%*	
	Cost of capital	Equity risk premium, %	New York University Stern paper		*1.20%*	
	Sovereign wealth fund	USD fund size per capita (USD per capita)	Sovereign Wealth Fund Institute, United Nations		*0.60%*	
Institutional quality				**5.00%**		
	Control of corruption	Standard normal distribution score	Worldwide Governance Indicators		*1.67%*	
	Rule of law	Standard normal distribution score	Worldwide Governance Indicators		*1.67%*	
	Regulatory quality	*Standard normal distribution score*	*Worldwide Governance Indicators*		*1.67%*	
Enabled population				**5.00%**		
	Inequality	GINI coefficient	World Bank		*0.83%*	
	Tertiary education	% population enrolled in tertiary education	World Bank		*0.83%*	
	Media independence	World freedom of press index	Reporters without borders		*0.83%*	
	Internet adoption	% population using the internet	World Bank		*0.83%*	
	Mobile phone users	Mobile cellular subscriptions per capita	World Bank		*0.83%*	
	Gender equality	*Gender parity index*	*World Bank*		*0.83%*	
Decarbonisation policy				**5.00%**		
	Climate policy framework	*Score for policy and Paris Agreement pledge*	*HSBC*		*2.50%*	
	Government effectiveness	Standard normal distribution score	Worldwide Governance Indicators		*2.50%*	
Health risk preparedness				**5.00%**		
	Hospital beds	*Per 1,000 population*	*World Bank*		*2.50%*	
	Surgical workforce	*Per 100,000 population*	*World Bank*		*2.50%*	
Green opportunities				**25%**		
Economic exposure and opportunities				**25.00%**		
	Climate revenues	Absolute level from nationally incorporated companies	HSBC		*2.33%*	*1.17%*
		Absolute level relative to GDP	HSBC, World Bank		*2.33%*	*1.17%*
	Industrial potential to produce cleantech	Green Complexity Potential	University of Oxford Institute for New Economic Thinking		*7.00%*	
	*Key minerals**	*Share of global reserves + production*	*United States Geological Survey, World Nuclear Association*		*7.00%*	
	Corporate climate policies	Company mitigation and adaptation policies per GDP	NAZCA portal, World Bank		*2.00%*	
	Technological innovation	Sum of relevant patents granted (2015-2019) per population	WIPO Intellectual Property Statistics		*2.00%*	
TOTALS				**100%**		

Source: HSBC. Note: Indicators in italics denote new additions vs Fragile Planet 2020 analysis.
*Key minerals: lithium, cobalt, copper, nickel, manganese, uranium, *platinum, rare earth oxide equivalent, indium, gallium, aluminium, chromium, molybdenum, silver, zinc, vanadium*

Why is this important to investors?

Monitoring individual country vulnerability to climate change factors is, in our view, important to investors for reasons including:

Inflation

Climate effects could impact food or energy output, driving up prices.

Attractiveness of foreign direct investment (FDI)

Smarter globalised companies are incorporating climate factors into operational growth strategies. Regions with low vulnerability to extreme events driven by climate change carry less risk.

Balance of payments

Countries with high exposure to climate factors could face higher trade deficits as companies choose to source goods from other countries where climate risks are lower to mitigate supply chain disruption.

Short-run growth

Damage costs from extreme climate events are a drag on economic growth, and create extra growth volatility. According to the Emergency Events Database, damage costs relating to extreme events in the G20 alone totalled USD978bn in the decade to 2018, up from USD630bn in the decade to 2008.

Long-run growth

The depletion of natural capital hurts overall productivity (eg, water depletion can increase the cost of energy), and thus affects a country's ability to generate long-term sustainable growth.

Supply chain disruption

Provision of goods and services may be disrupted, putting pressure further along production chains.

Infrastructure investment requirements

Countries will need to invest in power, transport, waste and buildings infrastructure to be resilient to high probability extreme weather events and slow-onset climate-driven physical factors. Water infrastructure is also very important. The consequences of 'water stress' depend to a great extent on how efficiently the resource is managed.

Social risks

Climate change has been given as one factor behind incidences of large-scale migration and conflict, such as in Syria and Mali, highlighting the requirements to understand the nature of exposure to countries where social impacts occur.

Inequality

The poorer regions of the world, concentrated in the tropics, are more susceptible to climate impacts. Poorer populations within countries are also likely to be less able to adapt. Evidence shows that women are often more affected by climate impacts in many developing nations.

Health issues

Higher temperatures and changing water patterns increase the public health risk.

Opportunities

Some countries are well placed to earn revenues as the world decarbonises, by producing the products and technologies that will drive the transition. Certain countries are already producing cleantech today or have the diverse industrial base to do so in greater quantity in the future.

Investors can click the 'buttons' interspersed throughout the report to receive the full dataset underlying this analysis

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Overall rankings

From greatest resilience to most vulnerable

1. Sweden	41. Croatia
2. France	42. Israel
3. Finland	43. Mexico
4. Germany	44. South Africa
5. United States	45. Brazil
6. Denmark	46. Argentina
7. Switzerland	47. Thailand
8. United Kingdom	48. Peru
9. Norway	49. India
10. Austria	50. Malaysia
11. Belgium	51. United Arab Emirates
12. Canada	52. Kazakhstan
13. Czech Republic	53. Vietnam
14. Korea	54. Philippines
15. Australia	55. Serbia
16. Iceland	56. Indonesia
17. Portugal	57. Mauritius
18. Spain	58. North Macedonia
19. Japan	59. Bahrain
20. Poland	60. Qatar
21. Chile	61. Morocco
22. Netherlands	62. Botswana
23. New Zealand	63. Colombia
24. Mainland China	64. Jordan
25. Romania	65. Ghana
26. Ireland	66. Saudi Arabia
27. Lithuania	67. Egypt
28. Italy	68. Sri Lanka
29. Slovenia	69. Pakistan
30. Malta	70. Kenya
31. Slovak Republic	71. Kuwait
32. Estonia	72. Oman
33. Latvia	73. Tunisia
34. Hungary	74. Tanzania
35. Turkey	75. Côte d'Ivoire
36. Singapore	76. Bangladesh
37. Greece	77. Nigeria
38. Bulgaria	
39. Russia	
40. Cyprus	

Source: HSBC based on proprietary analysis of 49 indicators. Colour coding by market: red = DM, grey = EM, black = FM. Classifications according to FTSE market classifications.

We acknowledge the contribution of Abhishek Kumar, Payal Negi and Anushua Chowdhury, climate change analysts, Bangalore, in the preparation of this report

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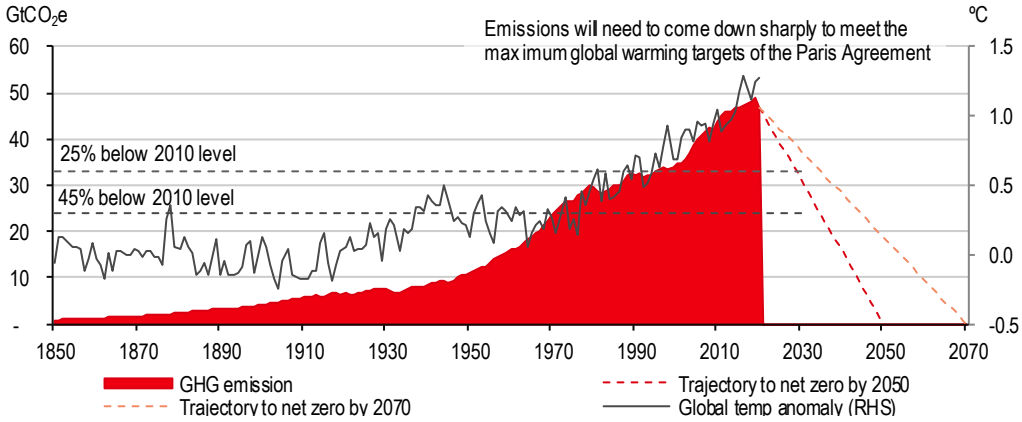
Energy, carbon and the macro economy

- Denmark has the lowest transition risk, as our findings show huge variance once again
- We analyse emissions, alternative energy and fossil fuel dependence metrics, adding hydrocarbon subsidy data in this report
- Our analysis finds oil&gas-rich countries to be most vulnerable, headed by Kazakhstan and Gulf states

To limit global warming, the world must lower its greenhouse gas emissions. All 197 parties to the United Nations Framework Convention on Climate Change (UNFCCC) have either signed or ratified the Paris Agreement[6]. The main emissions goal of the Paris Agreement is to **hold the increase** in global average temperature to **well below 2°C** above pre-industrial levels (in 2100) and to **pursue** efforts to limit the temperature increase to **1.5°C** above pre-industrial levels. To achieve these goals, virtually all countries around the world will need to remove carbon and other GHGs from their energy systems and broader economies.

Figure 4. As emissions rise, so does the temperature



Source: PRIMAP, UK Met; Note: GHG emissions for 2018 and 2019 are based on CAGR from 2007 to 2010 and 2010 has been estimated based on CO_2 emission reduction in 2020 compared to 2019 . In a 2021 report, UN Climate Change put out 2030 target levels of 25% below 2010 for 2°C alignment, and 45% lower for 1.5°C alignment

Emissions have risen, particularly since the second half of the C20th

Yet annual emissions are still rising, as Figure 4 makes apparent (with 2020 as an anomaly due to the collapse in economic activity associated with the COVID-19 pandemic). And moving in tandem with emissions has been a rise in the temperature, up around 1.2°C since the mid-19th century. The figure also shows the rapid rate at which emissions must fall to reach net-zero

6 At the most recent annual conference of parties to the UNFCCC (COP25), progress was limited, in our opinion – see COP 25: Intransigence, 16 December 2019

emissions by 2050 or 2070. These are the rates broadly aligned by scientists with limiting warming to 1.5°C or 2°C, as well as the medium-term 2030 cuts of 25% and 45%, respectively, vs 2010 levels which the UN says are necessary *UN synthesis report - way, way off the 1.5°C track*, 4 March 2021.

So in this section we ask the question:

How embedded is carbon in national economies?

Metrics to understand transition risk

To answer this, we review a range of datapoints. These metrics allow us to analyse, at the country level, which countries are systemically more **carbon intensive** and those that are more exposed to the risks that economic **dependence on fossil fuels** brings. Another way to describe this is to ask which countries have ***higher transition risk***. (Figure 5 lists the full range of metrics used here and we discuss these in the remainder of this chapter.)

Our rankings in relation to this question on carbon-embeddedness are as follows (with 1st denoting most resilient to these transition risks and 77th most vulnerable):

GREATER RESILIENCE

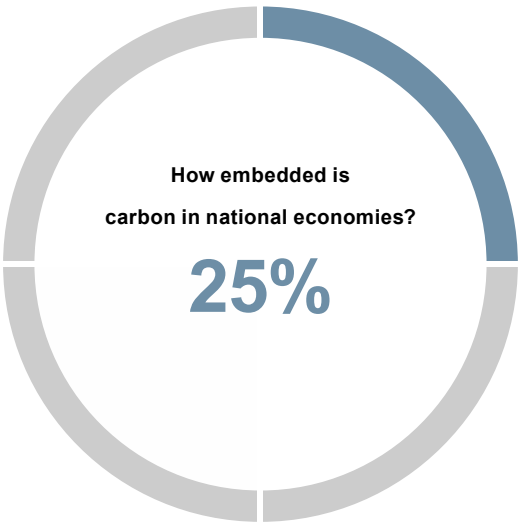
1st. Denmark
2nd. Romania
3rd. Switzerland
4th. United Kingdom
5th. United States

MOST VULNERABLE

1st. Kazakhstan (ranks 77th)
2nd. Oman (ranks 76th)
3rd. Saudi Arabia (ranks 75th)
4th. Bahrain (ranks 74th)
5th. Tanzania (ranks 73rd

Figure 5.

Energy, carbon and the macro economy



Economic carbon intensity	**12.5%**
1. Alternative energy	
2. Emissions per capita	
3. Emissions per GDP	
4. Emissions from LULUCF	
Economic diversification and fossil fuel dependence	**12.5%**
1. Fossil fuels in the economy	
2. Fossil exports	
3. Fossil reserves-to-breakeven ratio	
4. Energy subsidies	

Source: HSBC. Note: LULUCF = Land use, land use change and forestry

The findings show European countries dominating the top half of the list. These are most resilient in a world striving for decarbonisation – they have lower transition risk. **Denmark** (first place) and the **UK** (fourth place) have low emissions per GDP, and low reliance on fossil fuel exports. Meanwhile, while **Switzerland** (third) has low emissions as it generates the vast majority of its power from alternative energy sources. **Romania**, in second place, is perhaps less intuitive – however, it has also built out more hydro power and thus uses much less coal than many of its European neighbours. Meanwhile, it scores very well on emissions relating to its sizeable, largely intact forests. The **United States** scores well overall given a lower reliance on fossil fuel exports, and on having relatively large and low cost oil and gas reserves.

At the more vulnerable end of the spectrum which faces greater transition risk, lie oil-rich **Kazakhstan** and the **Gulf states**, much less of a surprise given their dependence on the old energy economy for both economic output and domestic energy supply. The best performance among these economies is on the change metrics associated with economic diversification – **Saudi Arabia** performs well on reducing fossil fuel related rents, export reliance and pre-tax subsidies. **Oman** and **Bahrain** demonstrate a similar pattern.

Tanzania's vulnerability (ranked 73rd) in this section is associated with having relatively low emissions per capita (unsurprising as it is one of the less wealthy states in our sample set). However, the country performs poorly on the change aspect of this metric, and on an emissions per GDP basis. Indeed, the challenge for countries such as Tanzania is, as total GDP and populations increase, ensuring that corresponding growth in energy demand is met through cleaner sources, especially in power generation capacity, but also in transport and other sectors.

Economic carbon intensity

We begin by analysing the carbon intensity of a country and its economic activity, before looking at use of alternative energy sources.

All countries consume energy, for use in homes, services, industry and transport. A high proportion of energy consumed – over 85% – comes from burning fossil fuels.

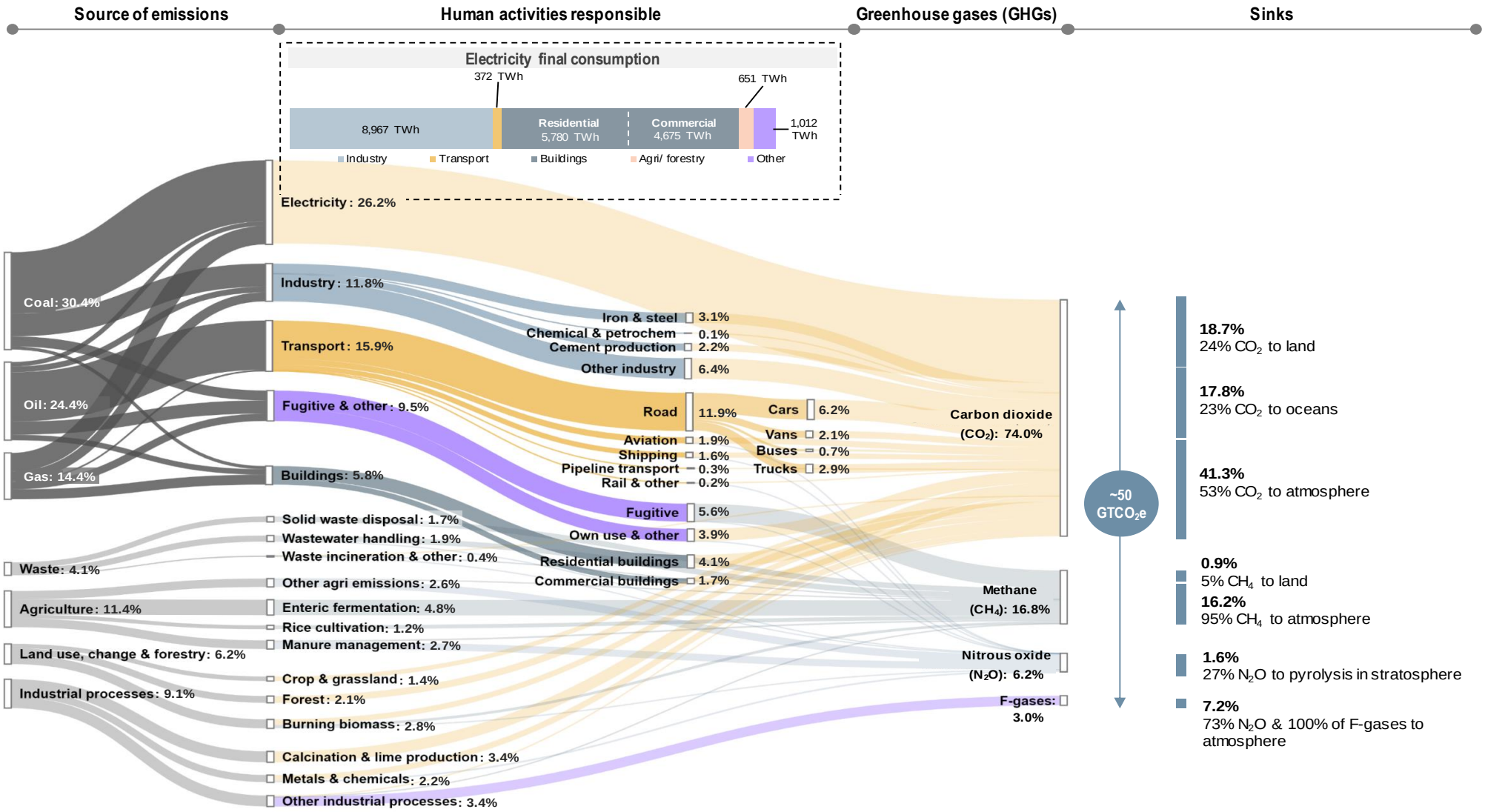
Emissions – mostly from energy

Around 70% of GHGs come from burning fossil fuels for energy (Figure 6); in terms of which sectors using fossils generate emissions, the power generation sector is highest, mostly via coal and gas use, followed by the transport sector as the next highest emitter, almost entirely via oil.

We consider both current levels as well as change indicators in these areas – this is about both crediting those countries with low-carbon profiles *and* about capturing the transition away from carbon intensity over time.

> **"The power generation sector is the highest emitter, mostly via coal and gas use, followed by the transport sector as the next highest emitter, almost entirely via oil**

Figure 6. How do we emit? Global GHG emissions in 2017



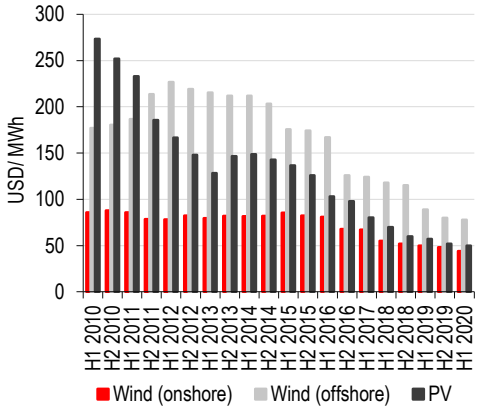
Source: HSBC, IEA, EDGAR, Global Carbon Project; values for sinks adjust calc. error; F-gases sources are not shown here but typically include refrigeration, air conditioning, aerosols and high voltage switchgear ; LUCF is Land Use Change and Forestry; data for LUCF values are inherently uncertain and may show variations based on accounting; Own use & other includes losses and agricultural use of energy; Other agri emissions includes direct emissions and emissions from agri waste burning & other indirect emissions; Other industry includes non-ferrous metal, paper & pulp and mining & quarrying;; Energy and process emissions from calcination and cement production is nearly 2.5 $GtCO_2$. production of coke for iron & steel, feedstock for chemicals and petrochemicals, and some parts of oil & gas refining are classified as other industry.

