ECOLOGICAL THREAT REPORT 2022

Analysing Ecological Threats, Resilience & Peace

IEP

Institute for Economics & Peace

Quantifying Peace and its Benefits

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EXECUTIVE SUMMARY

This is the third edition of the Ecological Threat Report (ETR), which analyses ecological threats in 228 independent states and territories. Produced by the Institute for Economics & Peace (IEP), the report covers over 3,638 sub-national administrative districts, or 99.99 per cent of the world's population, assessing threats relating to *food risk, water risk, rapid population growth and natural disasters*.

Many ecological threats exist independently of climate change. However, climate change will have an amplifying effect, causing further ecological degradation.

The research takes a multi-faceted, multidimensional approach by analysing risk at the national, administrative district and city level, while also assessing these entities by ecological threats, societal resilience and levels of peace. Additionally, the research provides projections to 2050. To assist the international community in prioritising its focus, IEP has identified the countries, administrative districts and cities most at risk.

The main finding from the 2022 ETR is that without concerted international action, current levels of ecological degradation will substantially worsen, thereby intensifying a range of social challenges, including malnutrition, forced migration and illness. Current conflicts will escalate and multiply as a result, creating further global insecurity.

A nexus of interrelated challenges sustains and feed off each other. Systemic effects compound, ensnaring countries in conflict traps that are difficult to escape. This nexus is explored in the ETR, highlighting the significant impact of high population growth, ecological collapses, weak societal resilience and their relationship to conflict. These issues need to be addressed systemically.

Highlighting the gravity of the situation, 90 per cent of the 20 least peaceful countries face at least one catastrophic ecological threat, while 80 per cent have low societal resilience. Ten of the twelve countries with the highest ecological threat rating, in all four domains, currently suffer from conflict deaths, while 11 of these countries have moderate to high ratings for *intensity of internal conflict*.

Highly resilient countries better manage their natural resources and their citizens' socio-economic needs. Positive Peace is a proxy for socio-economic resilience and has been used to measure societal resilience throughout the report. Resilience includes effective water management, efficient agricultural systems, and better disaster preparedness. No single country with a high level of Positive Peace has an extremely low ETR score, underscoring the relationship between ecological fragility, conflict and societal resilience.

The number of people globally who are concerned about the future effects of climate change has decreased by 1.5 per cent to 48.7 per cent, since the beginning of the COVID-19 pandemic. In China, the world's largest polluter, only 20.1 per cent of citizens believed climate change was a major concern, a fall of three per cent since 2019, one of the lowest country scores. The third largest polluter, India, only had 38.8 per cent of its citizens' express major concern. The US, the world's second largest polluter, recorded slightly more concern than the global average at 51.5 per cent. The countries that will be most affected by climate change, mainly in Africa, recorded some of the lowest scores and were more concerned with terrorism, conflict, crime and economic security.

The 2022 ETR identifies 27 hotspot countries that face catastrophic ecological threats, while also having the lowest levels of societal resilience. These countries are home to 768 million people. They are mainly clustered in two regions:

- Two-thirds of hotspot countries are in sub-Saharan Africa (SSA).
- Countries in MENA account for another 18.5 per cent of hotspot countries.

Seven of the eight hotspot countries with the highest risk are in SSA. These are Burundi, Central African Republic, Chad, Republic of the Congo, Somalia, South Sudan and Uganda. The eighth country is Yemen.

To further define the focus areas for international action, IEP has identified the 37 administrative districts with the worst ecological impact scores, home to 34 million people. The four districts with the highest populations are located in Somalia, South Sudan, Central African Republic and Mozambique.

The ETR identifies 41 countries facing the most extreme food insecurity, with 37 of them in SSA. The number of undernourished people has steadily increased since 2017, rising by 35 per cent, to over 750 million in 2021. Ninety-two per cent of these people live in low or very low peace countries.

Compounding an already existing trend, food insecurity was boosted by dramatic increases in food prices driven by the COVID-19 pandemic, followed by the Russia-Ukraine War. Notably, the Food Price Index has increased by 50 per cent since the beginning of the pandemic.

An additional area of concern for many countries is their dependency on food imports from conflict-affected countries. This puts them at higher risk of food insecurity, a trend highlighted by the Russia-Ukraine War. The

countries with the highest conflict risk to their food imports are Zimbabwe, Tajikistan, Republic of the Congo and DRC. Their main source of food imports is from neighbouring countries.

Food insecurity and water stress are interlinked, as without adequate water capture it is impossible to provide sufficient food. More than 1.4 billion people in 83 countries face extreme water stress. All but one of the 52 countries in SSA are affected by extreme water stress. Several European countries are projected to have serious water stress by 2040, including Greece, Italy, Netherlands, and Portugal.

Water conflicts are increasing, having tripled in number between 2000 and 2019. The countries with the most water related conflicts over the last two decades were Iraq, Somalia, Yemen and Sudan, all very low peace countries. International rights to water are becoming increasingly contentious, as more of the great rivers of the world are dammed, affecting downstream flows. For example, the damming of the Mekong River continues to affect 300 million people in the Mekong delta.[1] Similarly, the Grand Ethiopian Renaissance Dam, Ethiopia will likely reduce flows to Sudan and Egypt, affecting the 200 million people who rely on the Nile.[2]

In 2021, the countries that experienced the highest levels of internal displacement from conflict and natural disasters included Syria, Ethiopia, DRC, Afghanistan and South Sudan. The Climate Security Nexus is likely to see larger refugee flows from forced migration, impacting both source and recipient countries. In 2021 the number of forcibly displaced people increased by 3.7 per cent to 89.3 million.[3] This does not include refugees from Ukraine. Turkey, Uganda and Pakistan received the most refugees in 2021, at least a million refugees each. The EU received almost three million refugees in 2021, with Germany receiving over 800,000 refugees, followed by Sweden with almost 160,000, and Greece with over 76,000.

The global population is expected to increase by 25 per cent to 9.8 billion in 2050. The distribution of this increase will be uneven, many European countries have negative population growth rates, while 15 countries in SSA have projected population growth rates in excess of 100 per cent.

The cyclic relationship between ecological degradation, societal resilience and conflict cannot be over-emphasised. It is a vicious cycle whereby degradation of resources leads to conflict, which further degrades the resources. Large increases in population only compound the situation. The total population of the 40 least peaceful countries is projected to increase by 1.3 billion by 2050, representing 49.5 per cent of the world's population. These countries also face the worst ecological threats, with the SSA population expected to increase by 95 per cent by 2050.

By 2050, 70 per cent of the world's population will live in cities, up from the 54 per cent in 2020. Megacities are cities with more than 10 million people. The report analyses the 33 current megacities and the additional 14 cities that will become megacities by 2050, identifying which are most likely to face the harshest challenges. Cities facing the harshest challenges are: Kinshasa, Nairobi, Lagos, Dhaka, Baghdad, Lahore, Kolkata and Delhi. These cities have high projected population growth rates, poor sanitation, lack of infrastructure, high crime rates and substantial ecological threats. Cities also face challenges from higher levels of air pollution, with nine megacities having more than 20 times the WHO recommended maximum level. These cities include Lahore, Kabul, Delhi and Agra. The highest number of polluted cities are in South Asia, and China.

Ecological threats, societal resilience and low levels of peacefulness will not be resolved without concerted international action. The 2022 ETR includes a number of policy recommendations generated by 60 experts aimed at supporting local communities to improve water capture, agricultural yields and resilience. Key recommendations include:

- Building resilience in a way that is holistic and broadens the range of actors involved. International agencies need new integrated structures that operate systemically, combining health, food, water, refugee relief, finance, agricultural, development and other functions.

- Empowering local communities. Community-led approaches to development and human security result in more effective programme design, easier implementation and more accurate evaluation.

- Many innovative programs build water resilience. Sand dams in Kenya, dispensers for safe water in Malawi and engineered wetlands in China provide examples of programs that build water resilience, cheaply and effectively.

- Farmer Managed Natural Regeneration (FMNR) has regenerated millions of hectares of degraded land in Africa and has exceptional potential, due to the cost of implementation and has the potential to improve the lives of tens of millions.

Ecological threats will continue to create humanitarian emergencies, increase conflict and result in forced migration, unless there is a sustained effort to reverse the current trend. Ecological threats are becoming more pronounced and affect more people than ever. Building resilience to these threats will increasingly become more important and will require substantial investment now and into the future.

KEY FINDINGS

SECTION 1: RESULTS

- Ecological threats and high levels of violence form a vicious cycle, whereby the systemic dynamics reinforce each other. The degradation of resources leads to violence and the violence leads to the degradation of resources.
- The prevalence of all four ecological threats increases as countries experience deteriorations in the *Safety and Security* and *Ongoing Conflict* domains of the Global Peace Index (GPI).
- 27 hotspot countries have been identified that face catastrophic ecological threat with extremely low societal resilience. These countries are home to 768 million people.
- These hotspot countries are clustered in three regions: SSA, Middle East and North Africa (MENA), and South Asia. These regions are also the three least peaceful as measured by the GPI.
- Seven of the eight most at risk hotspot countries are in sub-Saharan Africa. These are Burundi, Central African Republic, Chad, Republic of the Congo, Somalia, South Sudan and Uganda. The eighth country is Yemen.
- 37 administrative areas face catastrophic levels of ecological threat across all four domains. All are located in SSA with an estimated 34 million people living in these regions
- North America and Europe are the two regions with the best ETR score.
- IEP estimates that in 2050, 3.4 billion people will reside in countries facing catastrophic ecological threats, compared to 2 billion in 2022. Their populations will account for 34.7 per cent of the world's total population. Most of the increase will be in SSA.
- Over half of the 228 countries in the ETR face at least one catastrophic threat. Neither China nor India face a catastrophic threat. However, most countries have the necessary societal resilience to avoid societal breakdown.
- To address these ecological threats, interventions must be holistic, systemic and sustained over decades.

Climate Survey

- Between 2019 and the end of 2021 the world's population became less concerned about climate change with a drop of 1.5 per cent to 48 per cent. This may be partly explained by COVID-19 and concerns regarding more immediate issues, such as health and livelihoods.
- The three countries with the biggest falls in concern were Singapore, Namibia and Zambia, with falls of 24, 21 and 18 per cent respectively.
- Citizens of the world's biggest polluters, China and Russia, became less concerned about climate change, recording a substantial drop of three per cent each.
- China is one of the countries least concerned about the impact of climate change in the next 20 years at just 20.1 per cent. India, the third largest polluter, scores poorly at 38.8 per cent.
- Six of the nine regions of the world recorded less concern, with South Asia, North America and Europe regions being the only ones to improve.
- Regions exposed to the highest level of ecological threat, are on average the least concerned with climate change, with only 27.4 per cent of respondents in MENA and 39.1 per cent of South Asians perceiving climate change as a very serious threat.
- Sub-Saharan Africa and South Asia ranked war, terrorism, crime and violence as greater concerns than climate change.
- 55.9 per cent of Europeans and 55.7 per cent of North Americans perceived climate change as a very serious threat.

SECTION 2: ECOLOGICAL THREATS

- Forty-one countries face extreme food insecurity. In these countries, more than 65 per cent of the population were unable to afford food for their family at least once in the last year.
- Globally, 768 million people are undernourished, an increase to 10 per cent of the world's population in 2020 compared to 8 per cent in 2017.
- Since the onset of the COVID-19 pandemic, food security levels have deteriorated in seven of the nine regions in the world. The largest average deteriorations have occurred in South Asia, South America and sub-Saharan Africa. The countries with the largest declines were Colombia, Syria, Ethiopia and Mozambique.
- Sub-Saharan Africa has the highest rates of food insecurity. Of the 52 sub-Saharan African countries, 37 recorded an extremely high level of food insecurity in the ETR.
- Countries that have low domestic food security and low socio-economic resilience will be most affected by breakdowns in the food supply chain. Zimbabwe, Tajikistan, Republic of the Congo and DRC are the countries most at risk.
- More than 1.4 billion people live in regions experiencing severe levels of water stress. In these countries, at least 20 per cent of the population do not have access to clean drinking water.
- While sub-Saharan Africa is the most exposed, European countries such as Albania, Estonia, Greece, Italy, Macedonia, Netherlands, Portugal, Romania, Turkey and Kosovo are also projected to have substantial increases in water stress by 2040.
- Conflict over water has been increasing, with the number of incidents where water was a trigger of fatal conflict

KEY FINDINGS

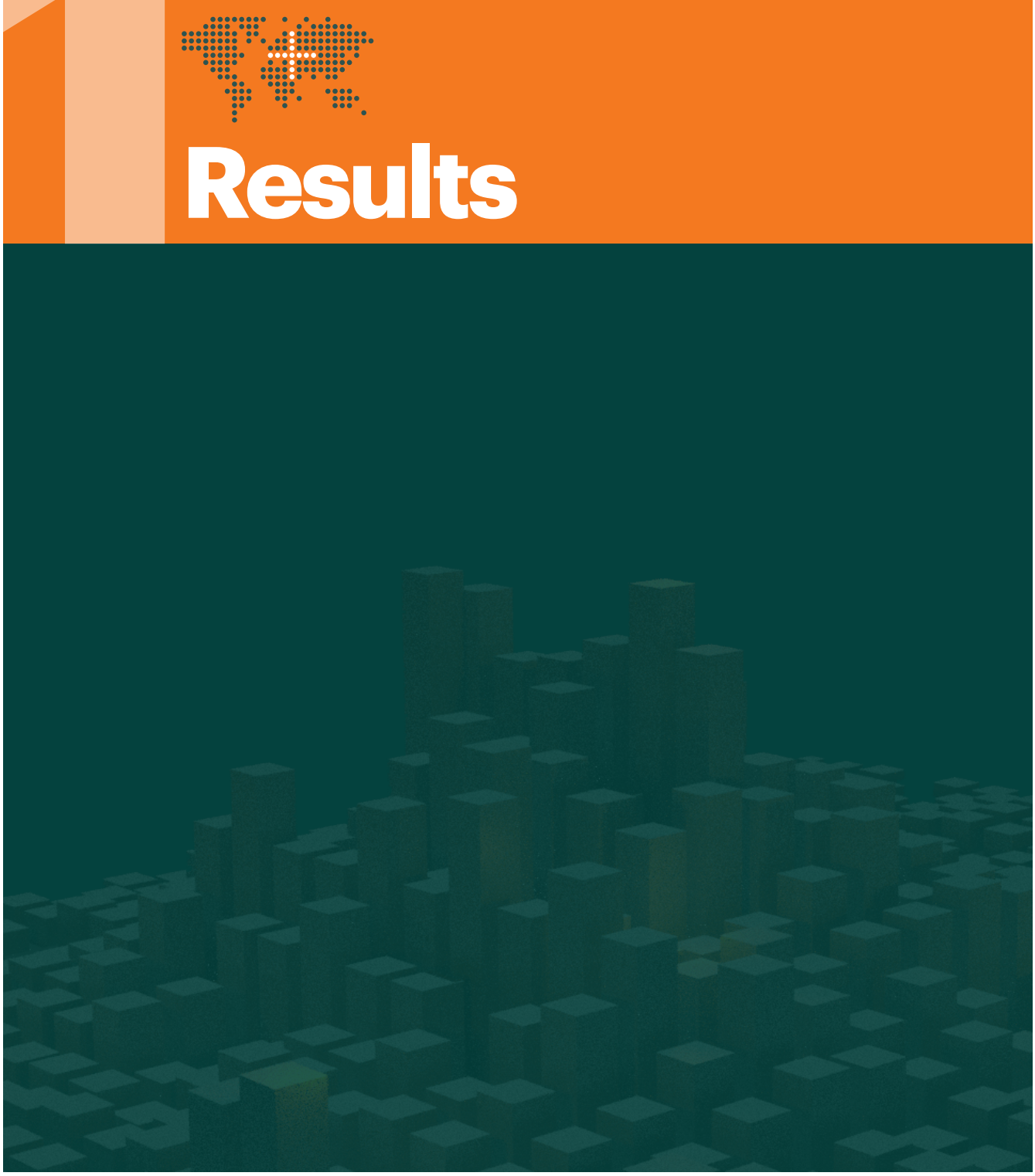
increased by 300 per cent since 2000. The countries that are most likely to see a continuance of water related conflict are Yemen, Iraq, Somalia and Sudan.

- The 40 least peaceful countries will have an additional 1.3 billion people by 2050, accounting for almost half of the world's population at 49.6 per cent.
- The population of sub-Saharan Africa is expected to increase by 95 per cent by 2050. Many countries, including India and China have birth rates below replacement rates. With concerted government efforts birth rates can be reduced.
- Since 1981, the number of natural disasters has tripled to 429 in 2021, costing on average $200 billion in the last decade. The most common natural disasters are floods and storms. The frequency of both have been increasing.

SECTION 3: ECOLOGICAL CHANGES AND MEGACITIES

- By 2050, 70 per cent of the world's population will live in cities, up from the 54 per cent in 2020.
- The past 70 years have seen the rise of "megacities" - these are cities with a population of greater than 10 million people. Over 60 per cent of these cities are located in low peace countries.
- There are currently 33 megacities with the number likely to increase to 47 by 2050, with a combined increase in population of 213 million people. Eight of the 13 new megacities have high levels of ecological threats, low levels of societal resilience and low levels of peace.
- The most unsustainable cities are Kinshasa, Nairobi, Lagos, Dhaka, Baghdad, Lahore, Kolkata and Delhi. They have projected high population growth, over 50 per cent, combining with other factors including, high levels of air pollution, poor sanitation, high homicide rates and substantial ecological threats.
- The cities with the highest population growth are in sub-Saharan Africa. These include Dar es Salaam, Nairobi, who will increase their population by more than 100 per cent in the next 30 years. Kinshasa, Lagos and Khartoum will increase by more than 80 per cent.
- Three megacities are expected to decrease in size – Osaka, Tokyo and Moscow.
- Megacities in low peace countries have the highest population growth rates. These cities also have low coping capacities and will struggle to provide infrastructure, jobs, security and manage their ecological threats.
- The high population growth rates in cities will create increasing challenges for peacefulness, especially for violent crime, organised crime and civil unrest.
- Nine cities have more than 20 times the WHO recommended maximum air pollution level. These cities include Lahore, Kabul, Delhi and Agra. The highest number of polluted cities are in South Asia and China.
- In 2019, the World Bank estimates that pollution was responsible for economic losses totalling US$ 8.1 trillion, or 6.1 per cent of global economic output.
- It is possible to address air pollution, as was seen with Beijing whose air quality in 2013 was 90 times higher than the WHO's recommended daily level; by 2021, it was only 7 times higher.
- A number of megacities are sinking creating long-term issues of viability, for example parts of Mexico City are sinking by 50 centimetres per annum, while North Jakarta is sinking by 4.9 centimetres per annum.
- Cities could have been responsible for as much as 70 per cent of global CO2 emissions in 2021, causing between 6-9 million premature deaths annually.
- The 2017 UN Human Development report estimated that $57 trillion in global infrastructure investment would be required to provide adequate housing for 1 billion people, living in sub-standard housing. The figure would be higher now.

1 Results



KEY FINDINGS

- Ecological threats and high levels of violence form a vicious cycle, whereby the systemic dynamics reinforce each other. The degradation of resources leads to violence and violence leads to the degradation of resources.
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- 37 administrative areas face catastrophic levels of ecological threat in all four domains. All are located in sub-Saharan Africa with an estimated 34 million people living in these regions.
- North America and Europe are the two regions with the best ETR scores.
- IEP estimates that in 2050, 3.4 billion people will reside in countries facing catastrophic ecological threats, compared to 2 billion in 2022. Their populations will account for 34.7 per cent of the world's total population. The majority of the increase will be in sub-Saharan Africa.
- Over half of the 228 countries in the ETR face at least one catastrophic threat. Neither China nor India face a catastrophic threat; however, most countries have the necessary societal resilience to avoid societal breakdown.
- To address these ecological threats interventions must be holistic, systemic and sustained over decades.

KEY FINDINGS - CLIMATE SURVEY

- Between 2019 and the end of 2021 the world's population became less concerned about climate change, dropping by 1.5 per cent, to 48 per cent. This may be partially explained by COVID-19 and concerns regarding more immediate issues, such as health and livelihoods.
- The three countries with the biggest falls in concern were Singapore, Namibia and Zambia, with falls of 24, 21 and 18 per cent respectively.
- Citizens of the world's biggest polluters, China and Russia, became less concerned about climate change, recording a substantial drop of three per cent each.
- China is one of the countries least concerned about the impact of climate change over the next 20 years at just 20.1 per cent. India, the world's third largest polluter, scores poorly at 38.8 per cent.
- Six of the nine regions of the world recorded less concern, with the South Asia, North America and Europe regions being the only ones to improve.
- Regions exposed to the highest level of ecological threat, are on average the least concerned with climate change, with only 27.4 per cent of respondents in MENA and 39.1 per cent of South Asians perceiving climate change as a very serious threat.
- Sub-Saharan Africa and South Asia ranked war, terrorism, crime and violence as greater concerns than climate change.
- 55.9 per cent of Europeans and 55.7 per cent of North Americans perceived climate change as a very serious threat.

Background

The Ecological Threat Report (ETR) is a comprehensive, data-driven analysis covering 3,638 sub-national administrative units in 228 independent countries and territories. It covers 99.99 per cent of the world's population and assesses threats relating to food security, water stress, population pressures and natural disasters.

The report identifies countries that are most at risk of catastrophic outcomes due to ecological threats and uses the lens of societal resilience to predict the countries most likely to suffer from instability and conflict in the future.

The 2022 ETR aims to provide an impartial foundation for the debate about ecological threats facing countries and sub-national areas, and to inform the design of resilience-building policies and contingency plans.

The report finds that many of these countries are already facing hardship, instability and conflict. For instance, rapid population growth and food insecurity in regions such as sub-Saharan Africa and parts of MENA have been stressors of socio-political instability for the past 50 years or more. Water scarcity has strained international relations in MENA, as Turkey, Syria and Iraq competed for the resources of the Euphrates-Tigris Basin. Similar tensions exist between Egypt, Sudan and Ethiopia in regards to the water of the river Nile and the New Renaissance Dam.[2]

There is a strong relationship between the number and intensity of ecological threats and conflict. Of the 12 countries to record a catastrophic level of ecological threat in all four ETR domains, six are currently in conflict, and another three are in a state of institutional and social fragility. These countries include Central African Republic, Mozambique, Niger, Somalia and Yemen.[3]

The Sahel region is facing numerous social, political and economic vulnerabilities and holds the world's highest concentration of hotspot countries. The region has high rates of conflict and terrorism. Six of the ten countries within the Sahel are classified as "hotspots", meaning they have low levels of resilience and face at least one catastrophic ecological threat. These include Chad, Cameroon, Guinea, Mali, Mauritania and Nigeria. Many of these areas are already experiencing instability through armed conflict.

The balance between human activity and the planet's ecology is coming under increasing stress. As many as 1.4 billion people live in areas with limited access to clean drinking water with the figure projected to rise to 2.6 billion by 2050. With the global population expected to grow by around one-quarter over the next 30 years, water shortages, food insecurity and the severity of natural disasters are likely to substantially increase.

Looking forward, climate change will act as a threat multiplier, potentially exacerbating competition and tensions among countries with low resources and resilience. The number of natural disasters, including floods and droughts affecting human settlements, has tripled over the last four decades and is likely to continue growing.[4] The latest IPCC report projects worse fires, longer droughts, and increasing numbers of floods.[5] Such ecological disasters also lead to mass displacements, as individuals search for basic security.

With the global population continuing to rise, growing consumption increases humanity's ecological footprint. As a result, the effects of ecological catastrophes are set to become more pronounced. While mitigation strategies are available, they are substantially underfunded, and the damage will be irreversible.[6] These ecological factors will interact, compounding the pressure on many countries and will have an adverse effect on existing social and political structures. Recent examples of forced mass migration show the impact of negative shocks often extends well beyond national, and even continental, boundaries. In 2020, natural disasters resulted in 30.7 million displacements across 144 countries.[7]

The key finding of the Ecological Threat Report is that ecological threats have manifested in many countries and regions, and without substantial effort will only get worse. To mitigate the humanitarian and economic impacts of these current ecological shocks, it is imperative to raise the levels of resilience in the most vulnerable countries. These actions need to be addressed holistically from a systems perspective and sustained over decades. Such action will help these countries to address their current issues and protect their populations and infrastructure from future shocks.

The 2022 ETR emphasises IEP's contribution to the debate on the linkages between ecological change and peacefulness. The ETR also underlines how societies can create resilience through building Positive Peace and systems thinking as described in Box 1.1.

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BOX 1.1

An introduction to Positive Peace, Resilience and Systems Thinking

Positive Peace is defined as the *attitudes, institutions and structures that create and sustain peaceful societies*. It was conceptualised in the 1960s and empirically derived by IEP in 2012 with the development of the Positive Peace Index (PPI).

Positive Peace is the social, economic and governance factors that create highly functional societies, including peace and resilience. Positive Peace is also statistically connected to many other things considered important including higher Gross Domestic Product (GDP) growth, stronger measures of well-being, better performance on ecological measures and better developmental outcomes. Countries that perform well in the PPI tend to operate with higher levels of peace as measured by the GPI. They also tend to improve more rapidly than their peers in their GPI ranking. Research has shown that a country that enjoys high levels of Positive Peace is more capable of shielding its population from the immediate impacts of adverse shocks and recover more quickly in the aftermath. Thus, the PPI is often seen as a gauge of socio-economic resilience.

Nations operate according to the principles of societal systems. This means that social, economic and political developments are interdependent, and it is difficult to identify unique causes of events and trends. Another feature of social systems is that their internal structure may be changed depending on the severity of a shock. If a system is hit by a weak shock, it will respond without changing its internal configuration. For example, if a country is impacted by a mild economic recession, it will require a lower level of response that does not alter the structure of the economy, or the fabric of society.

However, if a system is impacted by a high severity shock, or if the system has a low degree of resilience, the disruption may cause ruptures in the system's internal configuration. For example, there are many instances of nations that descended into a state of social disarray in 2020 and 2021 as a consequence of the COVID-19 pandemic and global recession. The Global Peace Index (GPI) 2022 highlights that during the pandemic, global peace deteriorated. This period placed heightened stress on pre-existing political and economic tensions in many countries. For example, Lebanon continues to grapple with deteriorating economic conditions and political instability which have triggered thousands of demonstrations nationwide as well as a reconfiguration of the political system. In Sri Lanka, violent demonstrations erupted in early 2022 in response to daily power cuts and shortages of essential items such as fuel, food and medicine, resulting in the eventual resignation of both the President and Prime Minister. The system adjusted by seeking IMF loans and debt forgiveness, as well as citizens adjusting their purchases and daily routines.

The threats assessed in the ETR can generate severe shocks to nations. A country's ability to cope will depend on the severity of the shock and its levels of socio-economic resilience. In nations with low socio-economic resilience, the shocks can trigger tumultuous breakdowns in their internal structure. This can result in frayed international relations, growing risk of conflict, forced displacement of persons both internal and cross-border, and a fertile environment for recruitment into radical militant organisations.