◆ INDICATOR: Alternative energy (level and change)

Cheaper alternative energy sources facilitate more rapid decarbonisation

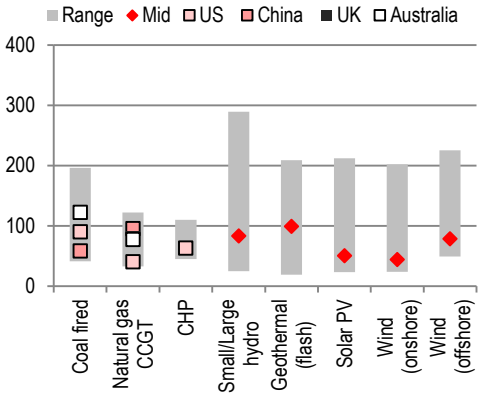
To reduce global GHGs, we think the use of fossil fuels in energy must be reduced where technology makes this possible and it is commercially viable. And the costs continue to come down (Figures 7 and 8). To assess the level and pace of decarbonisation, we have looked at the **share of alternative energy sources** – including solar, wind, hydro, bioenergy, geothermal and nuclear – in total primary energy demand and the change over the last decade (using World Bank data).

Figure 7. Renewables getting cheaper



Source: BNEF
Note: Levelised cost of energy (LCOE) is the cost to build and operate a power-generating asset over its lifetime divided by the total power output of the asset over that lifetime

Figure 8. PV and onshore wind among most competitive technologies (LCOE, USD/MWh)

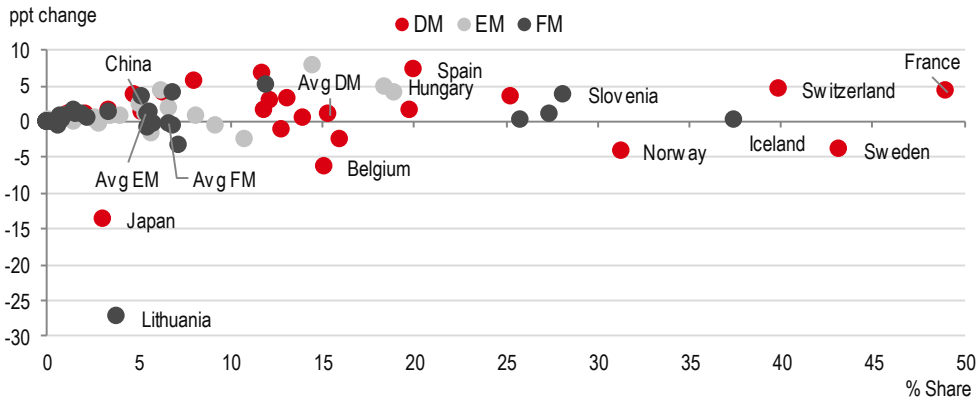


Source: BNEF
Note: LCOE is a useful measure to compare costs across different power generation technologies. Note: based on H1 2020 data

France is least dependent on fossils for energy

Figure 9 shows shares in alternative energy and the change in these. **France** has the highest share. 24 countries in our sample took more than 10% of total energy from sources other than fossil fuels. **Japan** has a low share of alternative energy in its mix – 3.1% – and this has been decreasing over the past decade, chiefly owing to the fact that nuclear power generation has been replaced with fossil fuel generation since the 2011 earthquake caused leaks at the Fukushima plant. Four countries in our sample set derive 0% of their total energy from alternative sources – i.e. 100% is derived from fossil fuels - **Bahrain**, **Kuwait**, **Oman** and **Qatar**. **Romania**, **Spain** and **Denmark** have experienced the largest positive change over the decade.

Figure 9. Alternative energy level (2015) and 2005-2015 change



Source: World Bank Notes: Includes nuclear

◆ INDICATOR: GHG emissions (level and change)

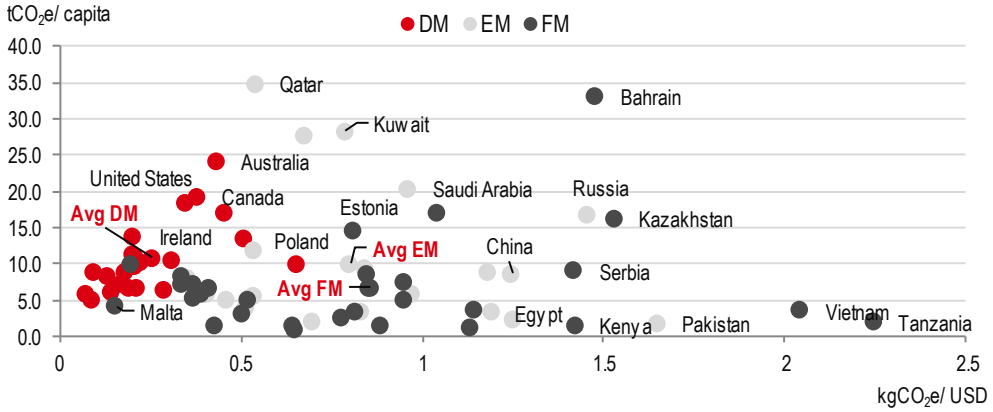
Relative emission levels

Next we look at metrics which consider a country's **emissions per capita** *and* **per unit of GDP**. We also consider **emissions from land use change and forestry** (per capita) to integrate an understanding of the importance of agriculture and other activities which can have a significant impact on a country's overall net emissions profile (we consider the importance of forests and land use change in *Paradise lost? Why investors must address the biodiversity crisis next*, June 2020, *Continental shift: Energy and climate change in the big six LatAm economies*, 5 July 2019 and *Climate change and land – Stranded on a desert planet*, 9 August 2019).

Switzerland, Sweden and **Norway** head the list of countries with lowest emissions per GDP. Countries with the highest emissions per unit of GDP include **Tanzania** and **Vietnam**.

Poorer countries have frequently have lower emissions per capita – **Côte d'Ivoire** being the lowest, followed by **Bangladesh** and **Ghana** – which is perhaps unsurprising given lower economic activity has a correlation with lower energy use. Figure 10 shows **Qatar** with the highest emissions per capita in our sample set, closely followed by **Bahrain** and **Kuwait**. However, these three countries have also all reduced their emissions per capita between 2006 and 2016. In fact, in terms of reduction over the decade, **Qatar** has seen the biggest reduction of our sample set. There are many signs of transition in the broader MENAT region, as we explored in *Continental Shift – Climate change and energy transition across the large MENAT economies*, July 2020.

Figure 10. Emissions per capita and emissions intensity (2016)



Source: PRIMAP Dataset, HSBC, World Bank; Note: GHG emissions ex LULUCF; not all countries are labelled on the chart; simple average calculated for DM, EM, FM

> **There are challenges to fossil fuel producers as the world decarbonises – with 'resource curse' challenges compounded by possible peak demand**

Economic diversification and fossil fuel dependence

Peak fossil demand?

Most projections see energy demand rising with population increases and greater affluence. However, there are challenges to fossil fuels as the world seeks to decarbonise. As we argue at length in *Future Frontiers*, March 2021, reducing emissions to a net-zero level by 2050 will necessitate wholesale transition away from the use of coal, oil and gas in power generation, across modes of transport, in providing energy to buildings and in the energy and material feedstocks which are necessary for a range of industrial activities.

Meanwhile, successfully managing fossil fuel *wealth* is a further challenge. The 'resource curse' is the term used to describe the phenomenon of natural resource economies growing slower over time than comparable economies that have lower natural resource endowments. (We have discussed these risks in greater length in previous *Fragile Planet* notes.)

So, there are challenges to managing commodity wealth: the 'resource curse' plus the risk of a decline in fossil fuel demand, which some energy system scenarios now project equates to potentially higher country transition risks. As our Oil & Gas team describes in *Big Oils and Climate*, 13 January 2020, the *"**sector faces unprecedented climate-related uncertainty** including future demand risks, a change in returns mix from new-energy ventures, evolving shareholder and societal expectations, questions over the sustainability of dividend pay-outs, potential climate and energy-related policy changes as well as technological disruption threats".*

Diversification is key to transition

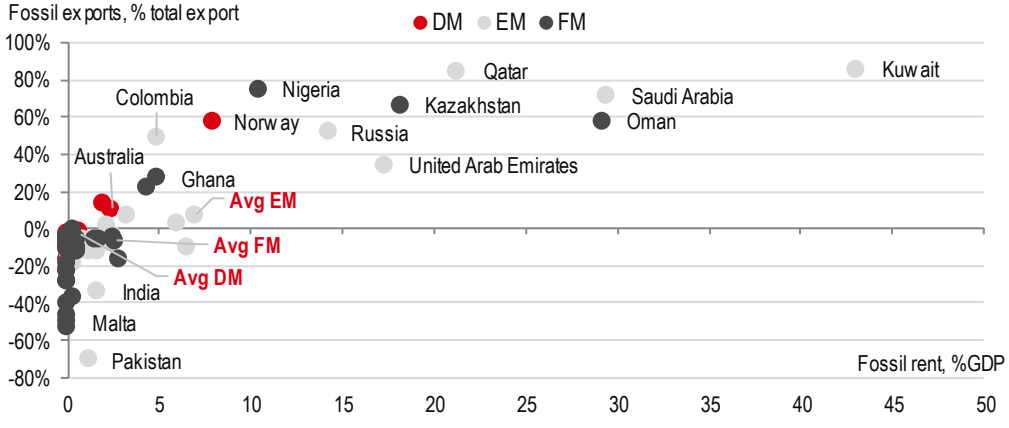
Managing the transition to a lower carbon economy is key to mitigating these downside risks. We think achieving diversification is key and look here at the extent to which the 77 countries under consideration are diversified in relation to fossil fuel, their exports and their economic production. Overall, emerging and frontier market countries are on average notably more exposed to fossils. Fossil fuel exports made up 4.0% (2018) of GDP in emerging and frontier market countries on average, compared to 1.7% in developed market countries. On average, fossil fuel exports made up nearly 15.3% (2018) of total export revenues in emerging and frontier markets. In developed markets, it is about half of that number, with only 8.6% of total exports coming from fossils.

◆ **INDICATOR: Fossil fuels in the economy (level and change)**

Focussed risks in MENA

Kuwait, **Saudi Arabia** and **Oman** are the three countries with the highest earnings from fossil production, as a percentage of GDP, predominantly oil in these cases. Some countries have been transitioning by reducing this share over time – in fact **Saudi Arabia, Qatar, Kuwait** and **Oman** have seen the biggest reduction of our sample set over this time. However, the dollar value of fossil fuel exports is a function of price as much as volume, so price fluctuations can drive such apparent transition datapoints.

Figure 11. Economic dependency on fossil fuels (2018)



Source: World Bank; UNCTAD, Note: GDP at constant 2010 USD

43%

Fossil fuel revenue of Kuwait's GDP, the highest in our sample

◆ ***MODIFIED* INDICATOR: Fossil exports (level and change)**

The balance of trade in a low-carbon world

Some countries have fossil fuels in abundance and can produce enough domestically to cover their energy requirements. Many states have an excess of commercially viable reserves – ie, they can supply more fossil fuels at current market prices than needed to meet domestic demand – and therefore export to countries which do not produce enough to meet their needs. **17 countries of our sample of 77 are net exporters of hydrocarbons, in economic terms[7].**

Over time, major fossil-producing countries have typically experienced a positive current account balance due to high fossil exports. However, such countries are susceptible to price inflation of other essential goods and this can be problematic when their current account balance reduces due to a decline in energy price or export volume. During 2020, oil prices were extremely volatile as the pandemic and associated lockdowns greatly disrupted demand – e.g. in April 2020 West Texas Intermediate (WTI) was trading at a negative price.

The opposite is true with heavy dependence on fossil imports, however, as such countries typically have more diversified trade baskets that lower their exposure to energy commodity prices. Nevertheless, countries with a high net dependence on fossil fuel imports are also exposed to transition risk, as the country will have to source fuel from elsewhere in a low carbon world. However, we consider the transition risk associated with falling demand for fossil fuels in a decarbonising world to be lower for net importers than net exporters.

Fossil exports exposure score

To capture these dynamics, we have calculated a *fossil exports exposure score*. Initially, we calculate whether countries in the sample set are net importers or exporters of fossil fuels, and what this net import/export value is as a share of total imports/exports (depending). Net exporting countries are assigned double the weighting to their fossils dollar value (vs. net importers), given the perceived additional burden of transition risk that we believe these fossil exporting countries are exposed to.

All countries are then ranked and scored based on these absolute values – a larger fossil trade exposure number leads to a lower ranking. All calculations are based on three year averages given the volatility of trade data.

Kuwait is most vulnerable on this metric, followed by **Qatar, Nigeria** and **Saudi Arabia**. However, many of the economies that have performed poorly on this absolute metric, have seen declining shares over the decade. Since the average of the three years leading up to 2009, Nigeria has seen the fourth largest reduction in fossil export shares of our entire sample set, and Saudi the seventh. **Oman** and the **United Arab Emirates** have seen the largest reductions of all.

It is worth noting that Nigeria's decline is largely due to an involuntary fall in oil production – i.e., outages and lack of external investment were the primary causes rather than a conscious government policy to reduce export dependency. Recent diversification away from fossil fuels has occurred for a number of countries, particularly in the MENA region, where positive increases over 1996-2006 turned to contractions in the following decade. **Colombia** and **Ghana**, both net exporters, are among those that have moved in the *opposite* direction, becoming more specialised in fossil fuels amongst their export balance over the past decade.

7 Based on three year averages to 2019. Note that this is UNCTAD data for "Mineral fuels, lubricants and related materials", and data for electrical current has been stripped out.

Picking winners and losers among hydrocarbon states

Fossil fuels have brought great wealth opportunities to many countries. In the preceding metrics in this section, we have treated a concentration of fossil fuels within GDP and exports as a negative, given issues relating to the notion of a resource curse and impending peak demand risks. Despite these risks, some countries will continue to *benefit* from their resource endowments, in our view. The rationale is that, even in a 2ºC world, we are very likely to use some oil and gas, particularly in sectors where it is technologically much harder to replace them, including aviation and shipping (see *The second frontier*, 15 January 2019), and petrochemicals.

85%

Fossil fuels still underlie the majority of energy consumption

Fossil fuels in a low-carbon world

Even in a world aiming for net zero emissions within coming decades (consistent with the stronger Paris Agreement target of limiting warming to 1.5C (see *Does 1.5ºC matter*, 8 October 2018), the use of *some* fossil fuels in certain harder-to-address sectors is foreseen, such as shipping, petrochemicals and aviation. These emissions can be offset, given that the earth – particularly forests – can absorb some carbon dioxide. And so we argue that those who can produce oil and gas at the *lowest cost* are likely to continue to take profit from the sector. (We assume thermal coal use is eradicated in a world aiming to meet Paris Agreement warming targets, and so do not credit countries here for coal reserves.)

◆ **INDICATOR: Low cost oil-and-gas: The R/B-2030 ratio**

Thus, we include a metric to capture which countries we believe are better placed to sell *oil and gas* in a world that is moving away from fossil fuels. This is a ***single datapoint* – a *ratio of reserve to breakeven-prices in 2030***, which we abbreviate to **R/B-2030**.

1. We use Rystad estimated total *proven and probable (2P) oil & gas reserves for 2030* for each country in our sample. (We use the date of 2030 because energy system scenarios that see a peak in oil and gas demand typically see this occurring in the 2030s. Furthermore, most pledges to the Paris Agreement cover the period until 2030, beyond which our expectation is that the decarbonisation ambition and policy will increase, which would support a further tightening of demand for fossil fuels.)
2. We calculate the *weighted average of the breakeven price* (i.e., the price at which a barrel of oil will need to be sold to meet production costs) across all price categories for the country. These categories are given by Rystad in the following breakeven ranges, in USD/barrel:

   5-10 *10-20 *20-40 *40-60 *60-80 *80-100 *100-125 *125-150 *Over-150
3. Then we divide the total reserves by the average breakeven price, to give the RB-2030, as per this formula, which illustrates the workings with the examples of United States and Canada:

$$United\ States'\ \boldsymbol{R/B\ 2030} = \frac{Total\ P2\ reserves\ at\ all\ breakeven\ prices\ (in\ mn\ barrels)}{(Weighted\ average\ breakeven\ prices\ in\ USD * 1{,}000)}$$

$$= \frac{76{,}376.3}{56.4 * 1{,}000} = 1.35$$

$$Saudi\ Arabia's\ \boldsymbol{R/B\ 2030} = \frac{26{,}095.7}{23.4 * 1{,}000} = 1.11$$

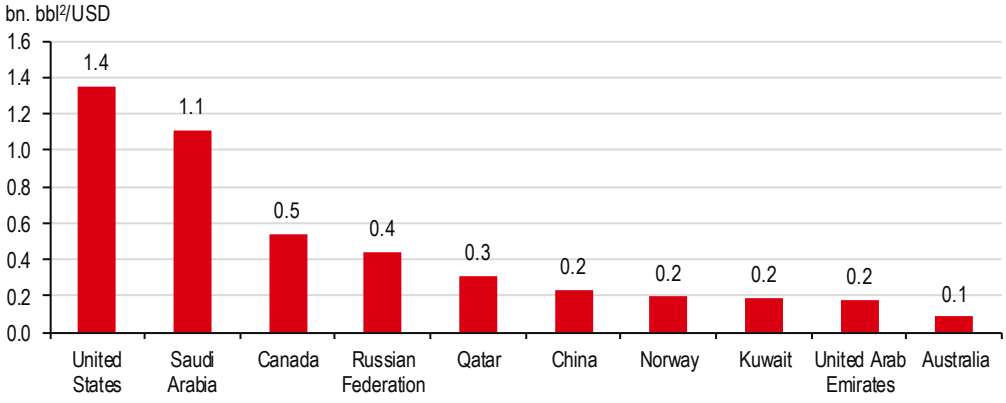
$$Canada's\ \boldsymbol{R/B\ 2030} = \frac{33{,}844.4}{62.3 * 1{,}000} = 0.54$$

Saudi Arabia is best placed on the R/B-2030…

Via this methodology, we are able to rank countries on this R/B-2030 ratio to argue which are economically better placed to meet global demand for oil and gas beyond 2030. A higher numerator – reserves – gives a higher ratio, as does a small denominator – breakeven prices. The **United States** scores the highest R/B-2030 ratio, in our workings, having both large reserves and a low weighted average breakeven cost of production across these. However, in a world where oil demand declines sharply, Saudi Arabia may nevertheless be better placed as, despite smaller reserves, it has a much lower average breakeven price, as the formulae above show, and so may ultimately be best placed to find economic upside in providing oil and gas in a lower carbon world.

By comparison, the United Arab Emirates has only about 11% of the US's 2P reserves in 2030 and not a significantly lower breakeven price, meaning it has a much lower ratio than the US. Figure 12 shows the ten countries that have the highest R/B-2030.