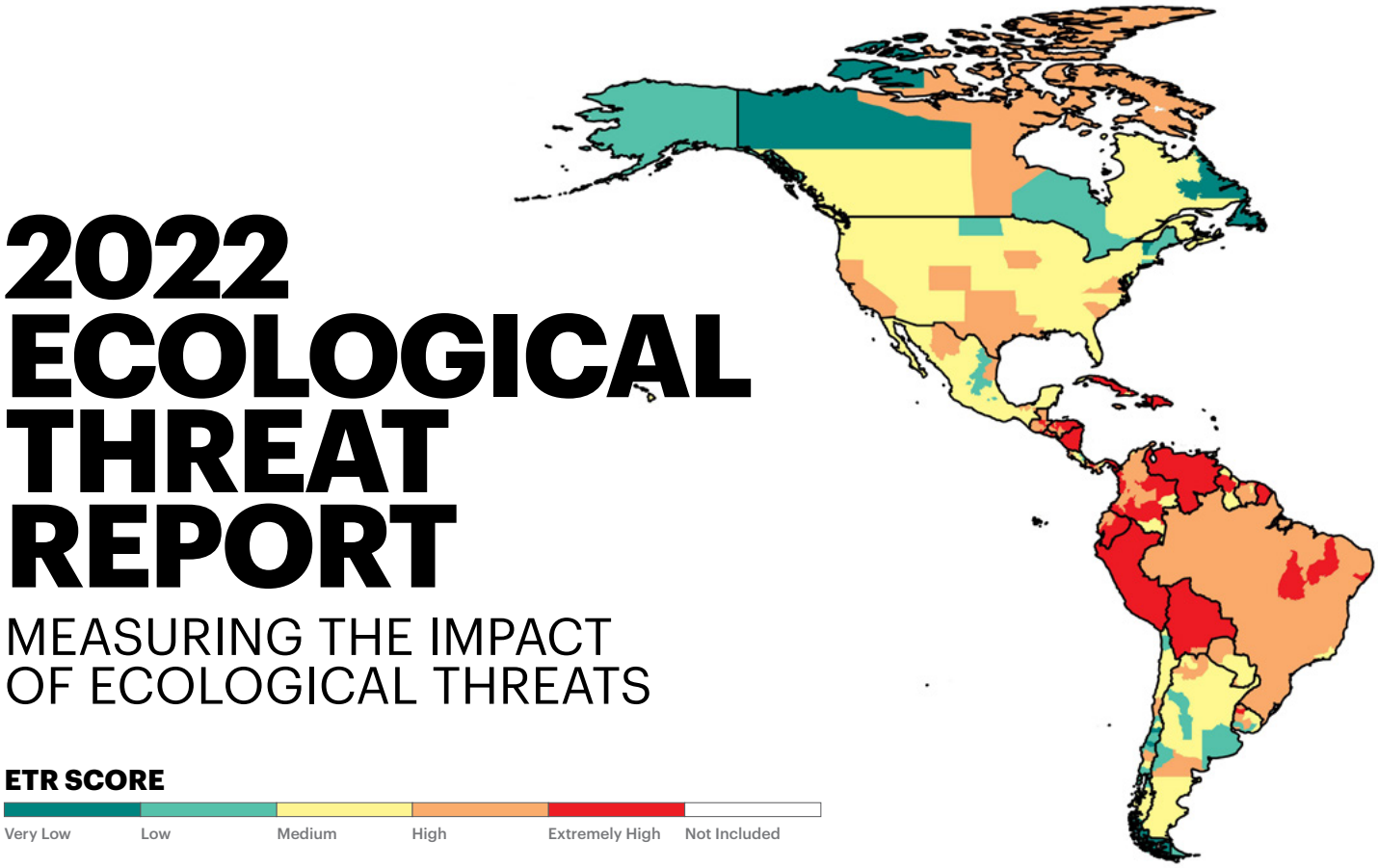
The concept of Positive Peace is discussed in more detail in the section 'Positive Peace and Hotspots' below. A more in-depth exposition is found in the Positive Peace Report 2022 (https://www.visionofhumanity.org/).

ETR Results

FIGURE 1.1

Ecological Threat Register Scores, 2022

Sub-Saharan Africa is the region with the most catastrophic ecological threats.



Source: IEP

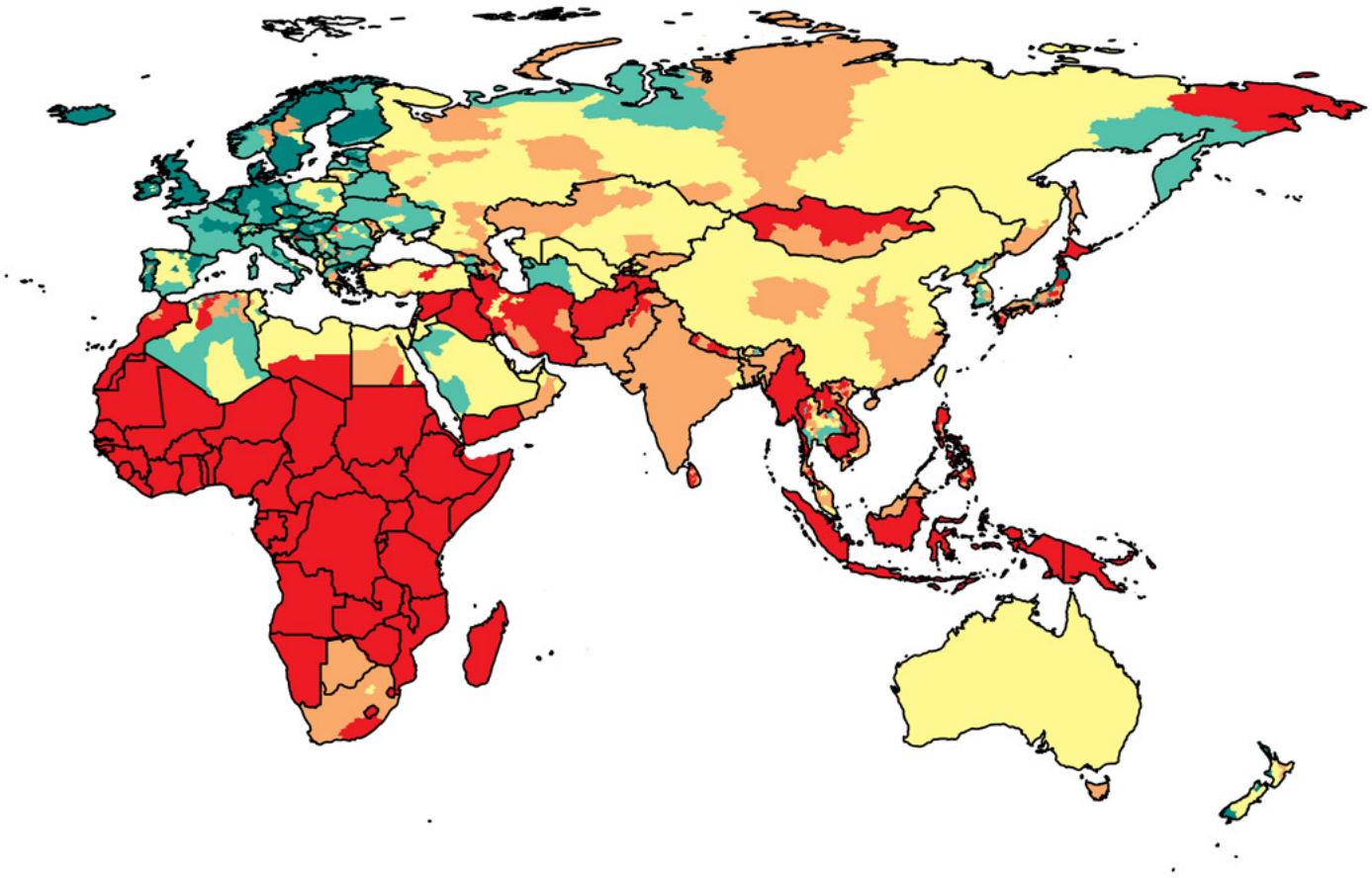
Ecological threats have the capacity to disrupt and undermine peacefulness. The ETR attempts to gauge the severity of such threats in an objective and transparent way.

The ETR focuses on four different threats that directly relate to drivers of conflict. These threats are classified in severity from *Low to Catastrophic*. A country is defined as facing a catastrophic threat if it exceeds one or more of the following thresholds:

- **Food Security**: More than 65% of the population could not afford food for their families in the past year.
- **Disasters from Natural Events**: More than 50 lives lost per 100,000 (or more than 3,000 displacements per 100,000) per year on average to natural events since 2016.
- **Population**: More than 70 per cent increase in population by 2050.
- **Water Stress**: More than 20% of the population do not have access to clean drinking water.

Figure 1.1 highlights the severity of ecological threats faced by 3,638 sub-national regions, with regions in red facing **at least one** catastrophic threat. It shows that the most vulnerable countries are clustered in certain geographical regions: sub-Saharan Africa, Middle East and North Africa (MENA), and South Asia. These regions are also the least peaceful, as measured by the GPI.

The ETR is calculated at the sub-national administrative level of a country, according to its relative threat level on four domains. A sub-national score is calculated as the maximum severity it faces across all four threats. For more details, see the methodology section or the methodology at a glance in Box 1.2.

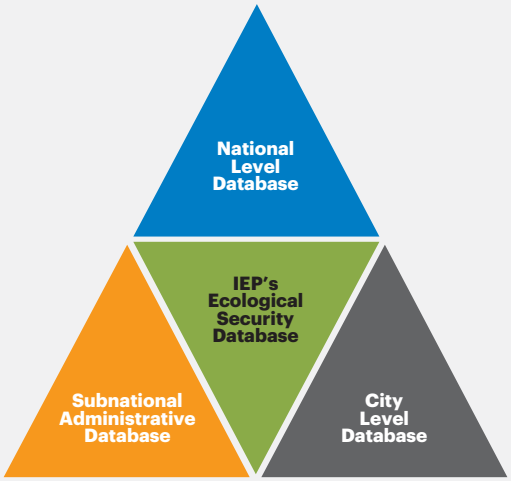


BOX 1.2

Methodology at a glance

The Ecological Threat Register (ETR) was developed to identify countries at the highest risk of ecological threats including water and food risk, population growth and disasters from natural events. The ETR analyses the potential of these threats combined with low levels of resilience to negatively impact peace today and into the future at the national, administrative district and city levels.

To produce the ETR, IEP has developed a comprehensive, ecological, geospatial and societal database based on 15 years of the Global Peace Index and Positive Peace Index. IEP's Ecological Security Database is shown in the following figure.



ECOLOGICAL THREATS AND CONFLICTS

TABLE 1.1

Correlation of ETR scores with GPI domain scores, 2022

Food Security and *Safety and Security* scores have the highest correlation, followed by *Water Stress* and *Safety and Security*.

	Safety and Security	Ongoing Conflict	Militarisation
Food Security	0.66	0.42	0.09
Water Stress	0.63	0.35	0.02
Population Increases	0.49	0.41	0.2
Natural Disasters	0.35	0.26	0.07

Source: IEP

There is a strong correlation between ecological threats and peacefulness. Table 1.1 displays the statistically significant correlations between the prevalence of ecological threats and the three GPI domains. The prevalence of all four ecological threats increases where countries score lower in the *Safety and Security* and *Ongoing Conflict* domains. *Militarisation* is the only domain not strongly correlated to ecological threat, as highly militarised countries such as the US, Russia, France and China face relatively low ecological threats. The strong relationship between peacefulness and ecological threats highlights that less peaceful countries have a higher prevalence of ecological threats, particularly food insecurity and water stress.

The strongest relationship is between the prevalence of food insecurity and *Safety and Security*, with a correlation coefficient of 0.66. This is followed by the relationship between water stress and *Safety and Security*, with a correlation coefficient of 0.63. These relationships would be expected as water stress and food insecurity can be either an exacerbating factor or direct result of conflict, violence or political instability.

THREAT SEVERITY

Figure 1.2 displays the distribution of countries by the severity of the ecological threat. Of the 228 countries in the ETR, 127 are identified as facing catastrophic ecological threats. These countries are home to more than 2 billion people or 26 per cent of the global population. By 2050, this figure is projected to rise to 3.4 billion people, with the largest overall increases occurring in Nigeria, Democratic Republic of the Congo and Ethiopia.

While not all of a nation's population will suffer from the direct impact of adverse ecological events, the indirect repercussions spread widely. This is especially the case if national resources, infrastructure and governance are stressed. Displacement of persons and competition for food and water resources may cause the impact of the original shock to transcend across national, and even continental boundaries.

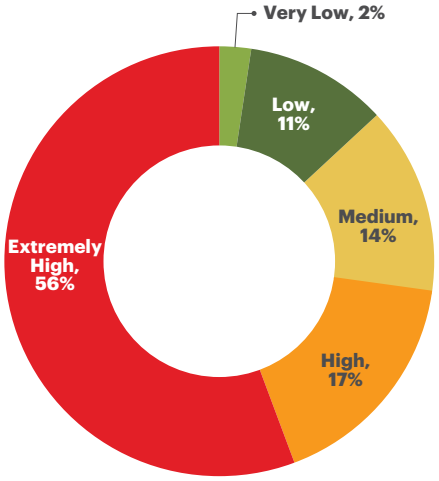
THREATS BY REGION

The level of ecological threat faced by countries is not uniform across regions. Some regions, such as MENA, have countries with low levels of ecological threats, such as Bahrain, Qatar and Saudi Arabia, while other countries face catastrophic threat levels. Figure 1.3 shows the overall average score for each region in the 2022

FIGURE 1.2

Distribution of the ETR threats, percentage of countries, 2022

56 per cent of the countries in the ETR are facing extremely high ecological threats.



Source: IEP

ETR. North America and Europe are the two regions with the lowest average score, whereas South Asia, sub-Saharan Africa and Asia-Pacific are the regions with the highest average score.

Sub-Saharan Africa has the worst ETR score, with approximately 206 million people at extreme risk of water insecurity. By 2050, sub-Saharan Africa's population is predicted to rise to 2.1 billion, an increase of over 95 per cent, which will dramatically increase pressure on existing food and water supplies. At 67 per cent, sub-Saharan Africa has the highest proportion of its population suffering from food insecurity, highlighting the severity of water and food risks in the region. Most countries across sub-Saharan Africa are dependent on rain-fed agriculture, making the region particularly vulnerable to changes in climatic conditions, such as prolonged droughts and seasonal floods.[8] Agriculture is the mainstay of most African economies, accounting for 65 per cent of GDP.

The second highest average ETR score for South Asia is influenced by the high level of water stress, with 40 million people living in areas in the region that record a catastrophic level of water stress. The region is also prone to natural disasters, such as earthquakes which exacerbates other ecological threats, particularly resource scarcity. Moreover, rapid population growth and unplanned urbanisation, coupled with environmental degradation and climate change, have increased the region's exposure and risk to natural disasters, resulting in more frequent, intense, and more costly disasters. However, three countries in the region - Bangladesh, Bhutan and Indonesia - have reasonable access to water, while the latter two also have reasonable access to adequate food, although Bangladesh does suffer from catastrophic floods.

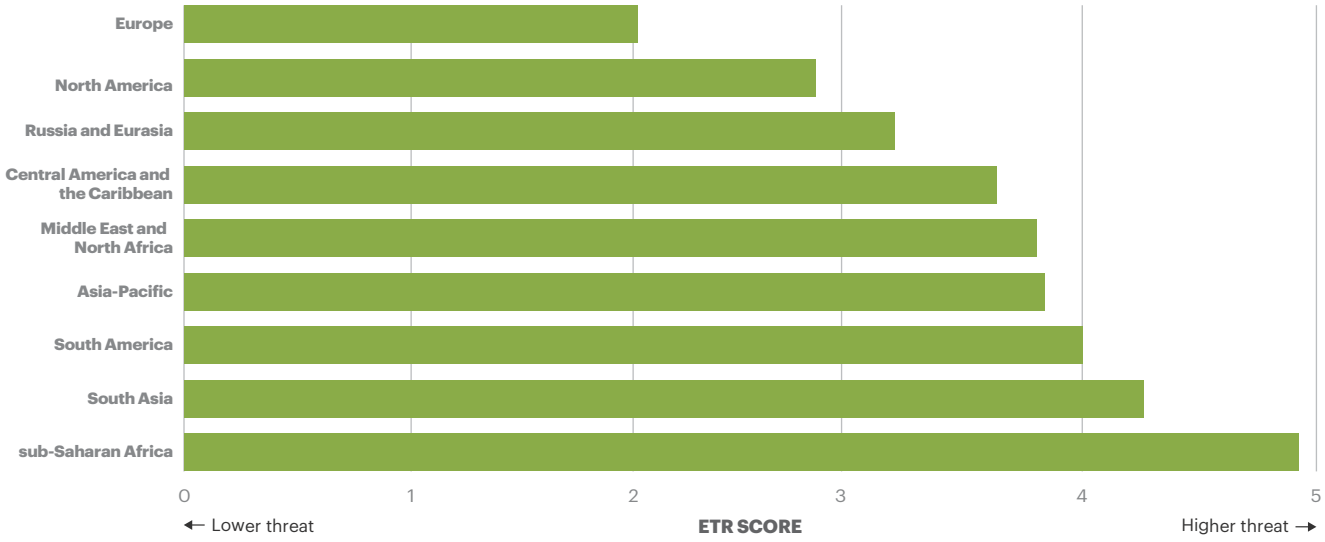
PERCEPTIONS OF CLIMATE THREATS

In an initiative by Lloyd's Register, the Gallup World Risk Poll conducted a global survey including a measure of the public perceptions of risk from climate change. Figure 1.4 displays the responses to the question "Do you think that climate change is a very serious threat to the people in this country in the next 20 years?"

FIGURE 1.3

Average ETR score by region, 2022

Sub-Saharan African and South Asian countries have the highest average ETR score.



Source: IEP Calculations

The global average response for citizens indicating that climate change is a very serious threat was 49 per cent.

On average, 65 per cent of South Americans perceive climate change to be a very serious threat over the next 20 years — the highest of all regions. In comparison, only 27 per cent of MENA respondents perceive climate change as a very serious threat — the lowest of all regions. Over half of citizens surveyed in North America, Europe, Central America and the Caribbean believe climate change to be a very serious threat. The second lowest score at 39 per cent was recorded for South Asia. In contrast, South Asian countries are amongst those most at risk of ecological threats in the world.

In 2021, just 20 and 37 per cent of the populations of China and Russia perceived climate change to be a major threat, a fall of three per cent each compared to 2019. These two countries are the first and fifth largest carbon dioxide emitters. In comparison, the US is the second largest carbon dioxide emitter and over 51 per cent of the population perceive climate change to be a very serious threat.[9] The third largest emitter is India, where only 39 per cent of the population perceive climate change as a serious threat.

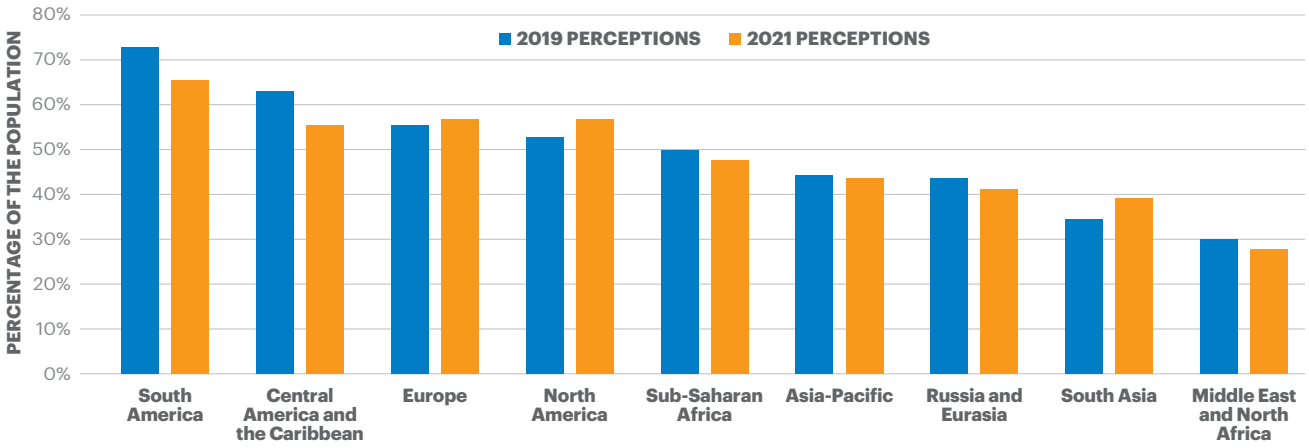
Globally the number of people concerned by climate change dropped by 1.5 per cent to 48.7 per cent on average between 2019 and 2021. This may be partly explained by COVID-19 and concerns regarding more immediate issues, such as health and livelihoods. Additionally, many countries in Africa rated conflict, crime and terrorism higher.

Between 2019 and 2021 South Asia, North America and Europe were the only regions to record an increase in the percentage of

FIGURE 1.4

Percentage of population by region that believe climate change will be a very serious threat over the next 20 years, 2019 and 2021

In 2021, 65 per cent of the citizens of countries in South America perceived climate change to be a very serious threat over the next 20 years compared to just 27 per cent in the MENA region.



Source: Gallup; IEP Calculations

citizens who were concerned with climate change, increasing by five, three and one per cent respectively. The other six regions recorded decreasing rates of concern. The country with the largest increase in concern was the Czech Republic, recording a 47 per cent rise during the period, followed by Israel at 34 per cent.

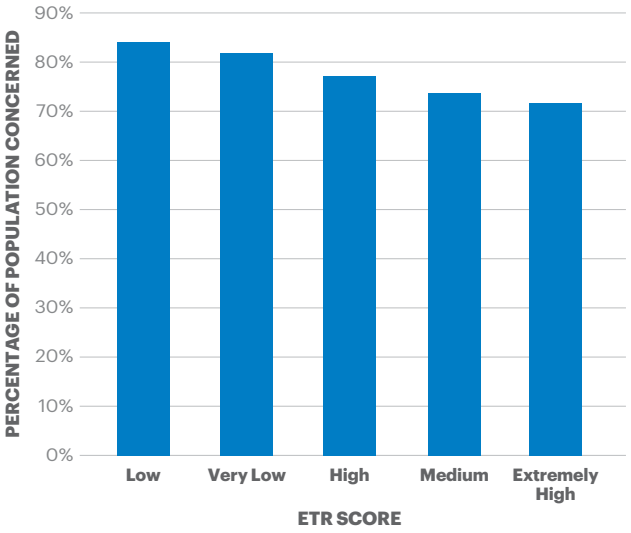
Of the other six regions South America recorded the largest decline, falling almost eight per cent, although it is still more concerned than any other region. Singapore recorded the largest fall in concern for climate change, with a decline of almost a quarter between 2019 and 2021 to 49.4 per cent. Citizens of Singapore were more likely to be concerned about road safety and their health than climate change, with 11 per cent of the population surveyed stating their primary concern was the COVID-19 pandemic. Namibia and Zambia followed Singapore, recording falls of 21 and 18 per cent respectively. More citizens of each country were concerned with their financial stability and the risk of crime and violence than the threat of climate change. Thirteen countries in Europe recorded a decline in concern for climate change between 2019 and 2021, with the largest being in Belgium. Only 42 per cent of Belgians were concerned about climate change, compared to 58 per cent in 2019, with citizens more concerned with road safety, personal health and crime.

South Asia and sub-Saharan African respondents ranked war, terrorism, crime and violence as greater concerns than climate change. This coincides with the findings of the 2022 Global Terrorism Index (GTI), with eight of the ten countries most impacted by terrorism located in either South Asia or sub-Saharan Africa. These regions combine high exposure to ecological threats with low levels of socio-economic resilience, as gauged by their ETR and PPI scores, respectively. In contrast, North American and European respondents appear more concerned with climate risk despite scoring relatively well in the ETR and PPI.

FIGURE 1.5

ETR threat level versus percentage of the population concerned about climate change

Respondents in countries at Low and Very Low risk of ecological threat are the most concerned about climate change.



Source: Gallup; IEP Calculations

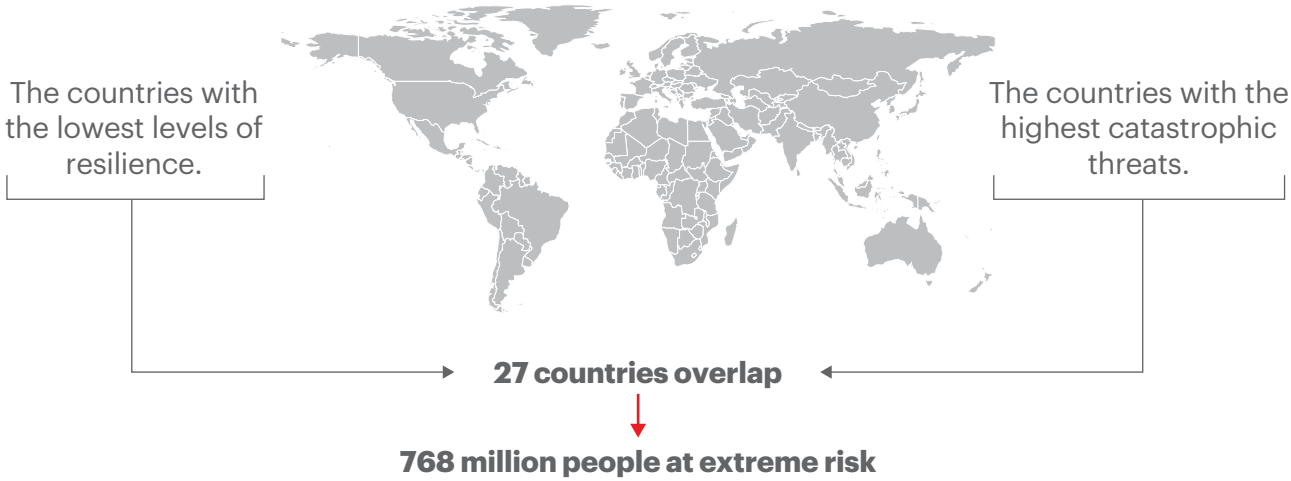
> Regions exposed to the highest level of ecological threat, are on average the least concerned with climate change, with only 27.4 per cent of respondents in MENA and 39.1 per cent of South Asians perceiving climate change as a very serious threat.

Country Hotspots

FIGURE 1.6

Calculating which countries are at risk to ecological threats

IEP estimates there are 768 million people living in countries where societal resilience is unlikely to be sufficient to withstand the impact of their ecological threats.



COUNTRY HOTSPOTS

Country societal systems have different levels of capacity to respond to ecological threats. This capacity can be measured through Positive Peace which provides a measure of resilience as Positive Peace measures the *attitudes, institutions* and *structures* of societies. These are the same factors that create capacity and adaptability.

Countries that rank higher in the Positive Peace Index (PPI) have strong societal mechanisms, which means they are better prepared to deal with ecological threats. Conversely, many countries have low levels of resilience as gauged by the PPI. This suggests that even moderate shocks may engender disorderly re-arrangements in the structure of the economy, the political system or lead to conflict.

Positive Peace shows high statistical associations with higher levels of food security, water security and the ability to manage natural disasters. This is because countries with stronger socio-economic development are better organised, have more resources and higher social cohesion. They also have more effective disaster response mechanisms and their governance systems are more transparent, responsive and adaptable.

IEP's hotspot analysis compares the countries and regions facing at least one catastrophic threat with the PPI. The overlap between the countries facing one catastrophic threat and the countries in the bottom 30 of the PPI yields the hotspots outlined in Table 1.3. The bottom 30 countries in the PPI are considered to have the lowest societal resilience. These regions are home to around 768 million people.

What is striking about this analysis is the high proportion of countries that overlap at the lower ends of the ETR and PPI. At this level, 90 per cent of countries with low Positive Peace face at least one catastrophic threat.

These countries are shown in Figure 1.7.