Figure 12. Oil & gas reserves-to-breakeven ratio of the top 10 countries (2030e)



Source: HSBC, Rystad Energy

◆ ***NEW* INDICATOR: Fossil fuel subsidies (level and change)**

Distortion to the energy transition

Energy subsidies distort the energy market by creating an uneven playing field (*Keeping it cool, - Moving towards global carbon pricing*, September 2015). Subsidies can be direct (cash payment, tax rebate) or indirect (under-pricing the externalities caused by that activity). Here we focus on direct subsidies for fossil fuels, which encourage their use and can discourage other investment in low carbon infrastructure, energy efficiency and renewables. We use UN data to explore this angle, specifically pre-tax subsidies for both consumption and production of fossil fuels, as a proportion of total GDP (%).

Using the most recent datapoint – 2017[8] – we find 22 of our sample of 77 countries have no subsidies, whereas **Egypt** gives the most significant amount, at around 6.3% of GDP. This is followed by **Saudi Arabia** and **Kuwait**[9].

However, on the change metric, Saudi Arabia, followed by Egypt and Bahrain perform the best, as they have all significantly reduced these subsidy levels since 2013. 17 of our sample of 77 have increased fossil fuel subsidies as a share of GDP during this period – albeit most often by small amounts. **Kazakhstan, South Africa** and **Tunisia** have seen the most significant increases.

* * * * *

The transition is under way

The pathway to delivering a decarbonised economy is extremely challenging, as we explore in *Future Frontiers*, March 2021. It exhausts a lot of the technological options currently available, in some areas requires further innovation and to compound this, there remain many policy gaps to stimulate the scale-up we need for removing emissions fast across a number of sectors. Additionally, some materials may prove to be scarce until adequate reserves or alternatives are found. Yet the cleantech build-out is under way, led by renewable power generation, and with challenges to the internal combustion engine's use of oil the next major step in lowering emissions.

In this section, we have analysed which countries are more dependent on carbon and which less so. Figure 13 captures the rankings in individual indicator areas for the five most resilient and five most vulnerable countries. Next, we move towards developing an understanding of which countries face greater risks from the impacts of climate change.

Figure 13. Energy, carbon and the macro economy

Rank	Country	Economic carbon intensity								Economic diversification & fossil fuel dependence						
		Alternative energy		GHG emissions						Fossil rents		Fossil exports		Reserves	Fossil subsidies	
		Share	Change	ex LULUCF pc	Change	ex LULUCF per GDP	Change	LULUCF pc	Change	Share	Change	Share	Change	to b/e	Share	Change
1	Denmark	23	3	45	3	4	48	33	19	47	27	2	33	34	1	41
2	Romania	16	1	24	29	41	7	1	3	49	33	12	49	31	1	41
3	Switzerland	3	7	28	25	1	67	32	55	1	60	5	40	66	1	41
4	United Kingdom	18	17	40	7	7	37	31	47	48	38	6	67	18	26	34
5	United States	22	21	70	6	23	34	35	72	46	31	3	9	1	34	26
73	Tanzania	66	48	8	57	77	14	75	10	36	76	57	43	43	68	70
74	Bahrain	74	54	76	28	73	38	44	38	64	19	66	6	28	72	3
75	Saudi Arabia	73	53	72	77	61	77	48	42	76	1	74	7	2	76	1
76	Oman	74	54	68	64	63	75	47	40	75	4	72	1	15	74	11
77	Kazakhstan	67	64	66	74	74	10	54	49	73	6	73	73	11	67	77

Source: HSBC

8 Note that 2015 datapoints have been used where data is missing.
9 Tax subsidies can often largely be allocated to producers, and so the pre-tax subsidy would be largely the consumer subsidy. And it's likely that the countries which produce at lower cost, i.e. generate high rent, will also sell fossil fuel derived products to their population at lower price than the international price.

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Climate change issues a key driver of commodity price trends

Climate change developments, as well as the pandemic, are having profound effects on commodity markets. The pandemic is expected to change some demand patterns permanently. In particular, working-from-home will accelerate digitalisation and reduce travel – with implications for oil demand. At the same time, the COVID-19 shock and the government spending programmes it prompted – plus a new US administration, the European Green Deal and Beijing adopting a net-zero target – have bolstered the momentum in global climate-change policy.

The intertwined nature of shifting climate change realities, policies and attitudes and the impact on commodity markets has increasingly meant that tracking and forecasting commodity market developments involves a clear perspective on climate change developments. In our view, commodity markets and climate policy cannot usefully be assessed in isolation, so much of our recent commodities coverage explicitly seeks to set out climate policy views to underpin the commodity market forecasts (for some of this coverage see '*Global Commodities: COVID-19 and Climate change*', 5 March 2020 and '*Global Commodities: Don't get too carried away*', 10 March 2021).

Climate change has clear impacts on demand for commodities. For example, government policy changes are motivating reduced carbon emissions, decreasing demand for carbon-intensive products, such as coal and oil, and favouring those commodities used in cleaner energy production, such as the battery and electricity network-related materials, lithium, cobalt and copper.

The supply-side for many commodities has also been heavily impacted by changing policies and attitudes towards climate change. Over the past couple of years there has been a distinct and rapid shift in corporate and investor policy. Major corporates across the world have sought to adopt net-zero emissions strategies. Large fund managers have been shifting their investment mandates, shunning investment in higher carbon-emitting technologies, such as coal mines. Financial innovations, such as green bonds, are facilitating these shifts.

In the commodities sector itself there has been increased recognition of the need to decarbonise production. Major producers of oil, steel and energy products have been announcing more stringent carbon mitigation strategies, to reduce the carbon-footprint of the production of resources.

At the same time, although many of the sorts of impacts on commodity markets are clear, for some commodities the effects can be counter-intuitive. For example, while high carbon emitting commodities, such as coal and oil, are set to see lower long-term demand, in the short run, a lack of investment in coal mines and large oil projects may limit near-term supply, lifting prices.

Beyond policy changes, climate change is also directly impacting the production of some commodities, particularly agricultural products. More frequent and extreme weather events disrupt agricultural supply chains, as some previously agriculturally-productive locations are unable to produce as much, and other locations become more productive. For instance, the recent La Niña event is driving grains prices higher as it constrains South American supply.

Climate change can also exacerbate other factors reshaping agricultural markets, such as worsening the impacts of disease and pests. For example, African Swine Fever has sharply reduced the hog herd in China, boosting demand for imported protein and re-shaping global meat and feedstock markets.

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Climate risks and adaptation

- The global temperature is rising, but increases are not linear and some countries are warming faster
- Climate change also drives water, food, ecosystem and extreme weather event risks
- Overall, Asian and African nations score as more vulnerable in this section of our analysis

We're already living through climate impacts

The impacts of climate change are no longer a future risk – they're happening here and now. This is reflected in scientific evidence, which shows rising temperatures in a majority of countries, changes to the hydrological cycle leading to water scarcity and increasing severity and likely also frequency of natural events.

Almost all regions were affected by extreme weather events in 2020, with the Australian bushfires perhaps the standout event, and records are now seemingly broken quickly in succession all around the world. The effects of these record breaking events are going well beyond physical damage and highlight the inadequacy of social infrastructure and welfare mechanisms in many areas.

We have observed that the rise in impacts and the need to adapt to these have become more prevalent on the global climate policy agenda. A key pillar of the Paris Agreement captures this:

- **Increasing the ability to adapt to the adverse impacts** of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production

And so, once again, the question which we seek to answer in this section is:

Which countries are at greater risk from physical impacts associated with global warming?

To answer this, in this section we look at an expanded set of metrics. The datapoints which allow us to explore these metrics cover **warming temperatures**, **water scarcity**, **food systems, air pollution** and **extreme weather events**, as in *Fragile Planet 2020*, January 2020. However, on this occasion, we are also including **ecosystem services** and **sea level risk** metrics in our analysis.

> **"the rise in impacts and the need to adapt to these have become more prevalent on the global climate policy agenda**

GREATER RESILIENCE

1st. Finland
2nd. Sweden
3rd. Switzerland
4th. Norway
5th. Canada

MOST VULNERABLE

1st. Sri Lanka (ranks 77th)
2nd. Nigeria (ranks 76th)
3rd. Egypt (ranks 75th)
4th. Indonesia (ranks 74th)
5th. Côte d'Ivoire (ranks 73rd)

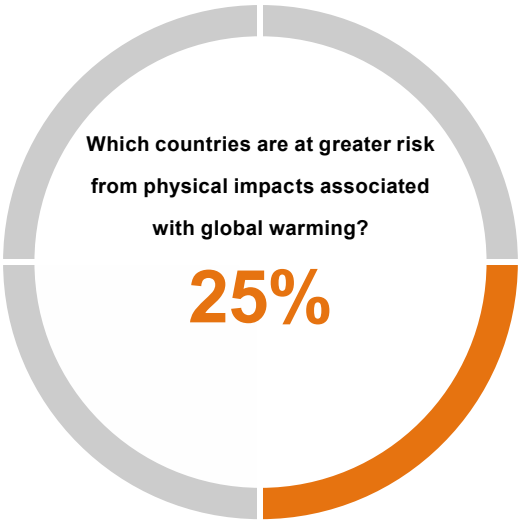
The **Nordics** score well on resilience in this section, once again, as do other wealthy European nations. **Canada** and the **US** both rank well in this section (5th and 9th respectively), despite carrying some high risk factors relating to extreme events, both in terms of increases in the number of people affected and damage costs over the past decade.

More physical climate risk in emerging and frontier markets

At the other end of the table, EM and FM countries dominate. Bottom-ranked **Sri Lanka** shows high vulnerability in relation to water metrics, deforestation, extreme weather events and biodiversity risks. **Nigeria** and **Egypt** rank as next most vulnerable.

Figure 14.

Climate risks and adaptation



Temperature	**3.57%**
1. Average and change	
Water scarcity	**3.57%**
1. Renewable water	
2. Basic drinking water services	
Air pollution	**3.57%**
1. Ambient air quality – PM10 levels	
2. Outdoor air pollution – fatalities	
Food systems	**3.57%**
1. Agricultural value add in GDP	
2. Food security – cereal dependency ratio	
3. Food security – food production variability	
Ecosystem services	**3.57%**
1. Deforestation	
2. Biodiversity – threatened species by population	
3. Biodiversity – threatened species by land area	
Seal level risks	**3.57%**
1. Land elevation – land area below 5m	
2. Land elevation – population living below 5m	
Extreme weather events	**3.57%**
1. Frequency of events	
2. Sensitivity – people affected	
3. Sensitivity – fatalities	
4. Sensitivity – damage costs	

Source: HSBC

Rising temperatures

Higher temperatures bring multiple risks

Warmer countries face different climate risks to colder ones. Indeed, there are several reasons to consider countries in hotter regions to be more exposed compared with those in colder regions, in our view. Countries in the tropics experience a lower seasonal variation in temperature compared with those in temperate (colder) regions. There are a number of associated impacts. For instance, warmer temperatures and wetter conditions can drive the spread of diseases, including insect-borne diseases like malaria and dengue fever, tick-borne Lyme's disease and a number of waterborne parasites (we described and discussed climate-exacerbated health risks in *A new metropolis – Future cities: global warming and the risks to health*, 5 November 2019). Rising temperatures can also affect ecosystems, rendering them less hospitable to native biodiversity and more susceptible to natural disasters, such as wildfires.

We've incorporated two metrics in our analysis:

- **INDICATOR: Average temperature (level and change)**

It's hot in the Gulf and the tropics…no surprise…

Qatar and **Bahrain** experienced the highest average annual temperatures from our sample at 28.37˚C and 28.33˚C, respectively, with **Singapore** third at 27.90˚C. We take the average absolute temperature in the decade 2007-2016.

…but the biggest increases over the past 20 years were in Eastern and SE Europe

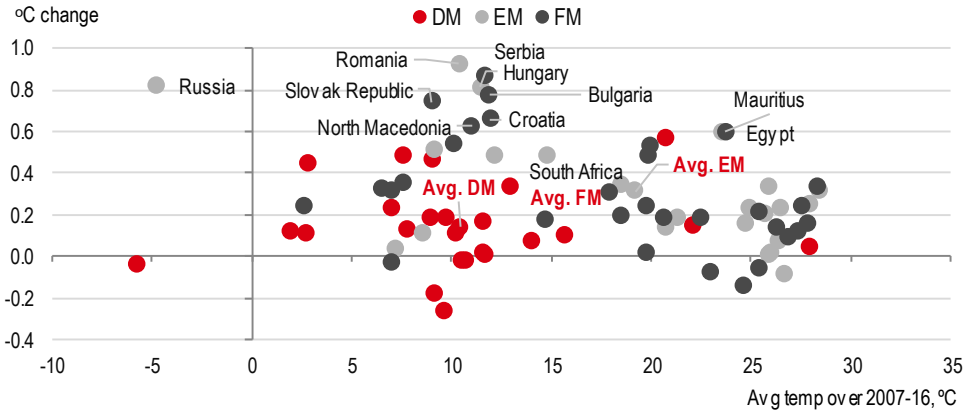
Using the same data, we look at the change in decadal average temperatures between 1997-2006 and 2007-2016. We have used national temperature data that average values recorded at multiple stations. We use data from the University of East Anglia's Climatic Research Unit. The country registering the greatest change over the two decades to 2016 was **Romania**, which warmed by close to 1˚C (0.92˚C), rapid warming over a 20-year timeframe. Interestingly, other countries in the region saw some of the largest temperature increases of our sample set too. **Serbia**, **Russia**, **Hungary** and **Bulgaria** ranked second to fifth in terms of temperature increases, respectively.

Countries, particularly large ones, may have considerable variation in rising temperatures *within* their boundaries. Intra-country regions may warm differently due to latitudinal variation. Equally, there may be topographical drivers. Inland regions may warm faster than coastal areas – such a disparity has been witnessed in **South Africa**. As we discussed in *South Africa: Next five years crucial to climate response*, 13 May 2019, World Bank data show an average change from 1901 to 2016 of 2.17ºC (from 16.88 to 19.05 ºC). This resonates with wording from South Africa's pledge towards the Paris Agreement, which noted on the front page that 2ºC of global warming "translates to up to 4ºC …by the end of the century". On a localised basis, the Department of Environmental Affairs claims that increases greater than 6ºC are possible for the western, central and northern interior, over the course of this century.

> **"Over the last 20 years, warming has been fastest in Central and Eastern Europe**

Large-scale subsistence farming in the tropics, where many EM and FM countries are, means larger populations are exposed to climate impacts on agriculture. We think that even though the cost of climate change will vary between the regions, it will be disproportionately high for countries in the tropics, many of which are classified emerging and frontier. We discuss impacts on agriculture again later in this section.

Figure 15. Getting warmer: national average temperatures – level vs change



Source: Climate Change Knowledge Portal, World Bank

Water scarcity

In this section we consider data showing the availability of water to a country's citizens. UN Water states that "water is the primary medium through which we will feel the effects of climate change"[10]. Climate change affects the full water balance, from precipitation, through to evapotranspiration and run-off. It is predicted to lead to greater variability in precipitation and decreased storage of water in snow and ice. This will then underlie increased variability in the flow of rivers, driving both flooding and drought, and thus less reliable surface water supply.

Water scarcity can often be a sub-national risk

Country level water statistics, which show water availability per capita on a country basis, are important for gauging broad structural risks faced. In many cases, centralised policy-making will indeed provide remedies to scarcity, in our view. However, we think the distribution of water resources within a country, and crucially whether water is located in the regions with high water demand from competing sectors, poses specific risks to local communities and economic activity. Globally, the population is projected by the United Nations to continue to increase for the rest of this century (despite any new challenges to the rate and trajectory associated with the pandemic, see *Population and the pandemic*, 6 January 2021), exacerbating pressures on global per capita water availability. We think understanding localised operating risks and reputational risks associated with companies is crucial for investors, especially where companies are using scarce water resources in operations, as well as measures taken by companies to manage their water-related risks.

We have used two metrics which rely on data from the United Nations Food & Agriculture Organisation (FAO) in this part of our analysis, as discussed here:

- **INDICATOR: Renewable water (availability per capita, level and change)**

Water availability can change because of *demand or supply variation*. On the demand side, this can be due to a growing population and/or a population with higher water use (for instance a more affluent country). In terms of supply, droughts and changing hydrological patterns can limit supply, while investment in water infrastructure, changes in economic activity and higher rainfall can increase supply.

The 77 countries analysed here had an average decline in annual per person water availability of 4.7% between 2007 and 2017, and only 13 of the 77 countries saw an increase in annual per capita renewable water availability during that time period.

10 Water and Climate Change, UN Water, unwater.org/water-facts/climate-change/

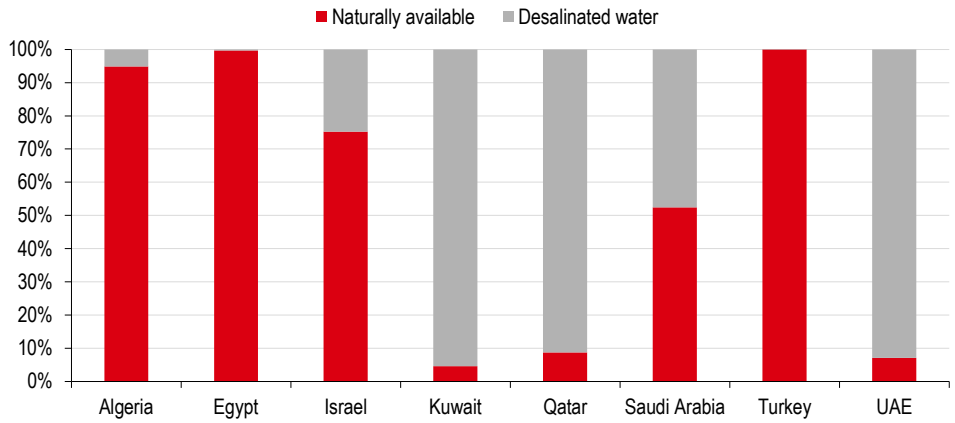
Of all countries in our sample set, **Kuwait** has the lowest water-availability per capita, with a value of 4.9m^3/ person/year, followed by the **United Arab Emirates** with 15.8m^3/ person/year. The developed market economies with the lowest per capita availabilities are Singapore and Israel.

Eight of the 10 worst performing countries on this metric are located in the Middle East. Similarly, of the top 10 countries that have seen the greatest decline in water availability over the past decade, all of them are located either in the Middle East or Africa.

Desalination is one solution, although it can be very energy intensive

Having very high levels of water scarcity requires countries to make greater efforts to increase water availability, conserve it and use it more efficiently. Some countries use large amounts of desalination, including in parts of the Middle East, with Kuwait, Qatar and the UAE particularly dependent on the technology.

Figure 16. Water availability across major MENAT economies (2017/latest available)



Source: Aquastat, FAO

Several countries have water abundance of over 5,000m^3 per capita. For example, **Iceland** has the most renewable water resources, at c508,384m^3 per capita, 103,103 times more than Kuwait. **Canada** follows in second place[11].

◆ INDICATOR: Access to basic drinking water services

Potable water is a key development challenge

Providing safe drinking water and sanitation for a population is a core development target, because it allows for a healthier, more resilient and productive population, which is also more likely to be better equipped to respond to the effects of climate change. Indeed, the world has made much progress on the provision of safe water and sanitation facilities to those that need it; in 25 years, the share of the global population using an improved drinking water source rose from 76% to 90%. The UN Sustainable Development Goals target universal and equitable access to safe and affordable drinking water for all by 2030, *Sustainability engaged*, 15 March 2019.

The COVID-19 pandemic has further highlighted our fragility in the face of emergent health risks. Nearly 1,000 children each day die due to preventable sanitation related and diarrheal diseases, an estimated 30% of the global population lacks access to safely managed drinking water, and 60% do not have access to safely managed sanitation facilities.

11 Internal Renewable Water Resources (IRWR): Long-term average annual flow of rivers and recharge of aquifers generated from endogenous precipitation. Double counting of surface water and groundwater resources is avoided by deducting the overlap from the sum of the surface water and groundwater resources.

…which links directly with climate change

Further, climate change and population growth are putting increasing pressure on water infrastructure. Altered water cycle patterns and extreme weather events are making it even harder to access safe drinking water, and changing temperatures can lead to more pathogens that make water unsafe to drink. In 2020, the theme of UN Water's annual World Water Day was "Water and Climate Change", which focussed on the link between the two and set out the need for climate policy makers to put water at the heart of their action plan.

We use the FAO's metric of "percentage of the population that uses at least basic drinking water services" as a proxy for access to safe water; and we use the level for the most recent datapoints available, which are for 2017. **Tanzania** ranks lowest here, followed by **Kenya**. 37 of the 77 countries in our sample provide access to at least basic water supplies for 99.5% of the population or more.

Air pollution

A local environmental risk…

Air pollution is a *local* environmental risk (unlike the global warming impacts of GHGs) and should be understood, and addressed, as distinct to global climate change. However, it is causally also closely coupled with climate change. According to the WHO, there were approximately 4.2 million premature deaths attributable to ambient air pollution globally in 2016, of which 88% occurred in low-and middle-income countries[12]. 40% of these deaths are attributable to ischaemic heart disease, 40% to strokes, 14% to respiratory diseases and 6% to lung cancer. Many studies have demonstrated links between air pollution and health risks[13]. Meanwhile, an academic paper found over 10 million deaths attributable in 2012 to outdoor air pollution from fossil fuels[14]. (We discuss air pollution risk in more detail in *A new metropolis – Future cities: global warming and the risks to health*, 5 November 2019.)

…linked to climate change

On the one hand, *air pollution can contribute to climate change* – ozone and particulate matter are both emitted in high levels in some areas by road transport, industry and coal-fired power generation and both have an effect on the climate as well as local air pollution. Air pollution is caused by the release into the atmosphere of SOx, NOx and particulate matter through fossil fuel use – vehicle exhaust emissions, oil use in residential cooking and heating, coal-fired power generation and industrial activities such as petrochemicals and metal-making. It is also caused by airborne dust particles from drying wetlands, deforestation and land erosion. Reciprocally, *climate change can also exacerbate air pollution* by increasing local levels of such air pollutants – which can persist for longer in warmer temperatures – and so exacerbating cardiovascular and respiratory disease levels.

In addition, dust storms associated with drought conditions contribute to degraded air quality due to higher airborne particulate counts. The Intergovernmental Panel on Climate Change (IPCC) released a *Special Report on Climate Change and Land (SRCCL)* in 2019. The key message was that humanity's reliance on the land for existence is under threat from climate change, yet our activities exacerbate a changing climate (see *Climate change and Land: Stranded on a desert planet*, 9 August 2019). One finding in this report was that changes in land cover and land use have caused dust storms to be more frequent and more intense, increasing air pollution and posing a risk to human health.

Here we use two indicators to understand the risks which country populations face:

- **INDICATOR: Ambient air quality**

12 WHO – Ambient air pollution GHO (Global Health Observatory data) link – i.e. attributable to air pollution alone and to air pollution which is exacerbated by climate change
13 https://www.nejm.org/doi/full/10.1056/NEJMe1909053?query=recirc_curatedRelated_article. Additionally, a 2019 paper from the University of California found that even small increases in particulate matter can increase mortality risks, and that even levels which are below WHO limits can be damaging.
14 https://www.sciencedirect.com/science/article/abs/pii/S0013935121000487

Cities typically have much higher pollution than rural areas, driven by high concentrations of transport and other activities that use fossil fuels. In 2016, the World Health Organisation (WHO) estimated that more than 80% of people living in urban areas that monitor air pollution levels are exposed to air quality levels that exceed the WHO's healthy limits.

Here we use data from the WHO which measures the PM10 counts for cities. We take the average levels for cities included in the WHO data.

On this indicator, **Pakistan** registers the highest reading of PM10 levels (averages taken across cities), followed by **Egypt** and **Bahrain**. African countries including Botswana and Nigeria also perform poorly here[15].

◆ INDICATOR: Outdoor air pollution – fatalities

Air pollutants can have many damaging health effects and can, in many cases and through several causes, be fatal for exposed members of the population. For this indicator, we explore outdoor air pollution impacts, where outdoor air pollution arises from industrial activities, transport and household consumption of fossil fuels for heat and cooking. Of all pollutants produced, the WHO finds that particulate matter has the most significant impact on human health.

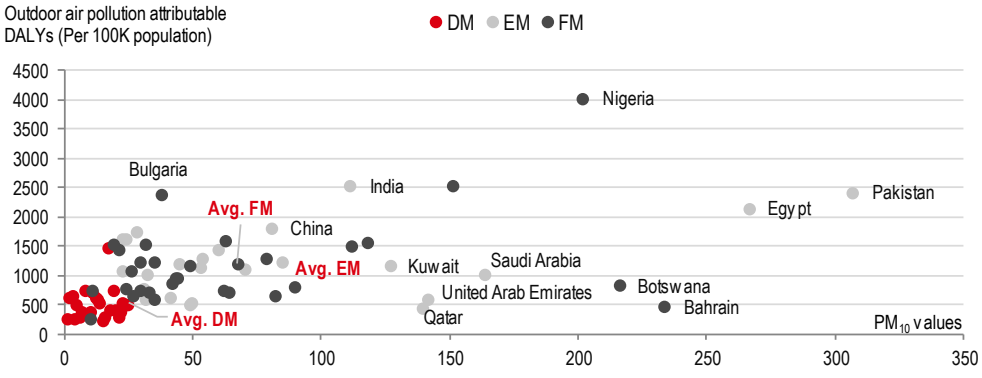
4.2 million

Deaths attributable to outdoor air pollution (WHO)

In 2016, ambient air pollution (outdoor air pollution) was responsible for 4.2 million deaths. Here we again include WHO data, which looks at ambient air pollution attributable DALYs (Disability Adjusted Life Years), normalised per 100,000 of the population.

Reflecting the WHO finding that particulate matter pollution is an environmental health problem that affects people in low- and middle-income countries disproportionately, we also find a similar trend among the countries in this report. **New Zealand, Canada** and **Iceland** display the highest resilience on this metric, while **Nigeria, Côte d'Ivoire** and **India** are most vulnerable, suffering the most health risks from our sample set of countries.

Figure 17. Urban air pollution is a killer



Source: WHO. Note: Air quality measures PM10 in cities. Note DALYs = Disability Adjusted Life Years

15 Note: Alternative data sources used for Nigeria, Kazakhstan and Botswana due to misisng datapoints. Alternative sources: World Health Organisation, World Bank Towards Cleaner Industry and Improved Air Quality Monitoring in Kazakhstan report, Research Journal of Chemical Sciences.

Food systems

◆ INDICATOR: Agriculture in the economy

Growing risks for a growing population

In a world facing climate risks, we think excessive economic dependence on agriculture poses a risk. Physical risks – from changing temperatures, water scarcity and extreme weather events – pose increasing risks to agribusiness. Additionally, as the world seeks to limit emissions, pressures on land use are increasing. Some countries, including the UK, are beginning to consider returning agricultural land to forest in order to limit emissions and protect biodiversity, while other actors, including oil & gas and aviation companies, are exploring afforestation as a means of offsetting their emissions from fossil fuel use.

Here we consider how much cultivation of crops, forestry, livestock production and fishing add to the economy. The World Bank provides dollar amounts which we consider relative to GDP. **Kenya**'s economy is most dependent on agriculture, followed by **Tanzania** and **Pakistan**.

Food security

Much deforestation occurs to clear land for agribusiness. However, deforestation does not guarantee food security.

Changes in agricultural prices can be driven by demand and supply-side forces. As HSBC Economist Paul Bloxham noted in *Fragile Planet – Commodities: From climate risks to agriculture*, 11 July 2018, on the demand side, population growth and rising incomes play the key driving role. Meanwhile, the rapid expansion of the middle classes, particularly in emerging Asia, is changing what types of commodities are in most demand. Large price changes and moves in consumer price baskets can, in turn, have significant effects on economic growth and political stability – food is, after all, a necessity. As a result, the prices of agricultural products play an important role in the outlook for a large range of emerging economies, and these can be negatively impacted by climate change and associated weather implications in the future.

So while we score economic dependence on food production negatively (above), we see self-sufficiency in food as a positive, in a world where food procurement may become increasingly competitive. To understand the ability of countries to be self-sufficient in food production, we consider the following indicators:

◆ INDICATOR: Cereal dependency ratio

Self-sufficiency

How able is a country to feed itself from its own production? In a world with increasing population, increasing food consumption and changing eating habits, and worsening climate change, we think there is potential for greater barriers to food exports in future. Governments of countries facing shortages may, in our view, implement increasing numbers of export bans.

And so we use FAO data for the cereal-imports-dependency ratio. This tells us how much of the available domestic food supply of cereals has been imported and how much comes from the country's own production. It is computed as (cereal imports - cereal exports)/(cereal production + cereal imports - cereal exports) * 100. While we acknowledge that there are other foods than cereals, this is a staple, and in a world with greater pressures on food supply is, in our view, likely to form a greater proportion of consumption than animal-based protein, for example, which is more water intensive and land intensive to produce.

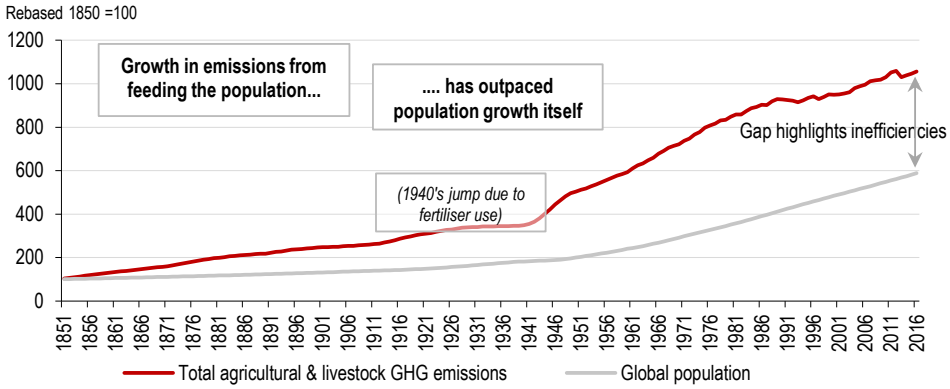
Lithuania is best-placed, followed by **Latvia** and then **Australia**[16].

16 Note that Bahrain, Qatar and Singapore do not have any cereal production and there is no data provided. They are thus assigned a ratio of zero.

◆ INDICATOR: Food production variability

When the amount of food produced is not consistent year-on-year, this can lead to challenges to resource allocation and budgeting for countries and other actors. Volatility is, in our view, likely to increase along with greater variations in temperature extremes and rainfall[17]. The FAO's per capita food production variability compares variations across countries and time. **New Zealand**, followed by **Spain** and then **Australia**, score lower here.

Figure 18. Our current food systems could be much more efficient



Source: PRIMAP, World Bank

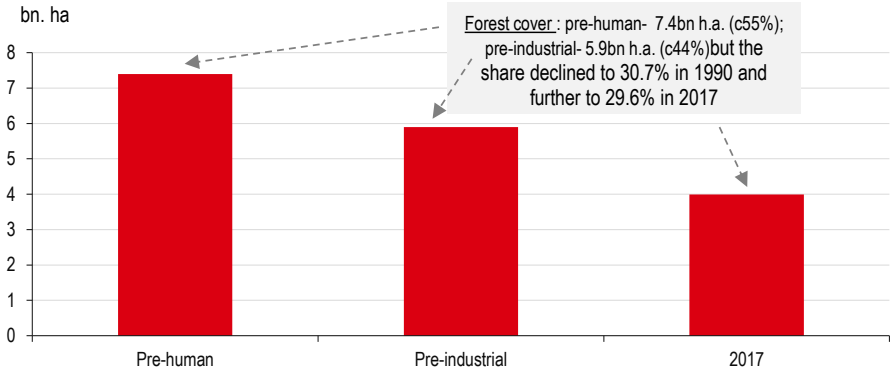
Ecosystem services

◆ INDICATOR: Deforestation

In many countries, forest cover is coming back up

Deforestation has been taking place for millennia, and some countries peaked deforestation many years ago – the UK, for instance, troughed in around 1900. However, data are patchy for long time series for many countries around the world. We focus here on more recent trends. Given global efforts to coordinate addressing environmental degradation and climate change have been broadly under way for three decades, and given many emissions reduction pledges use 1990 as a benchmark year, we also this date as our measurement starting point. And so we track whether deforestation or afforestation has occurred since 1990 and rank countries on this basis.

Figure 19. Change in total forest cover around the world



Source: FAO, Earth Policy Institute

17 The International Dietary Data Expansion Project states that food supply variability can also result from instability and responses relating to trade, consumption, and storage, in addition to changes in government policies such as trade restrictions, taxes and subsidies, stockholding, and public distribution.
https://inddex.nutrition.tufts.edu/data4diets/indicator/capita-food-supply-variability

UN FAO data show forest cover year-on-year at the country level. Of the countries in our sample set, 22 countries have lost forest cover between 1990 and 2016 (the latest year for which we have data), and **Nigeria** performs the worst of all, with only 38% of the forested area that the country had in 1990 currently remaining (previously, 19% of the land area was forest, now only 7% of the country is forested). **Indonesia** and **Argentina** are the next worst performing on this metric.

42 countries in our sample set have *gained* forest cover over this time horizon, with **Vietnam** seeing the biggest progress, increasing forest cover from 29% in 1990 to 48% in 2016. 13 of the countries in this analysis – many Middle Eastern economies – had forest cover of less than 5% in 1990 (perhaps due to high altitudes and/or desert conditions), and thus we have ascribed these countries a midpoint ranking.

38%

… of Nigeria's 1990 forested area remained in 2016

◆ ***NEW* INDICATOR: Biodiversity: Threatened species (by population and by square kilometres)**

Biodiversity loss and climate change are reciprocal, compounding threats

Measuring the loss of biodiversity and natural ecosystems is an important component of assessing climate vulnerability because climate change and the global biodiversity crisis are very closely linked. Global warming (along with factors including agriculture and hunting) is a key driver of biodiversity loss. And more relevantly for this report, **conserving ecosystems and biodiversity is important in combatting climate change**.

Nature-based solutions

The Paris Agreement made clear the vital importance of the world's ecosystems in achieving net zero emissions. The Agreement calls on countries to conserve and enhance natural carbon sinks and reservoirs of all types – biomass, forests and oceans, as well as other terrestrial, coastal and marine ecosystems – to fully harness their mitigation potential. We have written on the global biodiversity crisis and the role that investors can play in it in *Paradise lost? Why investors must address the biodiversity crisis next*, June 2020.

A Red List for vulnerability

The International Union for the Conservation of Nature provides a "Red List" database, which supplies statistics for the global extinction risk status for animal, plant and fungus species[18]. Established in 1964, the list provides critical information such as population size, range, ecology and threats to catalyse action on biodiversity conservation. The data are thus an effective tool for measuring and monitoring biodiversity risks, as well as progress made from conservation efforts around the world.

18 The list includes categories based on the risk of global extinction, ranging from extinct (species that have been lost), extinct in the wild (species which are known only to survive in cultivation/ captivity/ naturalized population), critically endangered, endangered, vulnerable, near threatened, least concern and data deficient (for species where there is inadequate information to make risk assessment). One important factor with this data (and representative of broader challenges associated with measuring biodiversity) is that many species have been yet been assessed for the ICUN Red List database – or indeed by any other data source – because species are still yet to be discovered, or their population and geographic range are difficult to measure. Therefore, this is a proxy for biodiversity risks based on risks to species that are known to exist and that have been assessed.

In this report, we use the dataset of "number of threatened species by country" from the UN Red List, in order to measure biodiversity risks across our sample set of countries. "Threatened species" include species that are listed in any of the following three categories: *critically endangered, endangered and vulnerable*. Any species that falls into these categories is, according to the IUCN, considered to be threatened with global extinction.

We consider the prevalence of threatened species in our database normalised by both population size and also by square kilometres of land area, in order to make the results comparable across countries. **Mauritius** and **Malta** score poorly on both the population and land area metrics; falling into the top 3 worst performers on both accounts. **Singapore, Slovenia** and **Cyprus** also appear near the top of the worst performers on both indicators.

Sea level rises

Melting ice driving risks to coastal populations

As the world warms, the ice at the two poles is melting – faster through warmer months and with less re-freezing in polar winters. Ice melt means rising sea levels are an increasing threat, all around the world. Low-lying land areas are increasingly susceptible. Flooding risks threaten infrastructure, agriculture, industry and human settlements. Coastal cities are at heightened risk, with impacts threatening to compound as they literally sink under their own weight, with cavities created by extraction of ground water further exacerbating the issue[19]. And so we have now expanded our indicators to include a metric that covers this systemic risk.

- ***NEW* INDICATOR: Elevation above sea level (by share of land area and share of population)**

We use two World Bank indicators to explore risks related to sea level rises in this report:

1. the share of land area in each country where elevation is five metres or less below sea level
2. the percentage of the total population in a country, that is living in areas where elevation is five metres or below.

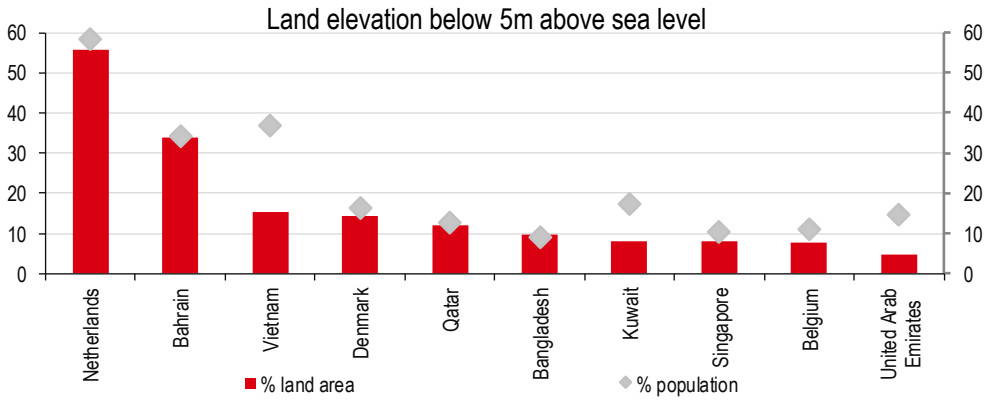
These two metrics give an indication of the extent to which a country is likely to be affected by rising sea levels with regards to both damage to human and manufactured capital[20].