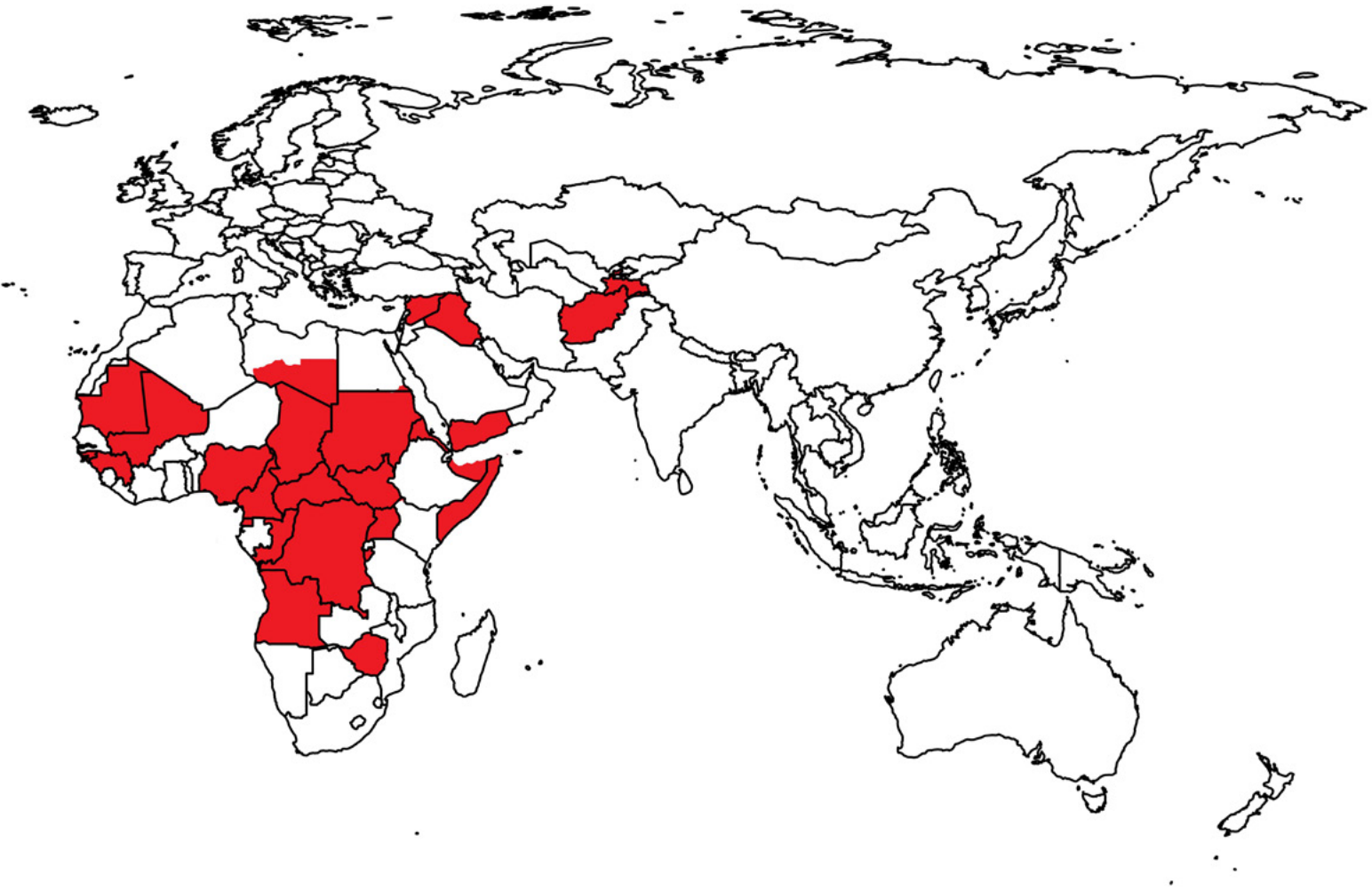
FIGURE 1.7

ETR hotspots, 2022

27 countries are identified as combining a catastrophic level of ecological threat with extremely low societal resilience as measured by the PPI.

Source: IEP

The relationship between peacefulness, food insecurity, water scarcity and population growth is complex. If multiple ecological threats occur simultaneously, they can converge causing a multiplier effect. For example, a country may be, exposed to water stress and dedicate resources to addressing this threat. However, the combination of water stress and a rapidly growing population may exacerbate food insecurity as water needs to be redirected to agriculture, thereby decreasing access to clean drinking water. Multiple stressors are more likely to lead to negative societal outcomes such as political instability, social unrest and violent conflict. In turn, this may cause more damage to physical infrastructure and further deplete already scarce resources, thus creating further food insecurity and water stress. The interplay between ecological threats and socio-economic dynamics may lead a country into a vicious cycle of progressively greater adversity.



KEY FINDINGS

768 million

27 hotspot countries have been identified that face catastrophic ecological threat with extremely low societal resilience. These countries are home to 768 million people.

Seven of the eight most at risk hotspot countries are in sub-Saharan Africa. These are Burundi, Central African Republic, Chad, Republic of the Congo, Somalia, South Sudan and Uganda. The eighth country is Yemen.

3.4 billion

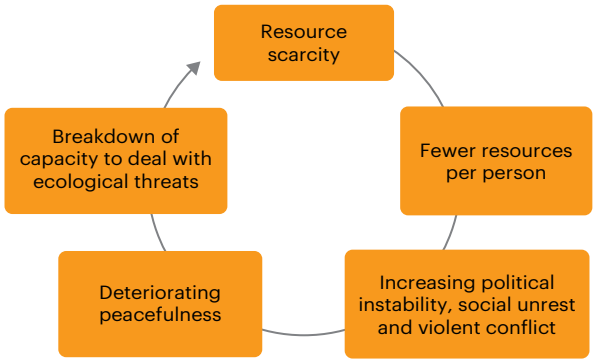
IEP estimates that in 2050, 3.4 billion people will reside in countries facing catastrophic ecological threats, compared to 2 billion in 2022.

Figure 1.8 displays the vicious cycle for changes in resource scarcity and peacefulness.

FIGURE 1.8

Vicious cycle from deteriorating resilience

Increased stresses caused by ecological threats may damage resilience and make a society less equipped to deal with future threats.



Source: IEP

Table 1.2 highlights the worst sub-national regions by population that face catastrophic threats in all four domains. All four of these sub-national regions are located in sub-Saharan Africa, with 13 million people living in these regions exposed to catastrophic levels of water scarcity, food insecurity, population increase and natural disaster threat.

HOTSPOTS: SHOCKS AND RESILIENCE

Shocks are sudden substantial inputs to a system. This input, if large enough, will overwhelm the internal structures of the system, causing it to change. The resulting system may be better or worse, depending on the resilience of the system and the way the shock cascades through the system. The COVID-19 pandemic was a shock to society because a new input, fear of contagion, changed how individuals, groups and companies operate affecting the economic, political and health systems of countries.

Shocks can be internally generated, if they are the result of a societal system's own dynamics. These are known as *endogenous* shocks, with examples including political revolutions, civil unrest or economic crises. *Exogenous* shocks are those whose causes and triggers lie outside the social system, such as some types of natural disasters, invasions or pandemics. Shocks are often amplified by *stressors* – factors not necessarily related to the shock itself, but which reduce the ability of a social system to cope and recover.

Resilience is a social system's ability to minimise the effect of a shock and recover in its aftermath. When faced with a shock, systems will first attempt to limit its direct impact on their sub-systems. This is termed coping capacity, and has been defined by the UN as "the ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters."[10]

High levels of resilience mean that national systems have superior coping capacity in terms of physical infrastructure, regulatory frameworks, economic strength and diversification, emergency preparedness and response systems. In addition, they also have superior capacity to rebuild their socio-economic systems in the aftermath of the shocks.

For small to moderate shocks, the social system will limit the negative repercussions on the population and the economy, while the recovery will lead to a return to pre-shock levels of wellbeing. However, if the shock is severe enough, as in a catastrophic level threat, a system may have to reconfigure its internal structure. This means that the recovery will require more time and effort. But it also means that the reconfigured system may not be able to reach the same levels of wellbeing experienced before the shock. The concept of resilience is illustrated in Figure 1.9. In contrast, a highly resilient system when struck by a shock can reconfigure to become a more resilient system and be more capable of dealing with future shocks.

Positive Peace is an effective predictor of socio-economic resilience for countries and regions, as discussed in previous IEP research. This is because societies that operate with high levels of Positive Peace tend to:

TABLE 1.2

Worst sub-national areas facing catastrophic ecological threat by population

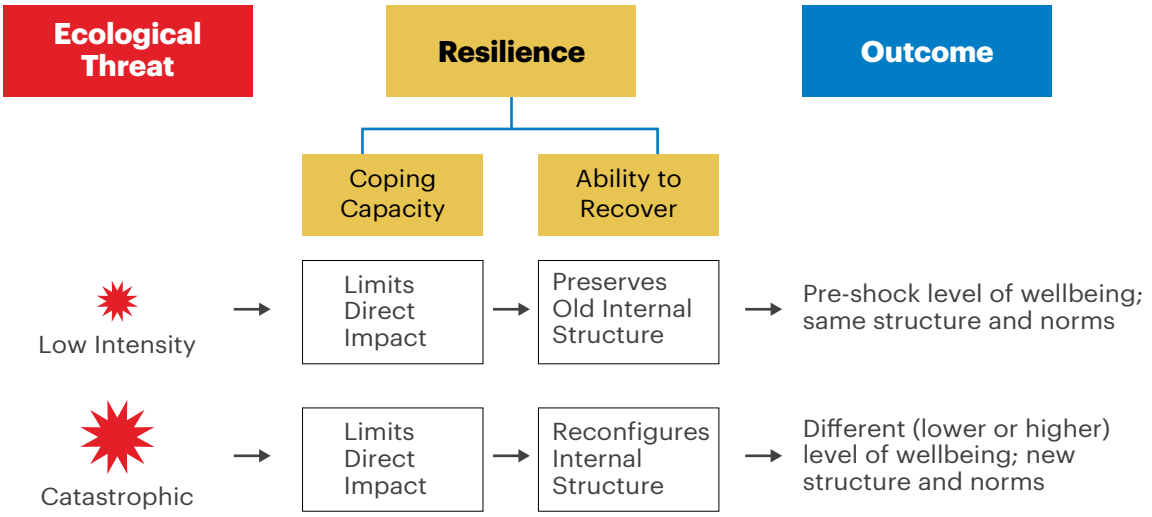
Country	Region	Sub-national Areas	Location	Description	2020 Population
Somalia	sub-Saharan Africa	Banaadir	South East	Administrative region of Somalia	5,788,490
South Sudan	sub-Saharan Africa	Jonglei State	East	Most populous state in South Sudan	2,934,960
Central African Republic	sub-Saharan Africa	Bangui	South	Capital and largest city of the Central African Republic	2,337,446
Mozambique	sub-Saharan Africa	Inhambane	South East	One of the oldest settlements on the eastern coast of Mozambique	2,060,850
South Sudan	sub-Saharan Africa	Warrap State	North	Located on the border with Sudan.	2,029,098
Somalia	sub-Saharan Africa	Jubbada Hoose	South	Southernmost state of Somalia, bordered by Kenya.	1,748,136
South Sudan	sub-Saharan Africa	Upper Nile	North East	Fourth most populated state in South Sudan.	1,669,730
Uganda	sub-Saharan Africa	Mbale District	East	Located close to the Kenyan border.	1,508,451

Source: IEP

FIGURE 1.9

Resilience involves coping with and recovering from shocks

Resilience is the ability to protect the population by limiting primary impacts of a shock and to restore the system, sometimes to higher levels of wellbeing. A catastrophic ecological threat may prompt the system to change its internal structures and norms.



Source: IEP

- be more effective in protecting lives and livelihoods from the impact of natural disasters;
- recover more rapidly from economic crises;
- adjust more easily and quickly to technological, business and social disruption; and
- promote the peaceful resolution of grievances and disputes between citizens and groups.

One example of resilience comes from national preparedness for and responses to natural disasters. These shocks occur with broadly the same frequency across countries with all levels of peace. However, countries with very low levels of Positive Peace have a fatality rate seven times higher than those with very high levels of Positive Peace. This happens because the Pillars of Positive Peace work in systemic ways to enhance a country's coping capacity. *Sound Business Environment* guarantees enough resources and infrastructure assets to treat people affected by the disaster and repair physical damage. *Equitable Distribution of Resources* means that all individuals, groups and demographics have access to protective infrastructure, equipment and services. A *Well-Functioning Government* allocates resources efficiently and transparently to groups or areas where they are most needed, and so on.

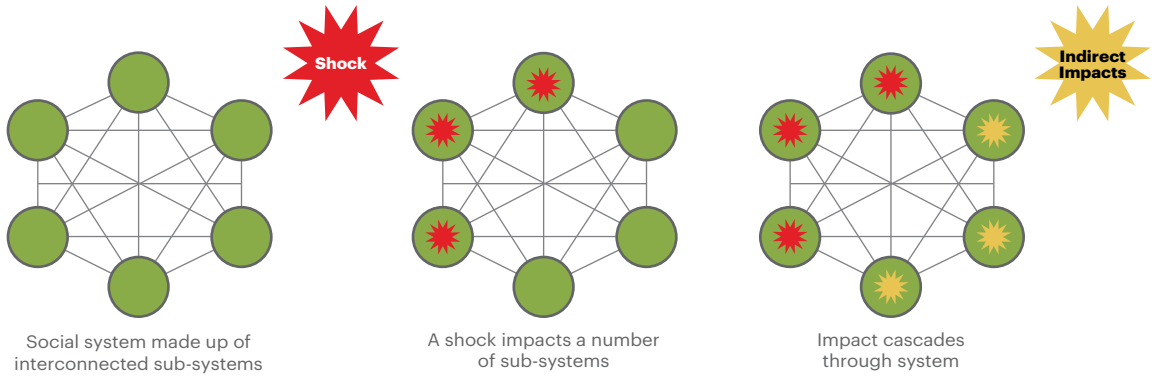
A socio-economic system, such as a nation, is comprised of multiple sub-systems. These can be concrete (such as households, cities or regions) or notional (such as a nation's education system or its judiciary).

When it first manifests, a shock may impact only some of a nation's sub-systems directly. In time, however, the interconnectivity between sub-systems retransmits the ramifications of the shock throughout the nation. This pattern is illustrated in Figure 1.10.

FIGURE 1.10

A shock's direct and indirect impact

A shock impacts system components in different ways. After the initial impact, the shock cascades through the system.



Source: IEP

The Japanese tsunami of 2011 offers one example of a shock transmission through sub-systems. In its direct impact, the disaster caused death and destruction in the north-eastern coast of the country. Subsequently, damaged nuclear power plants in the region contaminated crops and water supplies with radiation, affecting health and food production sub-systems in surrounding areas.