Nine of the 77 countries in our sample set are resilient to sea level risks in that 0% of the country's land area is below 5m of elevation. These include landlocked **Austria, Botswana, Czech Republic, Hungary, North Macedonia, Serbia, Slovakia** and **Switzerland,** as well as **Jordan.**

At the other end of the spectrum, there are many countries that face extreme threats from sea-level associated risks. **The Netherlands** performs worst of our entire sample set on both sea level indicators; 56% of the land area lies below 5m of elevation, with 59% of the total population living in these areas. **Bahrain**, **Vietnam** and **Denmark** are also exposed in terms of land area and population living there. 34% of the land area and population live below 5m of elevation in Bahrain, and in Vietnam, 37% of the population live in these low-lying areas, despite low-lying land area making up only 15% of the country's land area.

19 Rising seas and subsiding cities, *https://www.nature.com/articles/s41558-021-01009-6*, Nature Climate Change, 8 March 2021
20 The World Bank updates these indicators only every decade (and 2020 datapoints are not currently available), so we use 2010 data for this.

Figure 20. From ice melt to socio-economic risk exposure



Source: World Bank

Extreme weather events

Climate influence

Scientists are increasingly finding evidence of growing anthropogenic (human-influenced) effects on extreme weather events (as opposed to natural factors). A paper from the American Meteorological Society[21] showed that of 15 events examined in 2019, 12 were found to have had anthropogenic influence (see Figure 23), i.e. they were more likely to have occurred as a result of climate change.

576x...

...more extreme events in Mauritius (per 10,000 sq km) over the past decade than Russia

Climate change can increase the probability of specific extreme weather related events, as discussed in detail in the IPCC Synthesis Report 2014[22]. For example, it is *likely* (probability >66%) that the frequency of heat waves has increased in large parts of Europe, Asia and Australia and that human influence on the climate (i.e. via GHG emissions) has doubled the probability of its occurrence in some locations. The report also highlights that there are *likely* more land regions where the number of heavy precipitation events has increased more than where it has decreased.

- **INDICATOR: Frequency of extreme weather events (level and change)**

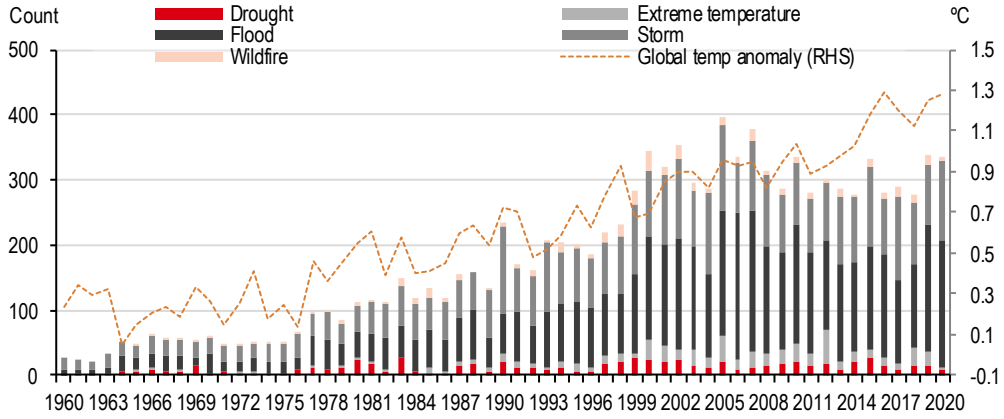
We look at the frequency of climate-exacerbated extreme weather events, defined as *droughts, floods, extreme temperatures, storms* and *wildfires*, for our scoring analysis. In this study, we use data from the EMDAT database, which compiles information on all natural disasters since 1900[23].

21 Explaining extreme events of 2019 from a climate perspective, Bulletin of the American Meteorological Society
22 Intergovernmental Panel on Climate Change (IPCC) Climate Change 2014, Synthesis Report, Summary for Policymakers
23 EM-DAT is a global database on natural and technological disasters, containing essential core data on the occurrence and effects of more than 21,000 disasters in the world, from 1900 to present. EM-DAT is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université Catholique de Louvain located in Brussels, Belgium. EM-DAT includes all disasters conforming to at least one of the following criteria: 10 or more people dead; 100 or more people affected; the declaration of a state of emergency; a call for international assistance.

More droughts, floods, wildfires, extreme temperatures and droughts…

Figure 21 shows all five categories becoming more frequent as temperatures have risen, over the past 60 years.

Figure 21. Extreme events and the global temperature anomaly (1850-1900)

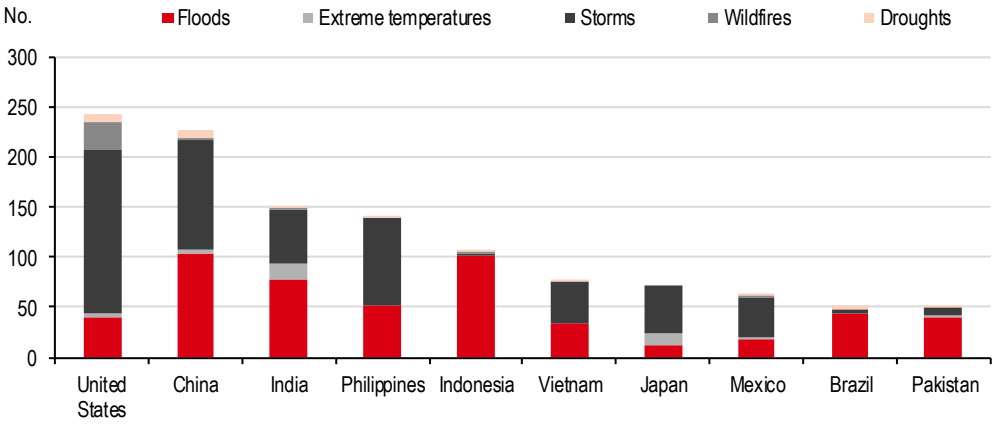


Source: EMDAT, UK Met

For our analysis, we have observed the number of events over a ten-year period to 2020, normalised by adjusting for land mass. The countries from our sample set that experienced the largest number of events over ten years in absolute terms are the United States, China and India. However, when normalising per land area, as we do in this report, the results are different**. Mauritius, Belgium** and **Sri Lanka** suffer the highest number of extreme events among the countries analysed here per square kilometre. We think this highlights the greater requirements for building resilience in small coastal and island nations.

We also look at the decadal change in the count between 2001-2010 vs 2011-2020. Here, **Israel** saw the greatest increase over this period – with its extreme weather event count increasing by 200% over the decades (albeit from a low base of 0.92 events per 10,000 square kilometres in the first decade, to a more notable 2.77 events per 10,000 square kilometres in the second decade). **Jordan**, **Oman** and **Côte d'Ivoire** rank as the next most vulnerable on this metric, with events per square kilometre doubling for all of these nations (although again from a low base)[24]. Of our sample set, six countries faced no extreme weather events during the decade 2011 to 2020: Bahrain, Cyprus, Finland, Iceland, Malta and Singapore.

Figure 22. Countries with the highest number of extreme weather events over 2010-2020



Source :EMDAT

24 Note that three countries (Kuwait, Qatar and the UAE) had zero extreme weather events during the first decade, increasing to a small positive (<1) number of extreme events per square kilometre in the second decade. Given the distorted % change that this represents, we have assigned these countries a midpoint ranking for the purposes of this analysis.

Figure 23. Attributing 2019 extreme events to climate change

Extreme events	Location	Anthropogenic influence on event
Extreme Heat	UK	Increase
Drought	Western Cape, South Africa	Increase
Drought	Southwest China	Increase
Marine heatwave	North Pacific	Increase
Heavy precipitation	Ottawa, Canada	Increase
Winter precipitation	Eastern China	Not defined
Heavy precipitation	Southwest China	Decrease
Low precipitation	Southwest China	Increase
Extreme annual Streamflow	North eastern US	Increase
Hurricane	US	Increase
Typhoon	South Korea	Increase
Fire season	Alaska	Increase
Wildfires	Southwest China	Increase
Cold Outbreak	Eastern US	Decrease
Poor Sunshine	Eastern China	Increase

Source: Explaining extreme events of 2019 from a climate perspective, Bulletin of the American Meteorological Society

Sensitivity to extreme weather events

From frequency to severity

The frequency of natural extreme weather events has been broadly increasing, globally. These will not have the same social and economic ramifications in some areas as similar events that strike elsewhere. To capture this, we now measure *sensitivity to physical impacts by* examining impacts on people. We define sensitivity as the impacts felt by society and the economy to the five categories of extreme weather events which are linked to climate change − droughts, floods, extreme temperatures, storms and wildfires. We use three areas of data to understand this:

- **INDICATOR: People affected (level and change)**

Extreme weather events can greatly disrupt the lives of those in the disaster areas. EMDAT data includes a category for 'people affected', which encapsulates people requiring immediate assistance during a period of emergency, i.e., requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance.

Vulnerability in Asia

The Philippines, followed by **Thailand** and **Sri Lanka**, saw the highest share of their population affected by disaster events over 2011-2020. In the Philippines the figure is particularly high, at 922 people per 1,000 population. The trend is worsening in some countries, for example in **Israel**, where people affected jumped from 2.6 per 1,000 of the population in the first decade to 227.9 in the second decade[25].

…and heightened social risks in the US

The number of people affected by extreme weather events across the **United States** continues to rise. In the first decade of the 21st century, 67 people per 1,000 population were affected by extreme weather events. This has risen by 303%, to 270 people, between 2011 and 2020, a sharper rise than other countries in this study.

- **INDICATOR: Fatalities (level and change)**

In the worst instances, extreme weather events may lead to loss of life, sometimes in high numbers. The number of deaths associated with extreme weather events over 2011-2020 was highest in **Bangladesh**, followed by the **Philippines** and then **France**. We think this again highlights the fact that events have high impacts in a geographically broad range of countries and regions[26].

25 Qatar and the United Arab Emirates saw no people affected in the first decade, and a positive number of people affected in the second decade, thus distorting the change numbers. We have assigned these countries the midpoint ranking.
26 Botswana, Ireland, Kuwait, Norway have distorted change numbers as they are going from 0 fatalities to a positive number. Thus, these countries are allocated around the median change number. They will now fall in the mid point of the ranking.

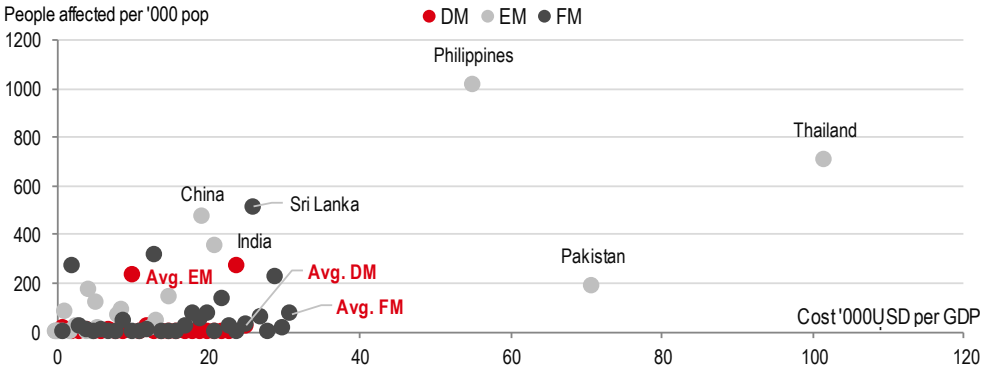
ASEAN exposure

◆ INDICATOR: Damage costs (level and change)

Extreme weather events can bring tremendous costs. We look at data which capture the estimated amount of damage to property, crops, and livestock. For each disaster, the registered figure corresponds to the damage value at the moment of the event, i.e., the figures are shown true to the year of the event.

Total costs incurred globally, attributable to climate-related weather events, amounted to 1.34bn USD between 2011 and 2020. This is a 38% increase compared to the level of damage costs experienced in the previous decade. Damage costs per GDP are highest in **Thailand,** followed by **Vietnam** and the **Philippines**[27]**.**

Figure 24. People affected per 000pop vs cost per 000GDP (2009-2019)



Source: EMDAT, World Bank; UN population data. Note: some sample countries are not named

* * * * *

The global population is projected by the United Nations to continue to increase for the rest of this century (albeit with slowing momentum), reaching 10.9 billion by 2100. This will, in turn, exacerbate pressures on populations as global per capita water availability goes down, more people face higher temperatures and must adapt to extreme weather events, air pollution risks persist and there are greater risks to food supply.

We think such pressures will be felt more acutely by the elderly and the young (see *a new metropolis – Future cities: global warming and the risks to health*, 5 November 2019), as well as the poor and disenfranchised communities around the world. These will increase the requirements to build greater resilience to climate impacts and develop robust adaptation frameworks.

In the next section, we consider which countries have greater potential to respond to these physical climate risks, as well as to the energy transition risks which they face.

27 Nine countries (Serbia, Peru, Botswana, Ireland, Tunisia, Egypt, Ghana, Qatar, Tanzania) experienced zero damage costs from extreme weather events during the first decade, according to the dataset we utilise, increasing to a positive number in the second decade. Given the distorted % change that this represents, we have assigned these countries a midpoint ranking for the purposes of this analysis.

Figure 25. Climate risks and adaptation

Rank		Temp		Water scarcity			Air pollution		Food systems			Ecosystem services			Sea level risks		Extreme weather events							
	Country	Av	Chng	Ren	Chng	Drinking	PM10	Fatalities	Agri value	Cereal dep ratio	Production var	Deforestation	Threaten. species		% land area	% pop	Freq	Chng	Ppl affected	Chng	Deaths	Chng	Costs	Chng
													pop	sqkm										
1	Finland	72	58	12	22	6	3	7	32	19	50	48	35	11	23	28	1	1	1	1	1	50	1	48
2	Sweden	5	24	17	37	4	6	5	17	17	31	54	31	14	34	44	11	49	1	39	11	48	18	12
3	Switzerland	8	45	33	46	3	7	10	7	58	33	23	48	61	1	1	65	19	12	6	17	7	23	15
4	Norway	3	25	3	47	1	10	6	24	47	17	57	56	16	52	46	4	4	17	24	10	36	1	1
5	Canada	1	7	2	41	39	4	2	21	11	69	58	15	2	48	30	5	23	41	70	23	69	56	67
73	Côte d'Ivoire	70	20	39	69	74	71	76	71	49	28	49	34	33	14	45	23	70	34	61	41	70	1	48
74	Indonesia	67	19	29	54	70	60	51	69	36	16	76	23	37	60	61	39	63	42	48	30	24	50	61
75	Egypt	55	68	66	66	43	76	72	66	54	26	33	5	9	45	74	8	29	26	68	18	63	27	36
76	Nigeria	72	46	56	71	75	73	77	74	38	40	77	6	21	21	36	21	43	54	57	43	61	32	70
77	Sri Lanka	71	26	46	30	69	59	32	61	55	27	71	63	73	54	40	71	68	71	52	68	67	67	69

Source: HSBC

Click to request data for this report

Climate governance

- Some countries have greater potential to respond to transition and physical risks
- Nordic and other northern European nations rank highest in our analysis here…
- …with their resilience supported by wealth, policy frameworks, institutional quality and, via newly included indicators, their gender equality and healthcare preparedness

We now move from the focus of the previous two sections – which essentially analysed the first two pillars of climate change, namely mitigating emissions and addressing the impacts – to an analysis, in this section, of **which countries are better placed to address climate risks**.

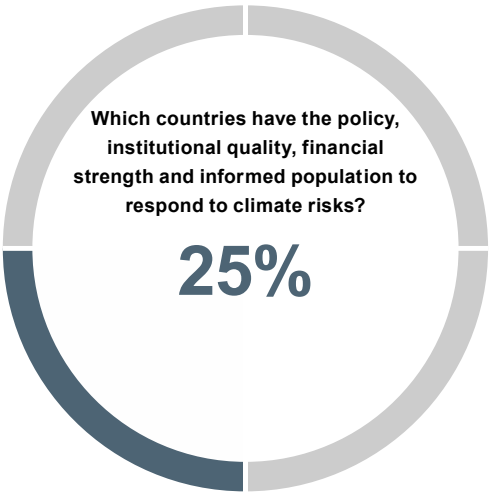
We distil this into a single question:

Which countries have the policy, institutional quality, financial strength, health preparedness and informed population to respond to climate risks?

The wealthy **Nordics** fare well in this part of the analysis, buoyed also by strong showings on finance, institutional quality and policy indicators. At the other end of the spectrum, **African** and **South Asian** economies look more vulnerable.

GREATER RESILIENCE	MOST VULNERABLE
1st. Norway	1st. Pakistan (ranks 77th)
2nd. Finland	2nd. Nigeria (ranks 76th)
3rd. Switzerland	3rd. Tanzania (ranks 75th)
4th. Germany	4th. Bangladesh (ranks 74th)
5th. Denmark	5th. Kenya (ranks 73rd)

Figure 26.
Climate governance



Climate finance	**5%**
1. Wealth – GDP per capita	
2. Borrowing potential – debt to GDP ratio	
3. Cost of capital – equity risk premium	
4. Sovereign Wealth Fund	
Institutional quality	**5%**
1. Control of corruption	
2. Rule of law	
3. Regulatory quality	
Enabled population	**5%**
1. Income inequality	
2. Tertiary education	
3. Media independence	
4. Internet adoption	
5. Mobile phone users	
6. Gender equality	
Decarbonisation policy	**5%**
1. Climate policy framework	
2. Government effectiveness	
Health risk preparedness	**5%**
1. Hospital beds	
2. Surgical workforce	

Source: HSBC

It's about money…

So, which countries are better placed to *respond* to the transition and physical risks analysed in earlier sections? We answer this by looking at *capital available* to do this, using various wealth indicators.

…the institutional ability to prudently deploy funds

We then explore *institutional quality indicators* as a guide to countries that are well placed to use this capital. This time, we have added an indicator for *regulatory quality* in this section. This reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. This can be supportive to the build-out by companies of climate-response technologies and infrastructure, both around energy transition and to physical risks.

…as well as an enabled population

We then explore the extent to which the population of a country is enabled to understand, be kept informed and ultimately influence leadership to mitigate risks it faces. Here we include indicators around equality, education and informational flow. Plus, in this report, we also now include *gender equality*, having studied growing evidence of links between gender equality and enhanced environmental outcomes[28]. At an educational level (which our gender equality metric considers), more equality of education provision increases the number of individuals that can access education and hopefully become productive members of society, the expertise of which may well allow for a stronger climate response. The COVID-19 pandemic has only further highlighted inequalities across societies around the world, and so we believe that including this metric is now more important than ever (*From gender to race*, 3 February 2021).

28 https://www.carbonbrief.org/tackling-gender-inequality-is-crucial-for-climate-adaptation#:~:text=Efforts%20to%20tackle%20gender%20inequality,change%20than%20their%20male%20counterparts.
https://www.iucn.org/resources/issues-briefs/gender-and-climate-change
https://www.wri.org/blog/2016/03/if-you-care-about-environment-you-should-care-about-gender

…and robust climate policies

Additionally, we have updated the methodology for our *climate policy outlook* scoring system in this iteration of the report, given that a number of countries have recently strengthened their climate policy pledges, including via the emergence of 'net zero' pledges. Having policy is one thing, achieving ambition is another, so we use the World Bank's Government Effectiveness indicator to gauge this aspect.

…plus a resilient healthcare system to support societies facing growing climate-exacerbated health risks

Finally, we include a new section in this analysis on *Health Preparedness*. With increased focus on health risks due to the COVID-19 pandemic, we believe it is important to explore which countries are better placed to deal with climate exacerbated health risks (*A New Metropolis - Future cities: global warming and the risks to health*, November 2019). Indeed, this will in our view be a growing factor in climate resilience.

Climate finance

Who can fund climate ambition?

We've previously talked about climate finance, or "2ºC finance", as the third pillar of addressing climate change. We defined 2ºC finance as **the allocation of capital for the development and provision of a low-carbon economy that minimises and is resilient to the impacts of climate change** (*Keeping it cool – Financing a 2ºC world*, 10 September 2014). A goal of the Paris Agreement is:

- **Making finance flows** consistent with a pathway towards low greenhouse gas emissions and climate resilient development

Many types of climate finance

Climate finance can come from a number of capital sources, including capital markets, asset owners, private wealth and corporate cash flows, and can be raised through many instruments including grants and loans, project finance and balance sheet financing. Here we focus on the finance available to governments – public financing – as well as to companies, and the broader level of wealth among the population. We utilise the following metrics to look at financial resources in the 77 countries in our sample:

- **INDICATOR: Wealth: GDP per capita**

Wealthier countries, theoretically, should have more money to deploy to transition from fossil fuels and adapt to climate impacts. Gross domestic product per capita (GDP pc) is a wealth indicator to help analyse the ability of the country and the population to respond to climate change. We have chosen this current USD-normalised indicator given energy and commodities are often exposed to *global* pricing, rather than local factors, and also because much cleantech equipment will be sourced internationally[29]. **Switzerland** is the wealthiest country on this metric, followed by **Ireland** and then **Norway**. At the other end of the scale, **Tanzania** comes lowest on earnings per capita, followed by **Pakistan** and **Kenya**.

- **INDICATOR: Borrowing potential**

Public debt is an indicator of the ability of *governments* to respond to climate change. Debt requires payment of interest and repayment of capital. Hence, if an entity owes money, this limits the capital available to be deployed elsewhere, in this case investing to achieve climate adaptation or a low carbon transition. So we look at the ratio of debt to GDP. A geographically diverse mix of mostly EM and FM countries dominate the top end of this ranking indicator – **Estonia** 1st, followed by **Russia** and then **Kuwait**. **Japan** has the highest debt-to-GDP ratio, followed by **Greece** and then **Italy**, theoretically giving them less headroom to raise debt to finance climate adaptation and mitigation.

29 This differs to our use of this metric at purchasing power parity (PPP GDPpc) in some of our previous Fragile Planet notes. PPP GDPpc also gives an indication of the wealth of the country's population; the rationale here was that the less wealthy a country is, the less likely it will be able to channel available capital specifically towards adaptation. We chose the 'PPP version' of this per capita indicator given much adaptation spend would occur within the local economy.

◆ INDICATOR: Cost of capital

This is primarily an indicator of the ability of *companies* to respond to climate change. The cost of capital can be defined as the rate of return required to persuade the investor to make a given investment, and that could have been earned by financing a different investment with equal risk (the opportunity cost).

Here we look at the *equity risk premium* – the rate that investors expect above the risk-free rate, typically that provided by a 10-year US Treasury Bond. A high equity risk premium means investors see investments in a country as more risky and so they are less likely to commit capital to projects which can include those that enable climate adaptation and mitigation. The equity risk premium source we used placed 11 countries as having the lowest premium, including, but not limited to, the **United States, Norway, Germany, Canada**, **Singapore** and **Australia**. All of the top performing 11 countries are developed markets.

At the other end, the premium investors expect is highest in **Argentina**, followed by **Ghana** and **Pakistan**.

◆ INDICATOR: Sovereign wealth fund

This is also an indicator of the ability of *governments* to respond to climate change. Sovereign wealth funds (SWFs) are established with variance in mandates – from shorter-term stabilisation of government finances during commodity revenue volatility, to ongoing contributions to public spending from dividends and interest, and through to seeking to establish a base of wealth for the future (inter-generational equity) – but typically act as a bank for excess commodity revenues until they can be efficiently invested.

A potential source of climate finance

We believe SWFs will increasingly be part of the equation for countries in transitioning to lower carbon and adapting to climate. By investing outside the domestic economy and by investing in non-fossil fuel companies, as some funds have pledged to, SWFs effectively offer diversification. Here we look at SWFs on a per capita basis – i.e., how much is theoretically available to spend on addressing climate change per person. However, we note that the mandates according to which SWFs are managed vary from country-to-country, and in our modelling we do not allow for this. To take into account the fact that SWFs are only a *potential* source of climate finance, and given that they are typically relatively small compared with the money that can be raised in debt markets or is generated in the economy overall (GDP), we have reduced the weighting of this metric compared with other financial indicators.

Norway has the largest fund per capita, followed by **Singapore** and then **Kuwait**. 33 **countries** in our sample have a SWF of some description.

Institutional quality

Institutional quality metrics to gauge national climate governance potential

National governance factors are crucial to understanding a country's potential to address risks

Having the funds available to spend on decarbonising the national economy is one part of a country's capacity to respond to climate change. However, we think it is important to consider which countries have the potential to use funds prudently to adapt. Here we look at three institutional indicators to capture a country's national governance potential:

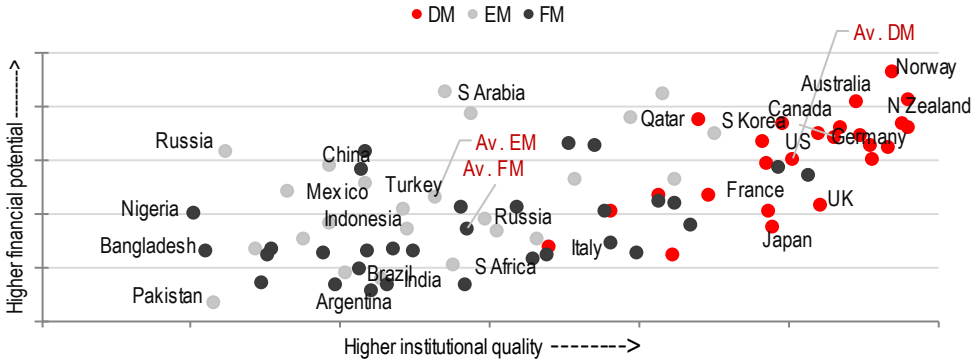
◆ INDICATOR: Control of corruption

This is a World Bank datapoint that represents the use of public power for private gain, as well as "capture" of the state by elites and private interests. A corrupt country is less likely to use funds for adapting to and mitigating climate change to the same degree as a less corrupt country, in our view. **New Zealand** performs best on this indicator, followed by **Singapore** and **Finland. Nigeria,** followed by **Bangladesh** and **Pakistan,** are last**.**

◆ INDICATOR: Rule of law

This captures the extent of confidence in the rules of society, and includes metrics on the quality of contract enforcement and property rights, as well as the likelihood of crime and violence. We have included this because we believe a country with relatively strong contract enforcement and property rights is more likely to be able to use the funds it has available to respond to climate change. **Finland**, **Norway** and **Switzerland** top the rankings here. **Nigeria,** followed by **Russia** and then **Pakistan** are at the other end of the spectrum.

Figure 27. Where financial potential corresponds with higher institutional quality



Source: World Bank, IMF, SWF, NYU, HSBC; simple average calculated for DM, EM, FM

◆ *NEW* INDICATOR: Regulatory quality

This reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. We think this is an important indicator of economies that are likely to attract companies and investment in projects which are positive for building greater climate resilience. **Singapore** has the highest regulatory quality, according to the World Bank's methodology here, followed by **New Zealand** and **Australia**. **Bangladesh**, **Nigeria** and **Egypt** sit at the bottom of the rankings.

Enabled population

Where is an informed population likely to push for climate action?
A better informed population with greater potential to receive, understand and leverage information is also key to addressing climate risks faced, in our view. We use the following six metrics to better understand this:

◆ INDICATOR: Inequality

We look at the GINI Index, which measures the extent to which the distribution of income within an economy deviates from a perfectly equal distribution. We believe that in a more equal society, more of the population will be focused on the risks faced due to climate change and these risks will be more evenly spread, meaning a larger part of the electorate able to put pressure on governments to take action. **Slovenia,** followed by **Czech Republic** and then **Slovakia,** are the most equal countries. **South Africa,** followed by **Brazil** and then **Botswana** are the least equal[30].

30 Note: New Zealand and Singapore take GINI estimates from Knoema. Bahrain, Qatar, Kuwait, Saudi Arabia, Oman have all been assigned the same estimate as the United Arab Emirates given a distinct lack of GINI Index estimates for the Middle East region. Research paper from World Inequality Database suggests GINI indices broadly in line across the region

INDICATOR: Tertiary education

Here, we look at levels of the population achieving tertiary education – a better educated population is more likely to have both the expertise to respond to climate change and an understanding of the risks faced. We believe this can translate through to pressure on leadership to act on climate change[31]. **Greece**, followed by **Turkey** and then **Australia**, register the highest tertiary enrolment, from our sample of countries, while **Tanzania**, **Pakistan** and **Côte d'Ivoire** come lowest[32].

INDICATOR: Media independence

Freedom of the press is important in informing citizens about affairs that concern them. A free press also supports formation of opinions and critique of decision and actions that may not align with the motivations and justifications of actors and those with financial and political power. An independent press can thus act as a watchdog that holds a range of institutions accountable. Many would say that a free press is an essential element of a democracy.

> **A free press is vital, as it can bring to the attention of populations what governments, companies and other actors are doing to limit emissions, and raise awareness of air pollution and extreme weather events.**

Awareness

We think a free press is vital in a world experiencing climate change, as it can bring to the attention of populations what governments, companies and other actors are doing to limit emissions, in terms of financing and building cleantech, as well as innovation in this area. The media can also quickly and comprehensively raise national and global awareness of physical risks, such as air pollution and extreme weather events and their human impacts.

Here we use the *2020 World Press Freedom Index*, compiled by Reporters without Borders. This measures the degree of freedom available to journalists in 180 countries, via a questionnaire that evaluates pluralism, media independence, media environment and self-censorship, legislative framework, transparency, and the quality of the infrastructure that supports the production of news and information[33]. **China**, **Vietnam** and **Saudi Arabia** are scored poorly on this external indicator, while **Norway**, **Finland** and **Denmark** do best.

INDICATOR: Internet adoption

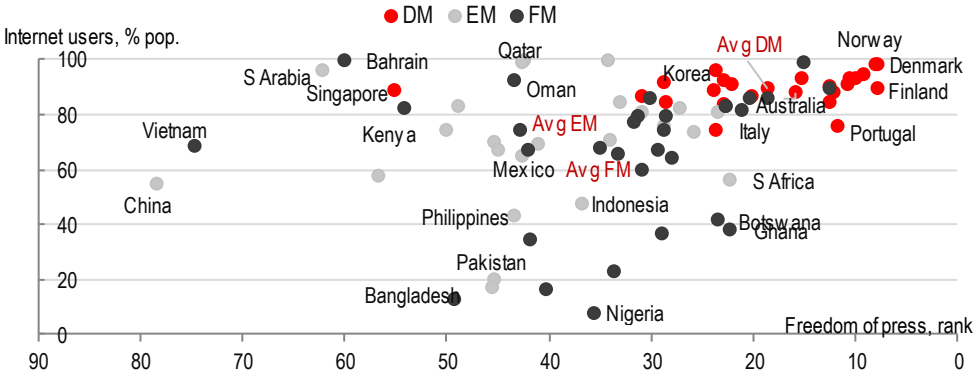
The internet is a major means of access to information. The digital and information revolution has changed the way the world learns, communicates, does business, understands risk and assesses opportunity. Technological advances – cheap laptops, smartphones and tablets – have accelerated internet accessibility. According to data provider Statista, almost 4.66 billion people were active users of the internet as of October 2020, equating to nearly 60% of the global population.

A population free and able to use the internet is more likely to be informed of the climate risks faced

While we note that parts of the internet are blocked in some jurisdictions, nevertheless, we think webpages and social media are hugely important means of allowing populations to gain an understanding of climate risks. This may be particularly the case where the mainstream media is less 'free'. We have written previously on how we believe the COVID-19 pandemic has rapidly accelerated the use of technology and the internet across the globe, (*Spotlight: The Edge of Disruption*, November 2020).

31 The Gilets Jaunes protests in France are an example of where a more educated country can see popular discontent around climate-supportive policies.
32 Note: World Bank data but Trading Economic data used for Brazil and United Arab Emirates. Japan takes the same datapoint as Korea due to missing data.
33 For more details on methodology, see https://rsf.org/en/detailed-methodology

Figure 28. An informed population? Internet users and freedom of press



Source: :World Bank, Reporters Without Borders, International Telecommunication Union, World Telecommunication/ICT Development Report and database. Freedom of press scores: 0 = the best score, or the most freedom; 100 is the worst score, or the least press freedom

In this report, we use the World Bank's Development Indicator – 'Individuals using the Internet as a % of the population'. There remains a sizeable range – with countries such as Burundi, Eritrea and Somalia at less than 3% of the population (latest datapoints being 2017, and note that these countries do not feature in our study), to Qatar and Bahrain reporting 99.7% of their populations in 2019 using the internet. In this research, MENA countries across the board have high rates of internet adoption, with **Bahrain**, **Qatar** and **Kuwait** at the top, followed by the **United Arab Emirates**. **Nigeria** has the lowest rate from our country sample.

- **INDICATOR: Mobile phone penetration**

Mobile phones allow communication around risks which may have been difficult to convey before. This can be relevant in a climate context when there are extreme events imminent. Mobile phones can also aid efforts in the aftermath of events. Increasingly, phones can also be a means of accessing the internet, as discussed above.

Here, we use the World Bank's Development Indicator – Mobile Cellular Subscriptions per 100 people, based on 2019 (or latest year) data. The **United Arab Emirates**, followed by **Thailand** and **Kuwait**, register the highest proportion, from our sample of 77 countries, while **Pakistan** comes in lowest.

- ***NEW* INDICATOR: Gender equality**

Traditionally, the link between gender equality and climate change has centred on the fact that impacts can lead to greater gender inequality to the detriment of women. This is because climate impacts tend to have a greater impact on the vulnerable in society and on those that have traditional home-maker roles - which is typically women in traditional societies.

> **Including women in climate policy and solutions can enhance the results, leading to more economic growth and sustainable outcomes**
>
> **Patricia Espinosa, Executive Secretary of UN Climate Change**

However, it is also important to note the importance of improving gender equality in order to mitigate the impacts of climate change. As one of the groups that is traditionally more impacted by climate change, women can also have valuable insights into factors critical to climate response, including sustainable resource management, local knowledge, insights and understanding of the local economy and environment.

A more equal society will mean greater participation in climate response

By empowering men and women equally in society, we believe that society has a greater chance of a strengthened response to climate change impacts. In economies where gender inequality is greater, then empowering men and women equally via education is likely, in our view, to lead to more productive outcomes – effectively, as all parties will have a more equal level of education that enables them to participate in climate resilience and mitigation.

> **Women commonly face higher risks … from the impacts of climate change in situations of poverty, and the majority of the world's poor are women. At the local level, women's inclusion at the leadership level has led to improved outcomes of climate related projects and policies.**
>
> **United Nations Framework Convention on Climate Change**

The UNESCO Institute for Statistics provides a Gender Parity Index (GPI), which measures the ratio of girls to boys enrolled at primary and secondary levels in public and private schools within a country. A GPI of less than one indicates that girls are more disadvantaged than boys in terms of accessing primary and secondary levels of education, conversely a GPI of more than one would indicate the other way around. A score of one would suggest gender equality.

Within our sample set of countries, a number of economies reach a GPI of close to one. The countries with the smallest deviance from a GPI of 1 are **Jordan, Denmark** and **France**. At the other end of the spectrum, **Pakistan, Bangladesh** and **Côte d'Ivoire** perform the worst on this indicator. Pakistan and Côte d'Ivoire both have numbers less than one, suggesting that women are disadvantaged relative to men on this metric. In Bangladesh, the GPI score suggests the opposite[34].

Decarbonisation policy

Net-zero targets are emerging

A number of parties (Japan, South Korea, China, UK, New Zealand, EU, Canada, Costa Rica) have publicly announced net zero goals[35] with many more considering such a target. At the Climate Ambition Summit in December 2020, 24 Parties announced plans to target net zero emissions or achieve carbon neutrality.

Meanwhile, the European Green Deal is far reaching, signalling the intention to revise or propose policies which would impact every part of the economy (see *Resetting the economy with a new growth strategy*, 12 December 2019), with huge implications for how we use energy and build climate resilience. The overall aim is to be the "first climate-neutral continent" by 2050.

In addition, a clean sweep in the US elections for President Joe Biden and the Democrats is fuelling optimism for a policy pivot on climate change in the US (*Biden administration maintains momentum on climate*, 28 January 2021 and *Georgia results pave way for Biden climate agenda*, 7 January 2021).

34 Note that for this indicator, Japan takes the same number as Korea, due to missing datapoints.
35 this does not equate to a formal submission to the UNFCCC

MODIFIED INDICATOR: Climate policy framework

We have updated our framework for scoring the climate policy outlook in place in countries, to include net zero targets. We have also given credit for 1.5˚C alignment in Paris Agreement pledges, where these have been updated. And we are more granular in relation to carbon pricing scores. See Figure 29.

The **UK**, followed by **France** and **Nordic nations** all score very well on these parts of the analysis.

Figure 29. Emissions reduction policy – scoring methodology

Metrics	Score
GHG emissions	***0-12***
- No quantitative target	0
- Conditional target	1
- Weak relative target	2
- Strong relative target	3
- Weak absolute target	4
- Moderate absolute target	5
- 2ºC aligned	9
- 1.5ºC aligned	12
Long term and net zero plan	***Max.: 4***
- Both Long term plan and net zero target	4
- Either Long term plan or net zero plan in national or proposed legislation	2
- Net zero policy document/announcement	1
Carbon pricing	***Max.: 4***
- Country level Market mechanism/ fossil subsidy reduction	4
- Regional Market mechanism/ fossil subsidy reduction	2
TOTAL	***Max 20***

Source: HSBC, UNFCCC, Note: GHG pledges, adaptation plans, sectoral contributions as per NDCs, carbon pricing as per national policies, net zero as per country submissions/announcements or policy documents and long term targets as per country communication to UNFCCC

INDICATOR: Government effectiveness

Policy implementation

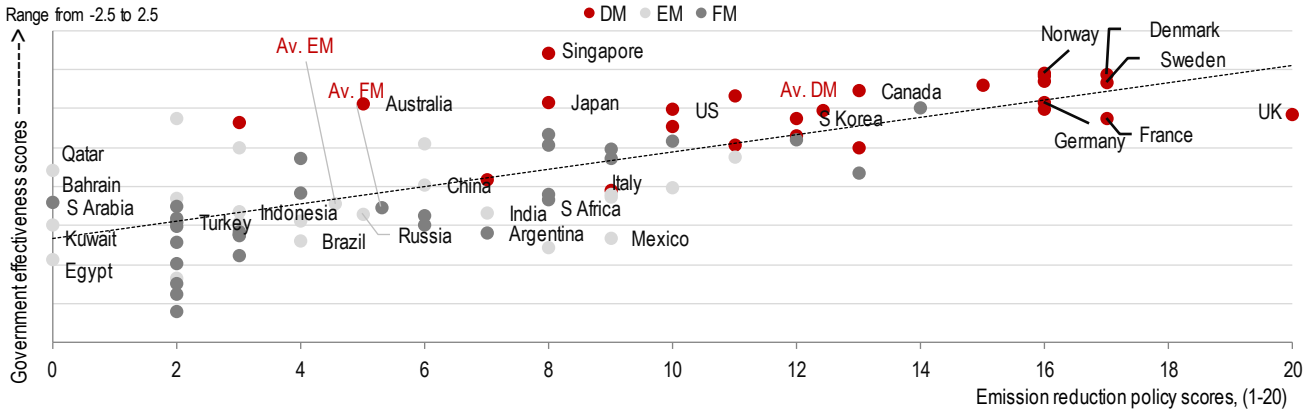
Setting policy is one thing, implementing it and achieving underlying goals can be another. Governments may not achieve their policy aims for different reasons: diminishing power, possibly following mid-term elections; change of policy priorities; economic capabilities; or simply a lack of will to do so. So, we have decided to use the World Governance Indicator's Government Effectiveness Indicator in our methodology to understand in which countries' climate policies and targets are more likely to actually be achieved. The Government Effectiveness indicator is focused on the period 1996-2019 and captures perceptions of:

- The quality of public services
- The quality of the civil service
- The degree of its independence from political pressures
- The quality of policy formulation and implementation
- The credibility of the government's commitment to such policies

Singapore has the highest government effectiveness, according to the World Governance Indicator's methodology, followed by **Switzerland** and **Denmark**.