Another example is the 2010 earthquake in Haiti, which caused severe loss of life and widespread destruction. After the immediate impact, the country experienced a breakdown of its law and order infrastructure contributing to civil unrest and looting.

Thus, the more catastrophic threats a country faces, coupled with weak resilience, the more fragile a country will likely be. Table 1.3 shows a ranking of countries based on the number of catastrophic threats they face.

TABLE 1.3

Hotspot countries, 2022

Two thirds of hotspot countries are in sub-Saharan Africa, followed by MENA, Central America and Caribbean, South Asia and South America.

Country	Region	Food Security	Natural Disasters	Population	Water Risk	Total No. of Catastrophic Threats	PPI Rank	GPI Rank
Burundi	sub-Saharan Africa	•	•	•	•	4	151	131
Central African Republic	sub-Saharan Africa	•	•	•	•	4	160	155
Chad	sub-Saharan Africa	•	•	•	•	4	159	136
Republic of the Congo	sub-Saharan Africa	•	•	•	•	4	145	111
Somalia	sub-Saharan Africa	•	•	•	•	4	163	156
South Sudan	sub-Saharan Africa	•	•	•	•	4	162	159
Uganda	sub-Saharan Africa	•	•	•	•	4	138	121
Yemen	MENA	•	•	•	•	4	161	162
Afghanistan	South Asia		•	•	•	3	153	163
Angola	sub-Saharan Africa	•		•	•	3	136	78
Cameroon	sub-Saharan Africa	•		•	•	3	146	142
Democratic Republic of the Congo	sub-Saharan Africa	•		•	•	3	158	158
Equatorial Guinea	sub-Saharan Africa	•		•	•	3	150	59
Eritrea	sub-Saharan Africa	•		•	•	3	156	132
Guinea	sub-Saharan Africa	•		•	•	3	141	123
Guinea-Bissau	sub-Saharan Africa	•		•	•	3	142	110
Haiti	Central America and Caribbean	•	•		•	3	148	115
Iraq	MENA		•	•	•	3	154	157
Nigeria	sub-Saharan Africa	•		•	•	3	135	143
Syria	MENA	•	•	•		3	157	161
Zimbabwe	sub-Saharan Africa	•		•	•	3	144	127
Libya	MENA		•	•		2	152	151
Mali	sub-Saharan Africa			•	•	2	137	150
Mauritania	sub-Saharan Africa			•	•	2	139	112
Sudan	MENA			•	•	2	155	154
Tajikistan	Russia and Eurasia			•	•	2	143	92
Venezuela	South America	•			•	2	147	148

Source: IEP

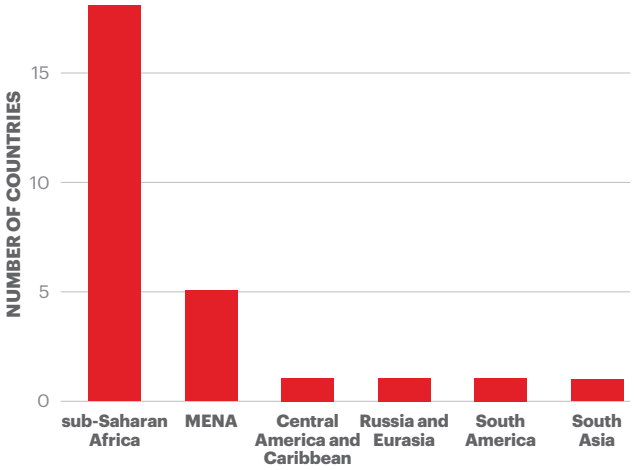
Among the 27 hotspot countries, eight countries recorded catastrophic scores on all four ETR domains. These eight countries are Burundi, Central African Republic, Chad, Republic of the Congo, Somalia, South Sudan, Uganda and Yemen. An estimated 146 million people live in these countries.

Ecological hotspots tend to be clustered in certain geographical areas. Figure 1.11 displays the number of countries identified as a hotspot by region. At 18 countries, sub-Saharan Africa has the highest number of countries of any region, followed by MENA with five countries. This clustering is significant because ecological and humanitarian crises often spill over across international borders. This spill over effect occurs through population flows, cross-border conflict and logistics links, to name a few.

FIGURE 1.11

Number of hotspot countries by region, 2022

Sub-Saharan Africa has the highest number of countries identified as hotspots.



Source: IEP Calculations

Temperature and Climate Change: Accelerating Ecological Threats

KEY FINDINGS

- Climate change will act as an accelerator for ecological degradation, raising many security implications both at the micro and macro levels.
- The Ukraine War has highlighted that many middle and high income countries are dependent on Russian energy exports. Dependency on exports from Low Peace countries therefore exposes importing countries to supply disruptions from instability caused by conflict.
- The developed countries with the highest dependency on energy imports from Low Peace countries are Japan – 84 per cent, South Korea – 74 per cent, Italy – 72 per cent and Belgium – 73 per cent. Many European countries are looking towards North Africa and Sahel as alternate suppliers of energy. Such countries also tend to be some of the least peaceful in the GPI.
- Increased attention from Europe, Russia and China will raise the geopolitical importance of North Africa and Sahel in the future.

The ETR shows ecological threats are a major issue across the globe today. Rising temperatures and other climatic changes serve to exacerbate and accelerate these existing challenges.

Greenhouse gas emissions, such as carbon dioxide (CO2), including the burning of fossil fuels are a major reason for the climatic changes. Such gases trap the sun's heat, warming the atmosphere. A temperature rise of one degree Celsius means that the air can hold around seven per cent more moisture, leading to more storms. Examples of how these will impact ecological threats are as follows:

Magnitude and Frequency of Natural Events: Increased capacity in the air to store moisture leads to more storms and extreme weather events.[12] There has been an increase in the most powerful Category 4-5 tropical cyclones. For example, the 2021/2022 rainfall season saw six cyclonic systems that caused widespread devastation in Mozambique and Madagascar; in April 2022, South Africa endured deadly floods that left hundreds dead and thousands without homes.[13]

Despite sub-Saharan Africa generating less than four per cent of greenhouse gas emissions, it has experienced the brunt of climate change. Natural disasters in the region have been impacted especially, resulting in an increase in the strength and rate of heatwaves, heavy precipitation and longer droughts.

Food Security: Irregular and intense rainfall as well as longer dry spells have increased pressure on agriculture, especially for subsistence farmers. Future changes to planting and harvesting will impact economies and peacefulness, as communities struggle to plan for the future.[14]

This is particularly concerning in the context of sub-Saharan Africa and South Asia where the extreme heat, rising levels of water stress, and flooding, along with sharp increases in population, have already had negative consequences on food security. Firstly, many farmers have tiny land holdings, which means it does not take much for yields to decline to unsustainable levels. Secondly, rising temperatures can increase or shorten the length of the growing season, which is very significant for crops grown in arid or semi-arid environments where additional heat will evaporate water faster. On a more macro level, many countries in sub-Saharan Africa are highly dependent on agriculture exports, as seen with Ethiopia, which means that the ability to earn currency is substantially weakened.

Water Stress: The changing climate, poor infrastructure, and overuse of water mean that billions of people face some form of water stress. This leads to more tense relations between people, communities and states. Water stress occurs when the supply of safe, usable water in a given area is insufficient to meet the demands. Changing ecological conditions can increase this stress.

The availability of freshwater will be impacted by global warming. In 2020, 2.3 billion people globally, or three in ten people worldwide could not wash their hands at home and one in four, or 2 billion people did not have access to safe drinking water.[15]

The effects are not limited to the developing world as it is projected that around one-third of the people living in the European Union will be under high water stress by 2070 unless more water is captured.[16]

Currently, the MENA region is the worst off in terms of physical water stress, as the region receives less rainfall than other regions. Rising urbanisation and persistent conflict in many countries have compounded the water stress situation because facilities and rivers have been destroyed or damaged. Additionally, inefficient water use has added to the water stress. Some countries have looked to mitigate and adapt to the water stress by developing desalination facilities or relying on technology to avert putting more pressure on their water supply.[17]

The rising level of water stress has a major impact on energy and economic growth. Europe is currently facing one of its worst droughts, with two-thirds of the continent in a state of alert.[18] European rivers have reached their lowest point in 1400 years, impacting the ability of barges to carry goods. In August 2022, Germany closed parts of the Rhine, as the water level reached 37 centimetre; operators were already operating at 20 per cent capacity, resulting in a rise in transport costs.[19] Due to the water shortages, some French nuclear power stations at the Rhône and Garonne rivers temporarily reduced their output because of fear that releasing water from the reactors would raise the water temperature too much for wildlife.[20] Another European country

affected by water stress is Norway whose electrical grid runs almost entirely off hydroelectricity. It had to temporarily stop its energy exports to maintain domestic electricity supply.[21]

ECOLOGICAL THREATS AND CONFLICT

Increased ecological threats from a changing climate will have security implications at the micro and macro levels. Local communities are more likely to experience ecological degradation sooner which can lead to political instability at a broader level. This can be seen in internal conflicts between herders and pastoralists in the Sahel where increases in population and resource scarcity both play a factor. It can also be seen in the precursor of the Syrian conflict, where a "mega-drought" increased migration from rural areas to urban cities, placing increased stresses on already stretched services and infrastructure.

Security can also be affected when mitigating actions taken by one community negatively affects another. This has been seen in the Al-Mejar district in Maysan province in southern Iraq where water was directed toward the farms in the northern part of the province, negatively impacting those living further down.[22]

A consequence of natural disasters, water scarcity, food insecurity, and above-average temperature is that they cause migration and displacement. Individuals fleeing harm, will put more pressure on towns and areas that are not directly affected. Migration intensifies competition over jobs, housing, and other resources.[23]

CLIMATE CHANGE, ECOLOGICAL THREATS AND GEOPOLITICS

Climate change does not affect regions equally. For example, if the temperature rise is not kept within 1.5 Celsius for the next several decades, (current trajectory is 2.4-2.9C),[24] Europe will see more flooding caused by extreme rainfall because of slowing weather systems, leading to slow-moving storms.[25] MENA, Sahel, and South Asia are projected to have more extreme heatwaves, with the prospects of farmland turning to deserts. The United States is likely to see more storms and hurricanes at one end of the country and greater droughts and extreme heat conditions at the other end of the country.[26]

The climatic changes have geopolitical implications. With more areas becoming less habitable due to extreme heat, increased flooding, and greater water stress, individuals will migrate out of necessity.

ENERGY DEPENDENCY ON LOW PEACE COUNTRIES

Reliable energy sources is imperative for national security. This will be especially true in a changing climate as patterns of energy will change to adapt to new seasonal trends.

The Russian invasion of the Ukraine underlined the dependency of many middle and high income countries on Russian energy exports. Many countries rely on energy imports from Low Peace countries facing ecological threats and with low societal resilience.

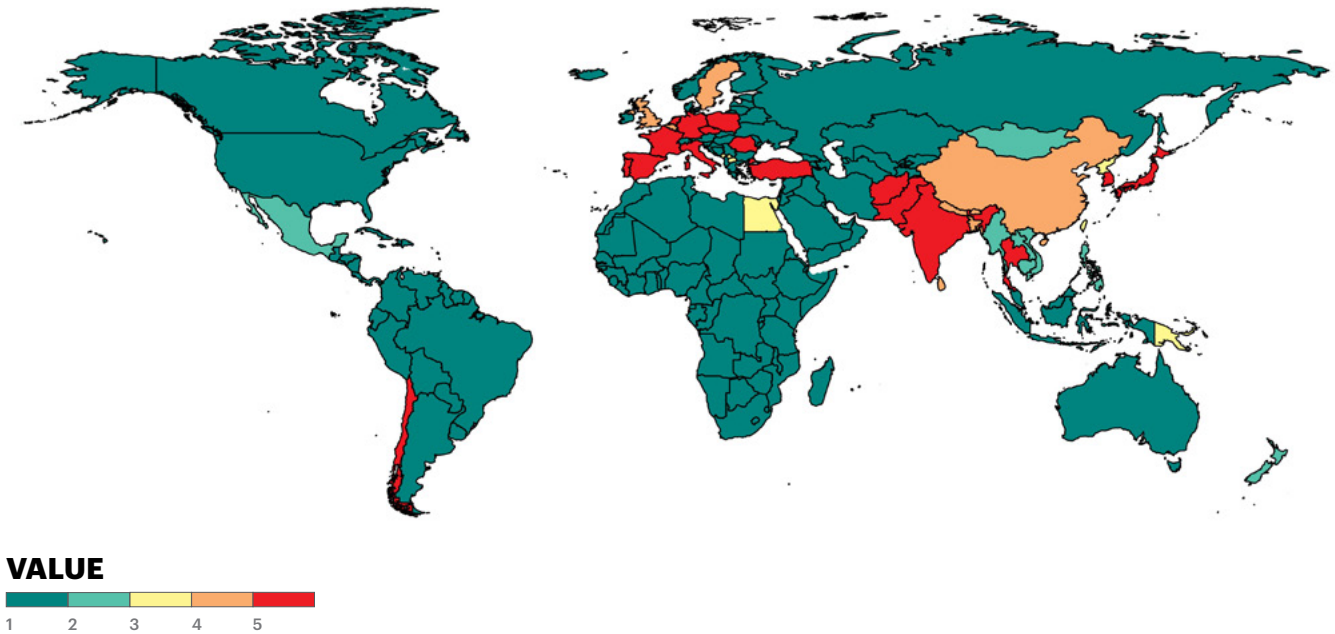
While the dependency on fossil fuels remains, unstable energy producing states can have a substantial impact on global stability. For example, shortages in the supply of fossil fuel due to the war in Ukraine initially resulted in a spike in the price of crude oil. The rise in prices has had the benefit of allowing countries such as Angola to pay off some of their debts,[27] while at the same time raising the cost of living for others.

Figure 1.12 shows countries that are most dependent on energy from Low Peace countries, which is defined as the bottom third of the GPI. The top ten dependent countries are shown in Table 1.4. These include Japan, South Korea and many European nations. All are middle to high income countries.