Figure 30 shows which countries score well on the combination of strong emissions reduction policy *and* on government effectiveness. **Denmark, Norway** and **Sweden** fall in the top right-hand corner of the figure here – ie, they have strong climate policy outlooks *and* a higher likelihood of implementation, given their government effectiveness scores.

Figure 30. Europe in pole position: policy vs government effectiveness



Source: HSBC, UNFCCC, World Bank, PRIMAP. Simple average calculated for DM, EM, FM

Health risk preparedness

Many health risks can be exacerbated by global warming

We have written previously on how climate change can present significant health risks to populations, for example via increased burden of vector borne diseases as a result of rising global temperatures, among other risks such as climate exacerbated air pollution, leading to respiratory complications, *A new metropolis: Future cities: global warming and the risks to health*, 5 November 2019. The COVID-19 pandemic has further highlighted the risks associated with poor health across societies, and further strengthened the argument for greater health preparedness.

> **The overall health effects of a changing climate are overwhelmingly negative… Areas with weak health infrastructure – mostly in developing countries – will be the least able to cope without assistance to prepare and respond**
>
> **World Health Organisation**

One possible indicator that we could have used to rank and score health preparedness of countries was healthcare expenditure by country. However, given the huge disparities in how healthcare expenditure is directed across countries (between labour costs, equipment costs and infrastructure, for example), we felt that it was not a fair or comparable measure. Further complications include differences in whether there is state or private provision of healthcare in countries. Thus we have chosen two indicators – **hospital beds per population** and **surgical workforce per population** – to provide insights on how much capacity and expertise a country has currently, with regards to healthcare. We believe that this can reflect, to some extent, the resilience of a country that sees increasing climate exacerbated health risks.

NEW INDICATOR: Healthcare – Hospital beds

…requiring greater hospital capacity

We use the World Bank indicator for the number of hospital beds per 1,000 of the population. This includes all inpatient beds across the country available in public, private, general and specialised hospitals and rehabilitation centres. Thus, while this is availability of beds across all settings and therefore not a gauge of the equality of healthcare provision across economies, we believe it nevertheless provides an indication of the capacity constraints that may face a country in the event of a climate exacerbated health emergency.

Japan, Korea and **Germany** have the greatest number of hospital beds per 1,000 of the population, with as many as 13.4 beds per 1,000 of the population in Japan. By contrast, **Nigeria**, the worst performing on this metric has only 0.5 beds per 1,000 of the population. **Pakistan**, **Tanzania** and **India** also perform very poorly on this indicator[36].

> **Climate change can present significant health risks to populations… COVID-19 has further strengthened the argument for greater health preparedness**

NEW INDICATOR: Healthcare – Specialist surgical workforce

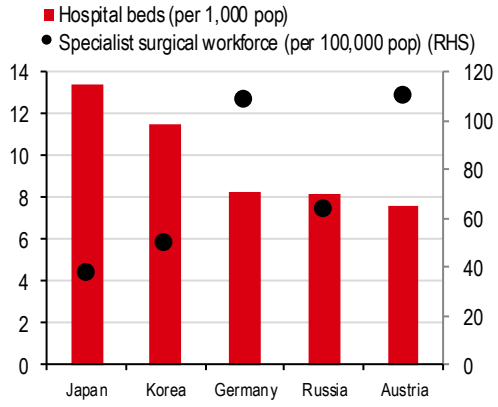
…and medical specialists

Our second health related indicator from the World Bank provides details on the number of specialist surgical workforce operating in a country (per 100,000 of the population). This encompasses the number of surgical, anaesthetic and obstetric providers, and gives information as to the level of health expertise in a country, and therefore how prepared the healthcare system would be to cope with new illnesses and emergent health risks, including climate change.

European countries perform relatively well on this metric. **Greece** ranks highest, with an average of 164 surgical specialists per 100,000 of the population, followed by **Italy** and then the **United Kingdom**. At the other end of the scale, African countries rank as most vulnerable on this metric; **Tanzania** has only 0.5 surgical specialists per 100,000 of their population. **Nigeria** and **Kenya** also sit at the bottom of the ranking on this datapoint[37].

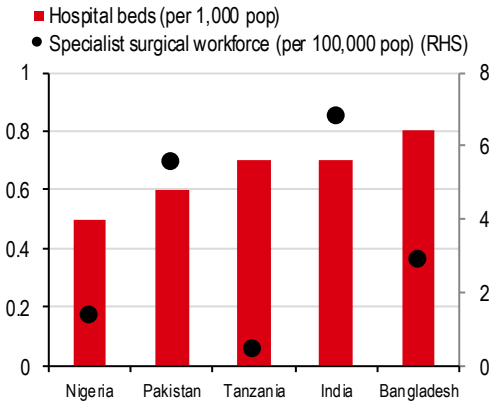
36 Note: *Cote d'Ivoire takes the number for Ghana due to missing datapoints. Netherlands, Nigeria and South Africa datapoints calculated using WHO metric on hospital beds per 10,000 population
37 For this indicator, United Arab Emirates, Saudi Arabia, Kuwait are using the average number for "Middle East & North Africa" classification, due to missing datapoints. Ghana takes the Ivory Coast's number given lack of datapoints. Indonesia and Vietnam take an average of Thailand and Malaysia's datapoints. Mexico takes the average number for Latin America and the Caribbean.

Figure 31. Top 5 performers on hospital beds…



Source: World Bank, World Development Indicators

Figure 32. …vs the bottom five



Source: World Bank, World Development Indicators

* * * * *

In the next section, we move from policy to the opportunity set – which countries are better placed to benefit economically from producing technologies and products where demand will be driven by a decarbonising world.

Figure 33. Climate governance

		Climate finance				Institutional quality			Enabled population						Decarbonisation policy		Health risk preparedness	
Rank	Country	Wealth GDP	Debt to GDP	Cost of capital -	Sov wealth fund	Control of corrupt.	Rule of law	Reg. quality	GINI index	Educat	Media	Internet	Mobile phones	Gender equality	Policy frame-work	Govt effective	Hosp beds	Surgical work force
1	Norway	3	17	1	1	6	2	6	5	16	1	7	59	44	5	5	28	26
2	Finland	13	43	12	17	3	1	5	6	9	2	20	32	69	5	4	24	19
3	Switzerland	1	27	1	77	8	3	10	31	42	6	12	38	52	5	2	21	12
4	Germany	14	46	1	25	9	13	8	22	30	9	24	34	60	5	11	3	10
5	Denmark	8	9	1	77	5	5	14	10	19	3	6	42	2	2	3	48	23
73	Kenya	75	41	69	77	72	68	69	63	73	49	72	63	67	51	71	64	75
74	Bangladesh	74	16	59	77	76	73	77	23	68	69	76	64	76	60	75	73	71
75	Tanzania	77	12	65	77	62	72	73	62	77	55	75	75	54	60	76	74	77
76	Nigeria	71	10	69	33	77	77	76	44	74	53	77	73	73	60	77	77	76
77	Pakistan	76	58	75	77	75	75	74	36	76	67	74	77	77	60	74	76	68

Source: HSBC

Green opportunities

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- In a world combatting climate change, opportunities abound for companies selling climate products and solutions
- Companies from China and US are already earning high revenues from climate solutions, while Japan's high patent approval rate translates to rapid revenue growth
- An expanded list of key transition minerals puts South Africa, China and Chile at an advantage given high shares of reserves and production

Greater resilience through climate revenues

Displaying resilience through the low-carbon transition is not *only* about being better placed to transition away from high-carbon domestic activities *or* having the policy outlook to move away from fossil fuels.

We see the transition as an opportunity for countries able to sell the products and technologies which allow it to happen. Indeed, we believe those countries that can generate more revenues as the global economy decarbonises are likely to be among the *most* resilient.

And so we ask a question:

How are countries placed to make economic profit from cleantech as the world decarbonises?

Expanded list of mineral endowments

In this section, we seek to identify in which countries there are companies earning more **revenues from climate change aligned themes**. Plus, we look forward and ask which countries have **parallel industries to cleantech production** necessary to the transition – these suggest which countries may be able to more easily switch towards the green opportunities, given their existing industrial base. Additionally, this year we have expanded our analysis of **mineral endowments of hard commodities** necessary for low-carbon technology deployment. As previously, we continue to examine the number of **companies establishing climate policies** and, lastly, to capture the level of innovation in national industry, we look at **patent registration data in relevant industries**.

Overall, we find **China** best-placed to make profits as the world moves towards a lower-carbon future, followed by **France**. At the other end of the spectrum, countries which are economically more dependent on fossil fuel production, particularly in the **MENA** region (five of the bottom ten are from this part of the world), as well as poorer countries, populate the lower end of the table.

GREATER RESILIENCE

1st. China
2nd. France
3rd. Japan
4th. Belgium
5th. Korea

MOST VULNERABLE

1st. Nigeria (ranks 77th)
2nd. Kuwait (ranks 76th)
3rd. Bangladesh (ranks 75th)
4th. Côte d'Ivoire (ranks 74th)
5th. North Macedonia (ranks 73rd)

Figure 34.
Green opportunities

Economic exposure and opportunities **25%**

1. Climate revenues
2. Climate revenues relative to GDP
3. Industrial potential to produce cleantech
4. Key minerals – share of global reserves and production
5. Corporate climate policies
6. Technological innovation

Source: HSBC

Economic exposure and opportunities

The opportunity to profit from decarbonisation

First, we look at national exposure to revenues from climate change themes. We think countries will benefit as their companies earn revenues from products and services which enable the low-carbon transition. **Countries with companies earning more in climate-themed revenues have the potential for higher tax receipts, more secure employment opportunities and greater export potential as the world transitions to lower-carbon.**

- **INDICATOR: Climate revenues (level and change)**

To do this, we analyse the revenues earned by publicly listed companies incorporated within countries, using HSBC Global Research's proprietary Climate Solutions Database ('the Database')[38]. The Database allows an analysis of this as the country of incorporation is important here (as it is a guide for repatriation of climate-linked revenues earned) rather than the country where sales are made.

> **We believe those countries which can generate more revenues as the global economy decarbonises are likely to be among the most resilient**

Explaining the HSBC Climate Solutions Database

The HSBC Climate Solutions Database comprises global companies that are focussed on addressing, combatting and developing solutions to offset and overcome the effects of climate change, thus enabling the transition towards a low carbon economy. The Database includes companies with varying levels of exposure to climate-related businesses and defines investment opportunity set within the climate change space. We believe companies in the Database are best-placed to profit from the challenges of climate change.

We can then use our framework to screen the Database for companies that offer solutions – products and services – which have significant exposure to climate change solving activities. In the past, we've pulled together stock screens offering exposure to a number of thematic ideas, including clean transport, smart cities. We've also created screens focussed on specific markets or regionals, including emerging markets, the US and LatAm. And we've focussed on styles, including screens which look at high dividend paying climate stocks and those which also perform well on change in revenue or in other environmental metrics. We recently updated 14 of these screens in our *Climate Solutions Playbook*, March 2021. catalysts, and styles.

The Database was launched in 2007 and currently consists of over 3000 global companies across all major regions and markets. The climate exposure of companies in the Database is determined based on the proportion of revenues that these companies derive from climate change related solutions. Climate revenues are mapped across four climate sectors, 21 climate themes, over seventy climate subthemes and almost hundred fourth level classifications. The first two levels of classification are outlined in the HSBC Climate Solutions Framework (we discuss the methodology in more detail in this *brochure*).

Companies' revenues are monitored on an annual basis and their climate exposure factors are revised, if necessary, depending on changes in their relevant exposure to climate change related activities. The database allows for identifying trends in climate integration across various climate themes as well as across regions and countries. The Database therefore enables screening for markets based on their highest and lowest share of climate revenue as proportion of macroeconomic variables, such as GDP. It also helps in identifying countries with relatively higher or lower rate of change in climate integration compared to other markets.

38 We acknowledge that this database only covers publicly listed companies and excludes private and state-owned enterprises, and so is in effect a partial analysis of total climate revenues available to countries. Nevertheless, it provides a strong proxy for the transitional potential of national industry, in our opinion.

> **The US and China have large absolute climate revenues already, but in terms of the share of GDP – France is top, then Denmark and Finland. Meanwhile, Japan's are growing fastest.**

Wealthy Europe, the US and the large East Asian economies leading the way on cleantech sales

In this report, using the Database, we calculate the total climate revenue of 77 countries spread across developed, emerging and frontier markets for the year 2019, and look for interesting trends in climate integration. For this, we aggregate climate revenues of companies in these markets to compute their overall climate revenue exposure. This enables us to compute markets' absolute climate revenues and their climate revenue growth rates over the past few years. In absolute terms, the **US** is top, above **China,** and followed by **Japan**. **China** also experienced the highest absolute increase in climate revenues over the five years to 2019, followed by **Japan** and then the **US**.

Separately, we re-run the exercise to compute the climate share of revenues in total GDP of markets. We then look at how the share of climate revenues in countries' GDP has changed over the past few years. We do this to understand which countries have industry that is moving towards cleantech production and which are moving increasingly quickly. In relative terms, **France** is top, followed by **Denmark** and then **Finland**. And in terms of the change, **Finland's** cleantech industry has grown most as a share of its GDP, followed by **Denmark** and **Belgium**.

A number of countries in our analysis do not have any public companies incorporated there which earn climate revenues, per our Framework: **Bahrain, Bangladesh, Botswana, Côte d'Ivoire, Cyprus, Ghana, Iceland, Kazakhstan, Kuwait, Latvia, Malta, Morocco, Nigeria, North Macedonia, Serbia, Slovakia, Slovenia, Tanzania and Tunisia**.

The cleantech growth opportunity – 'Green Complexity Potential'

In the earlier section entitled, '*Energy, carbon intensity and the macro economy'*, we looked at the degree to which sample countries are specialised in fossil fuels. Combatting specialisation means achieving diversification. However, in our view, the *type* of diversification achieved is also important.

Fossil diversification – an effective hedge?

Diversifying *within* oil production gives some protection against local cost and depletion factors. Natural gas production gives diversification within fossil energy supply. Meanwhile, refining gives diversification along the value chain and broadens commodity price volatility exposure. However, there is still residual risk, in this example, to some of the flows of the transition underway in the energy system. In a future where oil demand from the transport sector is negatively catalysed by new technologies – particularly electrification of road transport – then oil production in different geographies and refining businesses are all exposed to this trend.

> **The transition to the green economy will undoubtedly involve a transformation of production structures and economic activities around the world. This shift has the potential to alter the global competitive landscape and reshape countries' comparative advantages in production**
>
> **Penny Mealy and Alexander Teytelboym, University of Oxford**

And so **we think diversification should occur in non-hydrocarbon sectors, particularly for economies which are dependent on fossil fuels**. Furthermore, we believe national diversification will benefit in coming years from expansion into climate themed products and services.

- **INDICATOR: Industrial potential to produce cleantech (level and change)**

Path dependency in clean technologies

Next, we turn our thinking to **which countries may, *in future*, be better placed to benefit from the low-carbon transition**. To answer this, we use the methodology and rankings from a paper written by academics at the University of Oxford Institute for New Economic Thinking[39] (INET). This considers the question of how countries may re-orient their industrial structure to become more competitive in green products, and seeks to exploit the fact that industrial development tends to be path-dependent. The paper builds on evidence from other studies which demonstrate that countries are more likely to diversify into products or industries that require production capabilities similar to what they currently possess.

First, INET draws on measures that estimate the similarity in production capabilities between two products (proximity) and between a country and a product (proximity density) by considering countries' conditional probability of being competitive in one product given competitiveness in another – this allows creation of each country's Green Adjacent Possible (GAP). The GAP shows the set of green products that are proximate to a country's current production capabilities (i.e., the new green industrial opportunities that are likely to be the easiest to transition into, given what a country already knows how to do).

> **Countries are more likely to diversify into products or industries that require production capabilities similar to what they currently possess**
>
> **Penny Mealy and Alexander Teytelboym, University of Oxford**

Next, INET aggregates the information contained in each country's GAP into a single, comparable metric – Green Complexity Potential (GCP). We use the GCP rankings here in this section of our analysis, as it measures each country's average proximity to complex green products that it is not yet competitive in. This gives our analysis a forward looking analysis and effectively complements the data we hold in our HSBC Climate Solutions Database, in our opinion. **Italy** tops this metric, followed by **China** and **Spain[40].**

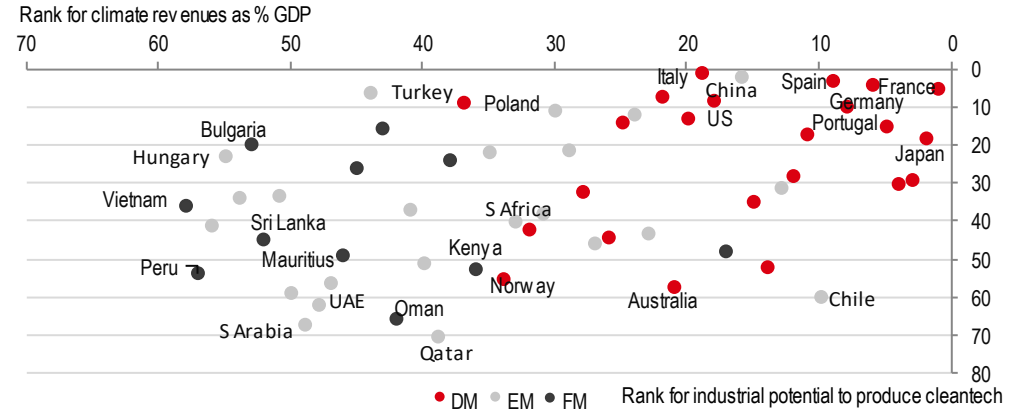
Combining the HSBC Climate Solutions Database with INET Green Complexity Potential
In combination, we are able to use HSBC's Database to say how much countries are drawing down climate-themed revenues, via their publicly listed companies, and with the INET data, also say which countries are better placed to move into climate themed sectors in the future, given what they produce today.

Who's producing today *and* who can tomorrow

Overall, we think those countries which both have high climate solutions scores today *and* which have high Green Complexity Potential rankings are well positioned to benefit from climate associated revenues through the global low-carbon transition.

39 Economic Complexity and the Green Economy, Penny Mealy and Alexander Teytelboym, University of Oxford, 2017
40 Note that we do not have Green Complexity Potential indicator data for the following countries: Bahrain, Belgium, Botswana, Cyprus, Iceland, Malta and Serbia. For these countries, we replace the GCP indicator score with an average of the two scores that are used for the climate revenue change. This thus acts as a proxy for a forward looking cleantech growth potential indicator such as the GCP.

Figure 35. Climate revenues and the industrial base to grow them further



Source: HSBC, Mealy, P. et al (2017). Note that countries with no climate revenues and/or no GCP score are excluded from this chart.

Mineral endowments

The transition needs raw materials

As sectors decarbonise over time, this will bring about an energy transition. In turn, this will entail a reduction in the use of fossil fuels to directly generate energy, in favour of electrification and hydrogen in particular – we explore these major transition trends in *Future Frontiers*, March 2021. Some scenarios see power demand growing by a factor of many (*A Global Energy Vision for a 2°C world*, 7 February, 2017). And given the ambition is to limit greenhouse gas emissions, the power will increasingly need to come from renewable resources.

- ***ENHANCED* INDICATOR: Key transition minerals (production and reserves)**

This demand for clean power, equipment facilitating use of alternatives to fossil fuels and many types of electrical equipment will in turn drive demand for minerals necessary in manufacture. In our previous Fragile Planet report, we identified **lithium**, **cobalt**, **copper**, **nickel**, **manganese** and **uranium** as important commodities in an electrification boom.

In this analysis, we are now expanding our list of key minerals to 16 key commodities in total, because of the rapid expansion of cleantech opportunities, to also include **platinum, rare earth oxide equivalent, indium, gallium aluminium, chromium, molybdenum, silver, zinc** and **vanadium**. We have outlined the main use cases for these commodities in Figure 36.

Figure 36. Cleantech requires a range of raw materials

	Wind	Solar Photovoltaic	Concentrating solar power	Carbon capture & storage	Nuclear power	Light emitting diodes	EVs	Energy storage	Electric motors	Electrolysers & fuel cells
Cobalt				x	x		x	x		x
Copper	x	x		x	x	x	x		x	x
Nickel	x	x		x	x	x	x	x		x
Lithium		x		x	x	x	x	x		x
Manganese	x			x		x	x			
Uranium					x	x				
Platinum		x	x		x	x	x			x
Rare earth oxide	x						x			
Indium*		x		x	x	x				x
Gallium*		x	x	x	x	x	x	x	x	
Aluminium	x	x	x	x		x		x	x	x
Chromium	x			x	x	x				x
Molybdenum	x	x		x	x	x				x
Silver		x	x		x	x	x			
Zinc		x				x				x
Vanadium	x	x		x	x	x		x		x

Source: HSBC, World Bank

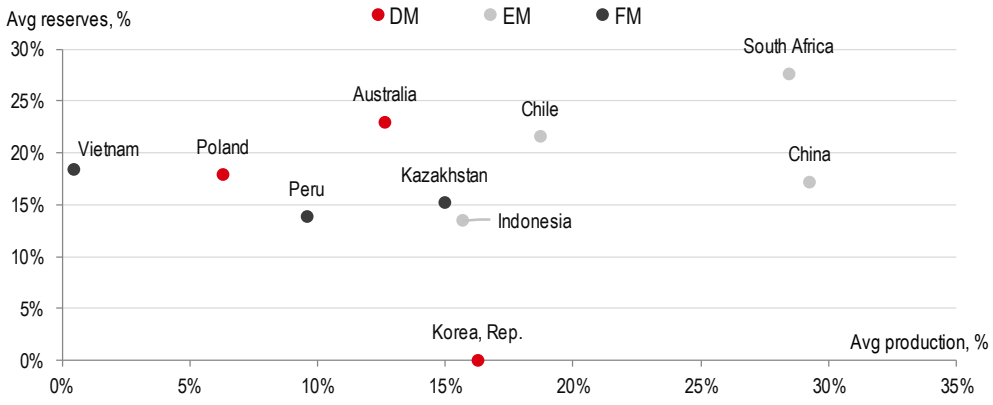
*No reserves data for Indium and Gallium

Here we look at the 2019 share of global production *and* at the share of global reserves for countries around the world. We use data from the United States Geological Survey's Mineral Resources Program, and the World Nuclear Association.

While production data are considered relatively accurate, reserves data is imperfect, given lack of exploration is some areas. However, we take a view that if countries *have* reserves, but have zero production currently, then there are likely to be technical, financial and/or institutional factors to overcome to allow production in the near future. (Note that we were unable to access reserves data for the commodities Indium and Gallium, and only included production numbers). ***We create a blended metric for production and reserves values for these commodities (weighting them all equally), in order to score and rank countries in this area.***

South Africa is ranked first here, followed by **China** and **Chile**. **Australia** comes in fourth, making it the highest ranking DM country on this indicator.

Figure 37. South Africa leads the way on exposure to 'fossil replacement commodities'



Source: HSBC, USGS, World Nuclear Association.

Corporate climate planning

In addition to countries having cleantech production and forward-looking potential to build the technologies the world needs to decarbonise, we have also looked for evidence of *companies* setting policies to address climate change. Additionally, we've looked at patent data as evidence of innovation taking place.

◆ INDICATOR: Corporate climate policies

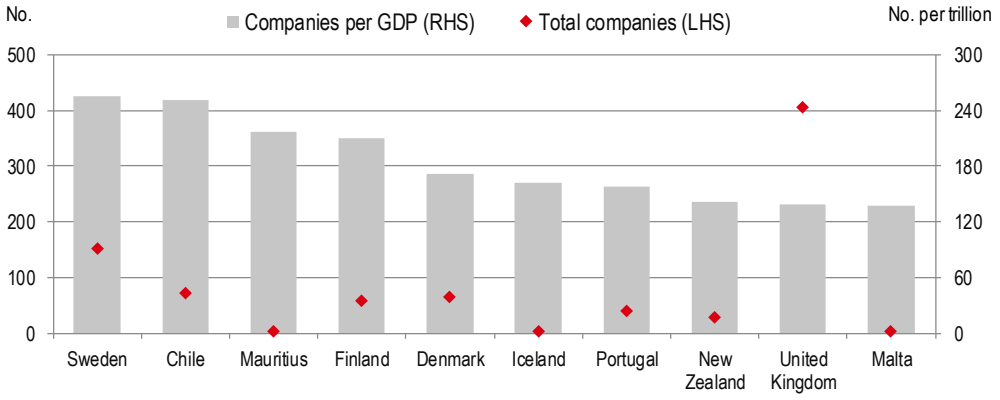
Companies are key non-state actors on climate

The UNFCCC is embracing the actions of so-called non-state actors (NSAs) – cities, regions, companies, investors and civil society – as a means to raise ambition levels for climate action. These efforts continue to aggregate – the NAZCA (Non-State Actor Zone for Climate Action) portal, launched via the 2014 Lima Paris Action Agenda, recorded 18,553 stakeholders and 27,494 actions as of February 2021. Of these, 4,299 come from companies and address both mitigation of greenhouse gas emissions and adaptation to the impacts of climate change. Furthermore, we think companies that are more climate-aware are more likely to find opportunities relating to the low-carbon transition. Companies are a central and substantial part of the overall economy and so more climate-awareness means an economy which is more likely to find opportunities for outperformance in this changing world, in our view.

To enable comparison, we normalise country totals of corporate climate policies by considering the total per trillions of GPD. While this doesn't adjust for the number of companies within a country (some have many smaller companies), it does give an indication of how widespread company policies are within an economy.

Sweden tops this indicator, followed by – perhaps surprisingly – **Chile** and **Mauritius.** However, in absolute numbers, other countries have many more, including the **US**, the **UK** and **China**.

Figure 38. Top 10 countries in terms of companies with climate policies in place



Source: NAZCA portal, World Bank

◆ INDICATOR: Technological innovation

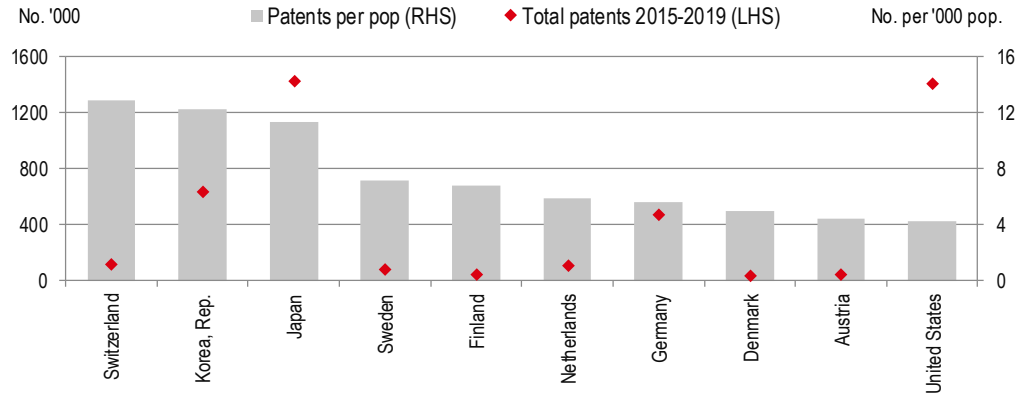
Patents are legal mechanisms used to protect the intellectual property of a new invention. Countries with more patents are generally seen as being more innovative, with more focus on research and development, as opposed to just mass production. More innovative industries should, in theory, be able to move more quickly with trends, technological advances, changes in demand patterns and emergent resource constraints.

Which countries invent and innovate?

Here **we focus on the number of patents in those sectors where technologies *may* be relevant to the low carbon transition.** Many of the patents will not be in cleantech industries – nevertheless, evidence of innovation and expertise in these areas is a signifier of the ability to innovate in these

areas. We calculate the sum of patents granted between 2015 and 2019. **China** has the highest absolute number of patents granted across the country, followed by **Japan**. However, for fair comparability, we normalise the count by the size of the population. On this metric, **Switzerland** performs best, followed by **Korea** and **Japan**.

Figure 39. Innovative populations…



Source: WIPO statistics database, World Bank. Note: we have taken the sum of patents between 2015 and 2019.

We use data from the World Intellectual Property Organization database and focus on the following sectors. Some may not seem immediately relevant to cleantech – yet there may be a relevant angle within that technological sector. For instance, *optics* includes lenses and specialist glass – future innovation here is expected in future to be crucial to build-out of mirror-based solar thermal power technologies. Meanwhile, *pharmaceuticals* will have a bigger role to play in addressing climate-exacerbated health risks as these intensify in years to come, as we anticipate (see *A new metropolis – Future cities: global warming and the risks to health*, 5 November 2019).

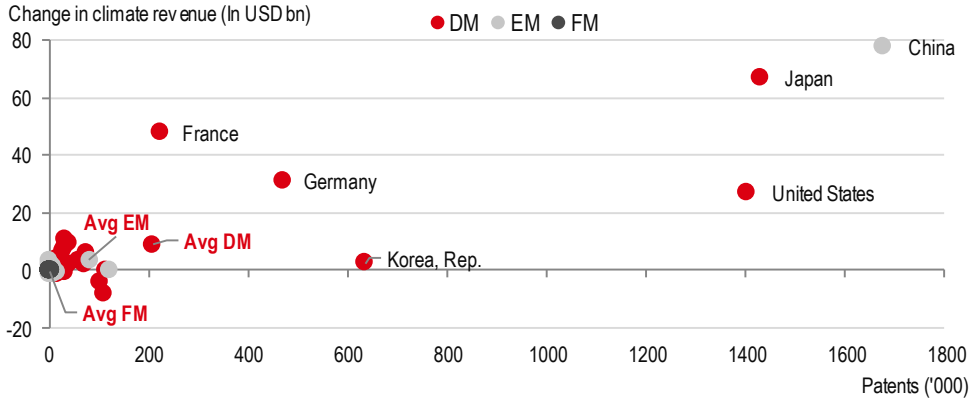
From patents to products

In our view, companies that perform well on this metric are likely to see these patents translate into products, many of which are likely to relate to the transition towards a cleantech industry. We have increasingly seen evidence of this, for example in Japan, which performed extremely well on both absolute number of patents granted and patents granted per population in our previous iteration of this analysis, as well as the current one. Our recent data on climate related revenues demonstrates that Japan has also experienced the second highest level of growth in climate revenues (as a share of GDP) of our sample set over the past five years, suggesting that indeed high levels of patent grants may well translate to more climate related revenues.

- Electrical machinery, apparatus, energy
- Measurement
- Analysis of biological materials
- Control
- Medical technology
- Organic fine chemistry
- Biotechnology
- Pharmaceuticals
- Macromolecular chemistry, polymers
- Food chemistry
- Basic materials chemistry
- Materials, metallurgy
- Surface technology, coating
- Micro-structural and nano-technology
- Chemical engineering
- Environmental technology
- Optics
- Machine tools
- Engines, pumps, turbines
- Other special machines

- Telecommunications
- Thermal processes and apparatus
- Mechanical elements
- Transport
- Civil engineering
- Digital communication
- Basic communication processes
- Computer technology
- Semiconductors

Figure 40. From patents to climate revenues



Source: HSBC Climate Solutions Database, WIPO statistics database

* * * * *

In this fourth and final piece of our analysis, we've combined data showing revenues linked to climate-related products and services with a forward-looking analysis of which countries are better placed. We've also integrated an understanding of where more companies have introduced climate policies and where there is more patent data. And we have expanded the range of commodities we include in our framework, as many more sectors become catalysed for change in a world where climate ambition is growing. Reiterating the five best-placed and five worst-placed countries in Figure 41, we also give their rankings on individual indicators used in this part of the analysis.

Figure 41. Green opportunities

Rank	Country	Climate revenue from nationally incorporated companies				Potential to produce cleantech	Key minerals*	Corporate climate policies	Technological innovation
		Level	Change	% GDP	Change		% av share	Per GDP	Patents
1	China	2	1	16	11	2	2	47	22
2	France	4	4	1	5	5	14	27	12
3	Japan	3	2	5	7	15	18	30	3
4	Belgium	15	8	7	3		25	23	15
5	Korea	9	9	12	17	28	5	35	2
73	North Macedonia	77	32	77	33	50	77	77	60
74	Cote d'Ivoire	77	32	77	33	64	77	34	75
75	Bangladesh	77	32	77	33	61	77	46	74
76	Kuwait	77	32	77	33	68	77	68	47
77	Nigeria	77	32	77	33	69	77	70	76

Source: HSBC

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Final rankings

The framework which we have developed in the series of Fragile Planet notes has formed foundational pillars for other analyses including:

- Analysis of agro-commodity risks in *Fragile Planet – Commodities, From climate risks to agriculture*, July 2018
- Regional deepdive into energy transition risks in the MENAT region, in *Continental Shift – Climate change and energy transition across the large MENAT economies*, July 2020
- Regional depdive into energy transition risks in the LATAM region, in *Continental Shift - Energy and climate change in the big six LatAm economies*, July 2019
- Analysis of countries with heightened biodiversity risks, in *Paradise lost? Why investors must address the biodiversity crisis next*, June 2020

To recap, in this report, we've looked at four areas and in each tried to address one question:

- ***How embedded is carbon in national economies?***
- ***Which countries are at greater risk from physical impacts associated with global warming?***
- ***Which countries have the policy, institutional quality, financial strength and informed population to respond to climate risks?***
- ***How are countries placed to make economic profit from clean-tech as the world decarbonises?***

We focussed on answering these questions and building an overall picture of resilience vs vulnerability, using **49 indicators – of which 12 are new - explored via 92 datapoints for each of the 77 countries** in this edition.

This enables us to then rank developed, emerging and frontier market countries on their resilience and, at the other end of the spectrum, vulnerability in relation to this one, overarching question:

Which countries are most resilient in the face of rising climate risks?

We've also expanded the list of countries to a total of 77.

Our final rankings are repeated at the end of this section. **Wealthy Europe** leads the way, with the four large **Nordic** economies in the top ten, joined by **France, Germany, the UK, Switzerland** and **Austria.** Behind **Korea,** other better-placed EM nations overall, include **Poland** (20th), **Chile** (21st) and **China** (24th). **African, South Asian** and **MENA-region** countries populate the bottom quartile.

> **To understand climate resilience, we've used 12 new indicators in this report, taking the total to 49, with 92 datapoints analysed per country**

However, while the final rankings (Figure 2) are interesting, we believe digging into the detail is more illuminating; i.e., the value in this report can be found in specific areas of risk and individual indicators. We think consideration of all four areas of this report – transition risks, physical impacts, the potential of countries to respond and the green opportunity set – are essential to understand resilience, at the country level.

> **Transfer of finance, technology, policy expertise and information can also help more vulnerable and less developed countries to face growing climate risks**

Decarbonisation requires technological innovation, economic support and policy formation and delivery. Similarly, the build-up of resilience to the negative impacts of warming will require a massive financial, technological and political response. Yet there are opportunities for countries which move quickly and prudently, to protect societies and even to enhance economic outlook, in our opinion. We believe it remains possible for countries to build social, economic and environmental resilience, but they must act rapidly and act radically.

> **Achieving the aims and ambitions of the Paris Agreement are not a given. The world needs to understand the urgency and complexity of what the international community has embarked upon.**
>
> **Patricia Espinosa, Executive Secretary of UN Climate Change**

In the short, medium *and* long term, *all* countries face climate risks of different types and will need to build resilience in this changing world. Transfer of finance, technology, policy expertise and information can also help more vulnerable and less developed countries to face growing climate risks. We believe these will all form part of the climate response of the 2020s.

Investors can click the 'buttons' interspersed throughout the report to receive the full dataset underlying this analysis

Click to request data for this report

Overall rankings

From greatest resilience to most vulnerable

1. Sweden	41. Croatia
2. France	42. Israel
3. Finland	43. Mexico
4. Germany	44. South Africa
5. United States	45. Brazil
6. Denmark	46. Argentina
7. Switzerland	47. Thailand
8. United Kingdom	48. Peru
9. Norway	49. India
10. Austria	50. Malaysia
11. Belgium	51. United Arab Emirates
12. Canada	52. Kazakhstan
13. Czech Republic	53. Vietnam
14. Korea	54. Philippines
15. Australia	55. Serbia
16. Iceland	56. Indonesia
17. Portugal	57. Mauritius
18. Spain	58. North Macedonia
19. Japan	59. Bahrain
20. Poland	60. Qatar
21. Chile	61. Morocco
22. Netherlands	62. Botswana
23. New Zealand	63. Colombia
24. Mainland China	64. Jordan
25. Romania	65. Ghana
26. Ireland	66. Saudi Arabia
27. Lithuania	67. Egypt
28. Italy	68. Sri Lanka
29. Slovenia	69. Pakistan
30. Malta	70. Kenya
31. Slovak Republic	71. Kuwait
32. Estonia	72. Oman
33. Latvia	73. Tunisia
34. Hungary	74. Tanzania
35. Turkey	75. Côte d'Ivoire
36. Singapore	76. Bangladesh
37. Greece	77. Nigeria
38. Bulgaria	
39. Russia	
40. Cyprus	

Source: HSBC based on proprietary analysis of 49 indicators. Colour coding by market: red = DM, grey = EM, black = FM. Classifications according to FTSE market classifications.

Notes

Notes

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