FIGURE 1.12

Countries dependent on energy imports from low peace countries

Europe and South Asia are highly dependent on energy imports from low peace countries.



Source: COMTRADE; World Bank; IEP Calculations

TABLE 1.4

Top 10 dependencies on energy imports from low peace countries

Country	Percentage of energy use imported from low peace countries
Japan	87.01%
South Korea	76.26%
Italy	74.18%
Belgium	73.01%
Turkey	70.02%
Portugal	69.28%
Spain	68.43%
Germany	65.33%
Chile	65.18%
Netherlands	59.75%

Source: COMTRADE; World Bank; IEP

While the transition to clean energy is underway, dependency of fossil fuels is still substantial and will remain that way for the near future. Political turbulence in energy exporting Low Peace countries poses a threat in the short to medium term for developed nations who are dependent on these imports to meet their net energy use. For instance, both Algeria and Libya could make up for Russian energy supplies, but it comes with risks. Algeria is the tenth-largest gas producer globally and one of the top five LNG exporters to Europe. Libya has Africa's largest known oil reserves and significant gas reserves.[28] Other issues of concern are Algeria's and Morocco's contentious relationship, and Algeria's historical relationship with Russia. For example, in 2020, it was Russia's third largest weapon importer.[29] Libya is risky because the country has remained unstable, with Moscow siding with General Khalifa Haftar. Clashes between Haftar and the Government of National Unity have prevented Libya from developing its energy fields and have at times stopped the shipping from Zawiya and Mellitah.[30]

For Low Peace countries, having to rely on fossil fuel for their income comes with substantial risks. Firstly, producer countries bear the substantial cost that comes with extraction. Secondly, it often makes the producer countries, if they are Low Peace, low-income countries, reliant on a single source of revenue. For example, if Europe achieves its plan to reduce its carbon footprint by at least 55% by 2030, it would represent a significant fall in income for fossil fuel exporting countries.[31] Nigeria, one of Africa's biggest oil producers underlines how vulnerable countries can be when oil is the major export earner. After the outbreak of the COVID-19 pandemic, Nigeria had to apply for more than $7 billion in emergency funds from international lenders, as around 60 per cent of its revenue and 90 per cent of its foreign exchange earnings come from petrodollars.[32] Additionally, as those countries look to gain as much foreign currency as possible, there is the tendency to not invest in domestic infrastructure which will remain wedded to fossil fuel. When there is an imbalance between the production and consumption, political turbulence follows.[33]

As European countries turn to North Africa and the Sahel for new energy supplies, the region is also gaining increased attention from Russia and China. Russia has signed military cooperation agreements with Nigeria and Ethiopia in 2021, and with Central African Republic and Mali in 2022. Russia is increasing its weapon sales to African countries with Africa accounting for 18 per cent of Russian arms exports between 2016 and 2020.[34] China has signed Belt and Road Initiative (BRI) agreements with every North African state. In 2013, China became Algeria's top trading partner, and between 2010 and 2020 made up almost 30% of Chinese arms sales to Africa. Chinese companies have been involved in the Hannibal undersea cable, which connects Tunisia and Italy and the undersea cable between Libya and Greece. In 2021, trade between China and Africa was valued at $254 billion, a 35 per cent increase from 2020.

SEA LEVEL RISE AND COASTAL FLOODING

A changing climate will see sea levels rise due to glacial melting. This is projected to be around 1 meter by 2100. Rises at this level represent an existential crisis for those living in low lying regions. Sea level rises and climate induced extreme weather events pose the most immediate threats to Small Island Developing Nations (SIDS), especially considering the majority of communities, infrastructure and economic activities are located in low-lying coastal areas. Low-lying nations with a majority of the population living within 5m above sea level are most at risk. In addition, as populations grow and coupled with climate change impacts, relocation to higher ground or beyond national borders will be a major challenge.[35]

The climate of these nations is influenced by ocean-atmosphere interactions such as trade winds, El Niño, monsoons and tropical cyclones. Table 1.5 shows the countries that will be most at risk are in Asia-Pacific and South Asia. Figure 1.13 shows the areas within these regions that are prone to coastal flooding.

TABLE 1.5

Highest share of population living within 5m above sea level

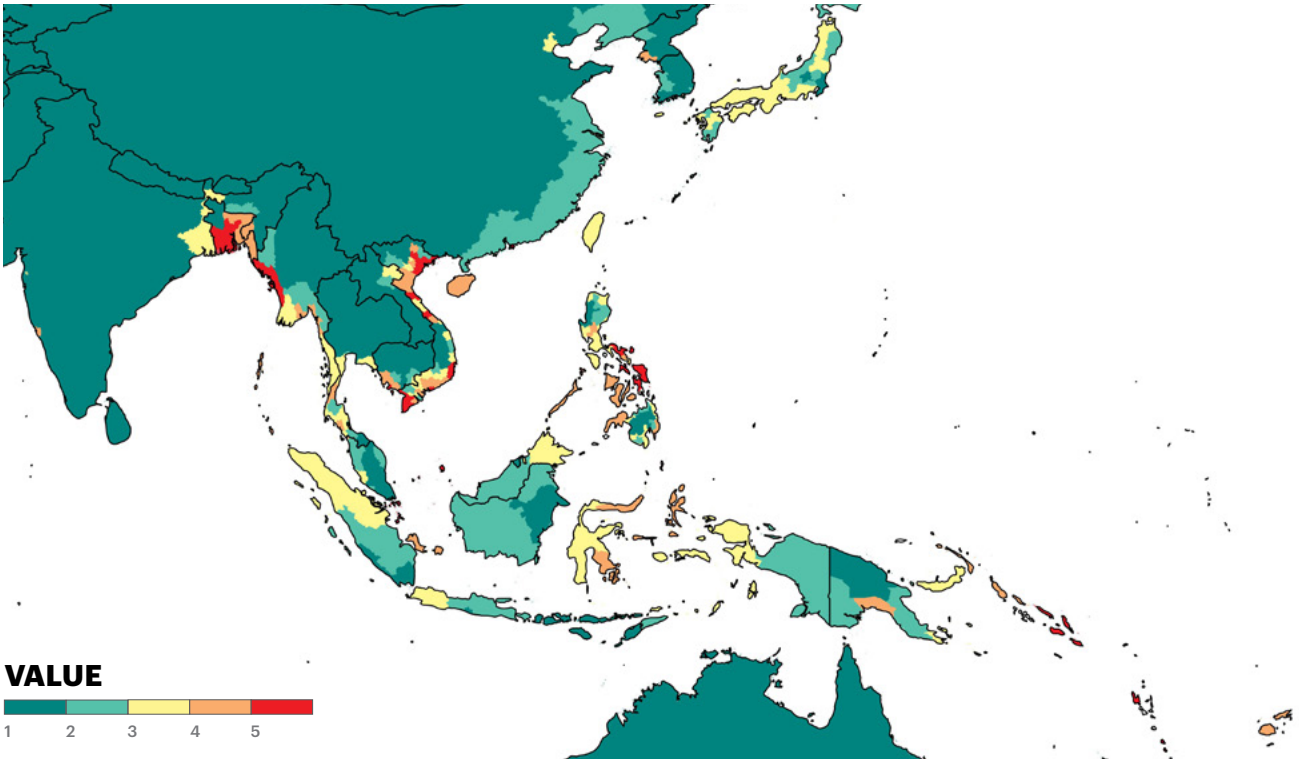
Country	Region	% of population living below 5m above sea level
Maldives	South Asia	100%
Tuvalu	Asia-Pacific	100%
Marshall Islands	Asia-Pacific	99%
Kiribati	Asia-Pacific	95%
Vietnam	Asia-Pacific	66%
Bangladesh	South Asia	32%
Myanmar	Asia-Pacific	28%
Vanuatu	Asia-Pacific	20%
Indonesia	Asia-Pacific	10%
Philippines	Asia-Pacific	7%
Solomon Islands	Asia-Pacific	7%

Source: UN; IEP

FIGURE 1.13

Regions prone to coastal flooding

The regions most prone to coastal flooding are in South-Asia and Asia-Pacific.



Source: World Resources Institute

2 Ecological Threats

KEY FINDINGS

- Fourty-one countries face extreme food insecurity. In these countries, more than 65 per cent of the population were unable to afford food for their family at least once during the last year.
- Globally, 768 million people are undernourished, or ten per cent of the world's population in 2021, compared to seven per cent in 2017.
- Since the onset of the COVID-19 pandemic, food security levels have deteriorated in seven of the nine regions in the world. The largest average deteriorations occurred in South Asia, South America and sub-Saharan Africa. The countries with the largest declines were Colombia, Syria, Ethiopia and Mozambique.
- Sub-Saharan Africa has the highest rates of food insecurity. Of the 52 sub-Saharan African countries, 37 recorded extremely high levels of food insecurity in the ETR.
- Countries with low domestic food security and low socio-economic resilience will be most affected by breakdowns in the food supply chain. Zimbabwe, Tajikistan, Republic of the Congo and the Democratic Republic of the Congo are the countries most at risk.
- More than 1.4 billion people live in regions experiencing severe levels of water stress. In these countries, at least 20 per cent of the population do not have access to clean drinking water.
- While sub-Saharan Africa is the most exposed region to water stress, European countries such as Albania, Estonia, Greece, Italy, Macedonia, Netherlands, Portugal, Romania, Turkey and Kosovo are also projected to see substantial water stress by 2040.
- Conflict over water has been increasing. With the number of incidents with water as a trigger for fatal conflict tripling since 2000. The countries that are most likely to see continued water-related conflict are Yemen, Iraq, Somalia and Sudan.
- The 40 least peaceful countries will have an additional 1.3 billion people by 2050, accounting for almost half of the world's population at 49.6 per cent.
- The population of sub-Saharan Africa is expected to increase by 95 per cent by 2050.
- Since 1981, the number of natural disasters have tripled to 429 in 2021, costing on average $200 billion per annum in the last decade. The most common natural disasters are floods and storms. The frequency of both have been increasing.

Food Security

Food security is an issue of rising importance. Population growth, depletion of agricultural resources and shifts in climatic conditions, create knock-on effects that influence political stability, conflict and migration. This section analyses the subnational and national implications of food availability and the likely effects on regional and country security. Food shortages and water scarcity are highly interrelated, as a lack of water leads to food shortages. Solutions to address food insecurity will need to consider water scarcity in order to be effective.

Sudden shocks not only disrupt accessibility to food, but they can also create knock-on effects that result in heightened political instability, greater civil unrest, increased forced migration and a higher likelihood of civil conflict.

To be food secure, people must have access to sufficient nutritional food that meet their basic preferences and dietary needs, and enough food to achieve an active and healthy life. Within the context of the ETR, food security comprises two elements: availability and accessibility.

- **Food availability** requires that a sufficient amount of food of appropriate quality be supplied, whether through domestic production, imports or aid.
- **Food accessibility** requires that legal, political, economic and social arrangements provide people with the ability to acquire food.

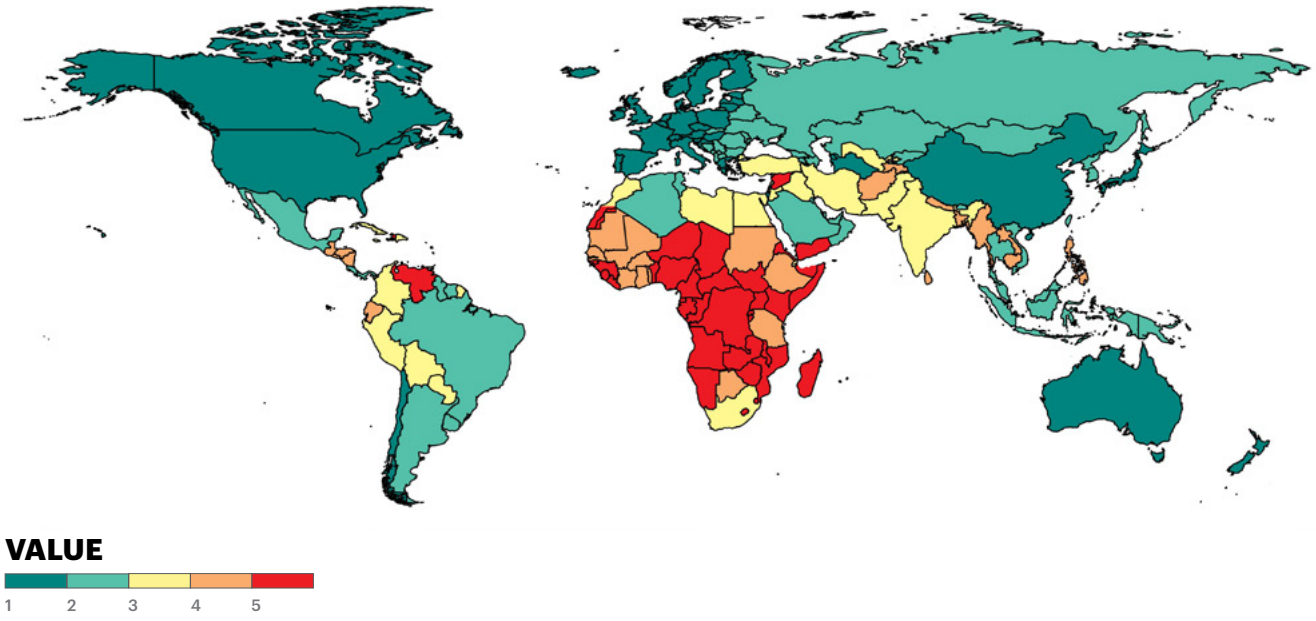
If either of these elements is missing, food security is compromised.

The ETR identifies 41 countries as facing extreme food insecurity. Surveys from these countries show that more than 65 per cent of the population of these countries have been unable to afford food for their family at some point in the past year. When large proportions of a country's population lack food security then economic development, social harmony, justice and social cohesion are affected.[1] Figure 2.1 shows the distribution of food insecurity across the globe.

FIGURE 2.1

Food Security domain scores, 2022

Over half a billion people live in countries that received the worst score in the Food Security domain, with the majority living in sub-Saharan Africa.



Source: EIU; Gallup World Poll; IEP Calculations

FOOD INSECURITY BY REGION

Sub-Saharan Africa has the largest proportion of its population living with catastrophic food insecurity, which is more than 14 times higher than the next region MENA. With 736 million people exposed, sub-Saharan Africa accounts for 89 per cent of the global total. Of the 52 sub-Saharan African countries, 37 recorded extremely high levels of food insecurity.

At 95 per cent, sub-Saharan Africa will also have the highest population growth by 2050, which if remains unchanged will have catastrophic impact on the stability of the region. The population is projected to reach 1.5 billion people, many of whom will inexperience water scarcity, food insecurity and above-average temperature increases.

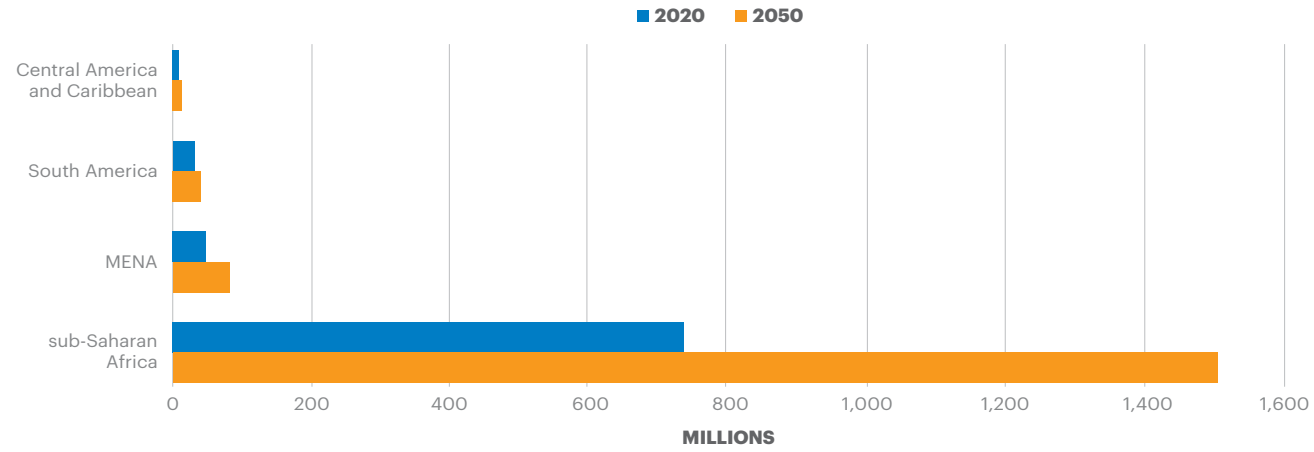
MENA has the second largest population living in countries exposed to catastrophic food insecurity, with 49 million people throughout the region. It is projected that by 2050, an additional 33 million people will be living in countries facing food insecurity in this region.

Regionally food security has been deteriorating since 2019, amplified by the onset of COVID-19. This is a reversal of the historic trend, as food security had been improving since 2012. Figure 2.3 shows improvements in food security have stalled, with South Asia and sub-Saharan Africa recording deteriorations over the period. The largest deteriorations since 2019 occurred in Colombia, Syria, Ethiopia and Mozambique.

FIGURE 2.2

Food insecurity by region, 2020–2050

Four regions have countries with catastrophic food risk. By 2050, 1.5 billion people are projected to be living in catastrophically food insecure areas of sub-Saharan Africa.



Source: IEP Calculations

FIGURE 2.3

Changes in Food Security since 2019

South Asia and South America recorded the largest deteriorations, while North America recorded the most significant improvement.

Source: EIU; IEP Calculations

BOX 2.1

Food insecurity and undernourishment

The concepts of food insecurity and undernourishment are related but not equivalent.

Food security primarily refers to access to food. If access is difficult, uncertain or intermittent, a person or group is said to face food insecurity.

Undernourishment takes place when a person or group's actual intake of food is insufficient to meet their dietary energy requirements.

Therefore, it is possible for a person or group to be food insecure but not undernourished. This happens when despite the difficulty and unpredictability of daily access to food, the actual intake remains on average at or above minimum required levels. However, this may mean that at times they do not have access to food.

The key concepts are defined below. Food security is achieved when at all times people have physical, social and economic access to sufficient, safe and nutritious food that meets their basic food preferences and dietary needs for an active and healthy life.[2]

- **Severe food insecurity** is where an individual may have exhausted their food or gone at least a day without eating. Their health, nutrition and well-being are at severe risk.
- **Undernourishment** is where an individual's habitual food consumption is insufficient to provide the dietary energy levels required to maintain their daily functions and a healthy life.

TRENDS IN UNDERNOURISHMENT

Over the past five years, deteriorating food security has resulted in increasing levels of undernourishment. This is where a person is unable to acquire enough food to meet their daily minimum energy requirements over a period of a year or more.[3] According to the FAO, in 2021, 768 million people worldwide were estimated to be undernourished, up by 46 million from 2020.

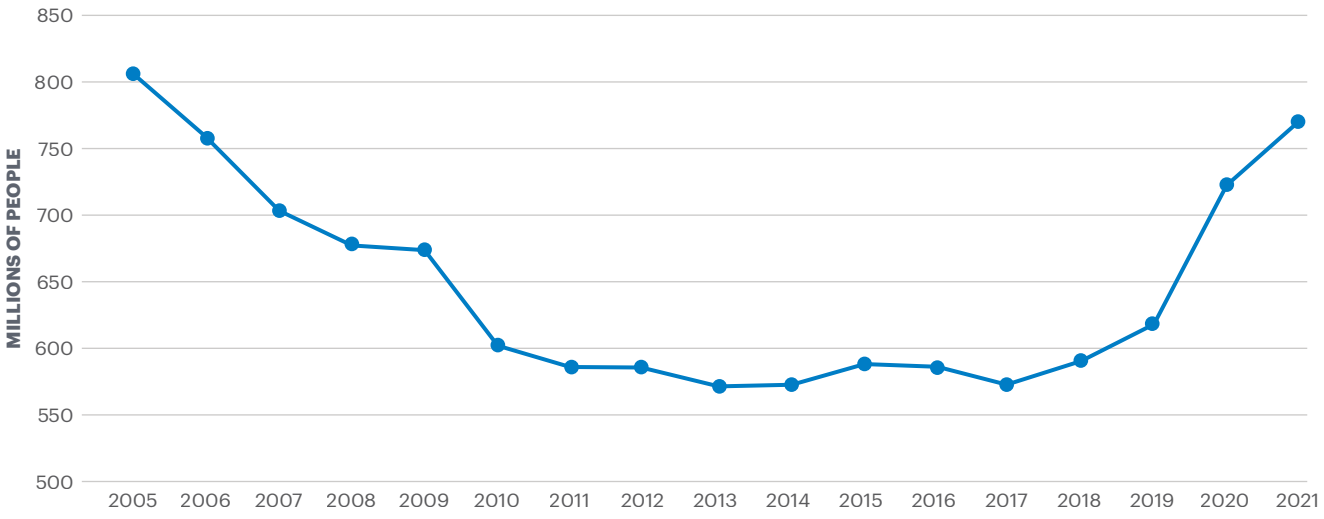
Figure 2.4 displays the levels of global undernourishment since 2005. There has been a consistent rise in the number of undernourished people since 2017. There are many contributing factors including rising food prices, economic shocks, COVID-19 lockdowns and protracted conflicts. This is a reversal of the trend for the prior decade, during which undernourishment had been declining.[4] This increase accelerated throughout the COVID-19 pandemic, and the number of undernourished people in the world today has nearly reverted to 2005 levels.

In 2021, almost ten per cent of the global population was undernourished, compared with seven per cent in 2017.[5] This trend is expected to continue over the next few years due to the ongoing effects of the COVID-19 pandemic, inflation, associated economic downturns, and disruptions to international food supply chains that have become apparent through the Russia-Ukraine War.

FIGURE 2.4

Number of undernourished globally, 2005–2021

In 2021, the number of undernourished people rose by an estimated 46 million.



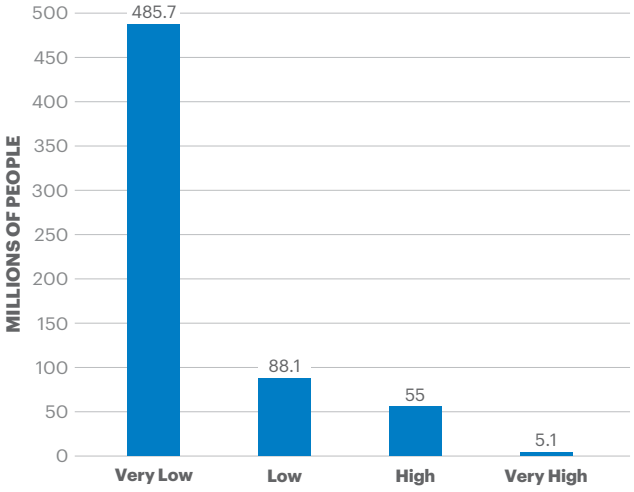
Source: FAO; IEP Calculations

In 2021, almost 78 per cent of the world's undernourished people lived in very low peace countries, with another 14 per cent living in low peace countries. Less than ten per cent of undernourished people live in high and very high peace countries. Figure 2.5 shows the total number of undernourished people by country peace levels.

FIGURE 2.5

Total undernourished population by peacefulness, 2021

Over 90 per cent of undernourished people live in low or very low peace countries.



Source: FAO; IEP Calculations

Food insecurity can be a direct result of over-population, lack of resources, violence, conflict, climate change or political instability. However, food insecurity can also be a trigger for and stressor to social tensions. Conflict, extreme poverty and severe food insecurity interact in systemic ways by generating negative feedback loops. This is where the social order deteriorates continuously, along with the food and water resources.

Yemen is an example of the interaction between conflict, extreme poverty and food insecurity, with persistent ecological shocks and conflict leaving around 400,000 people dead and 21 million in need of humanitarian assistance.[6] Due to the conflict, Yemenites have struggled to overcome the impacts of heavy rains, habitat destruction, environmental damage and pollution.[7] The situation in Yemen has been super-charged by competing international agendas which have prolonged and intensified the conflict.

FOOD SECURITY AND GLOBAL INSTABILITY

Food security globally relies on international trade routes and supply chains. As such, major international events can impact the food security of many nations. Figure 2.6 shows the trend of the FAO Food Price Index, benchmarked to 100 for 2000-2022 prices, along with major global events over the period.

The impact of international crises on food prices is clearly evident in Figure 2.6. An example is the 2007 Global Financial Crisis, where food prices on average rose 40 per cent in the following 12 months. Another example is that since the outbreak of the COVID-19 pandemic, where global food prices rose by 35 per cent. In the month after the Russian invasion of Ukraine, the Food Price Index rose by another 18 per cent.[8]

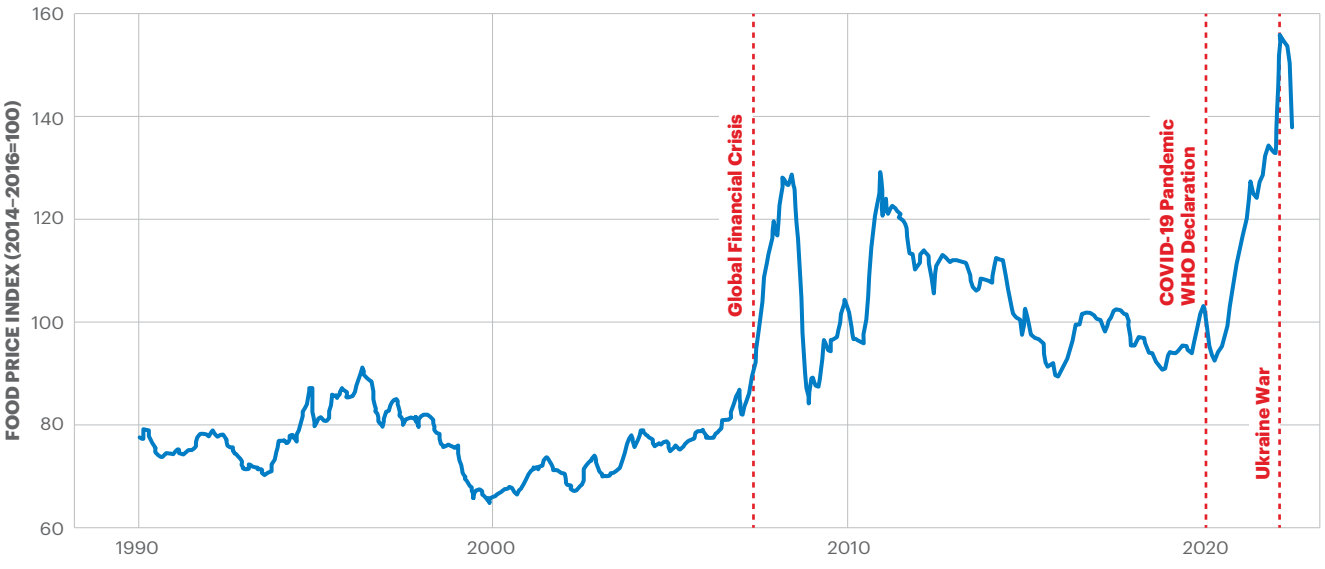
The Food Price Index demonstrates global instability, which largely occurs in low peace countries, leads to increased costs for food. Dependence on food imports from fragile and low peace countries represents a risk to food security. Self-reliant countries are better positioned to withstand such global fluctuations. Box 2.2 provides recent examples of impacts to food imports in Africa because of the Russia-Ukraine war.

Countries that import from low peace countries face more risk as increases in conflict will affect the reliability and quantity of supplies. Figure 2.7 shows that 80 countries have a high dependence on food imports coming from low peace countries, defined as importing from countries in the bottom third of the GPI. Such countries are more vulnerable if instability erupts.[9]

FIGURE 2.6

Monthly food price indices (2014–2016=100), 2000–2022

Food Price Indices increase in times of international crisis.

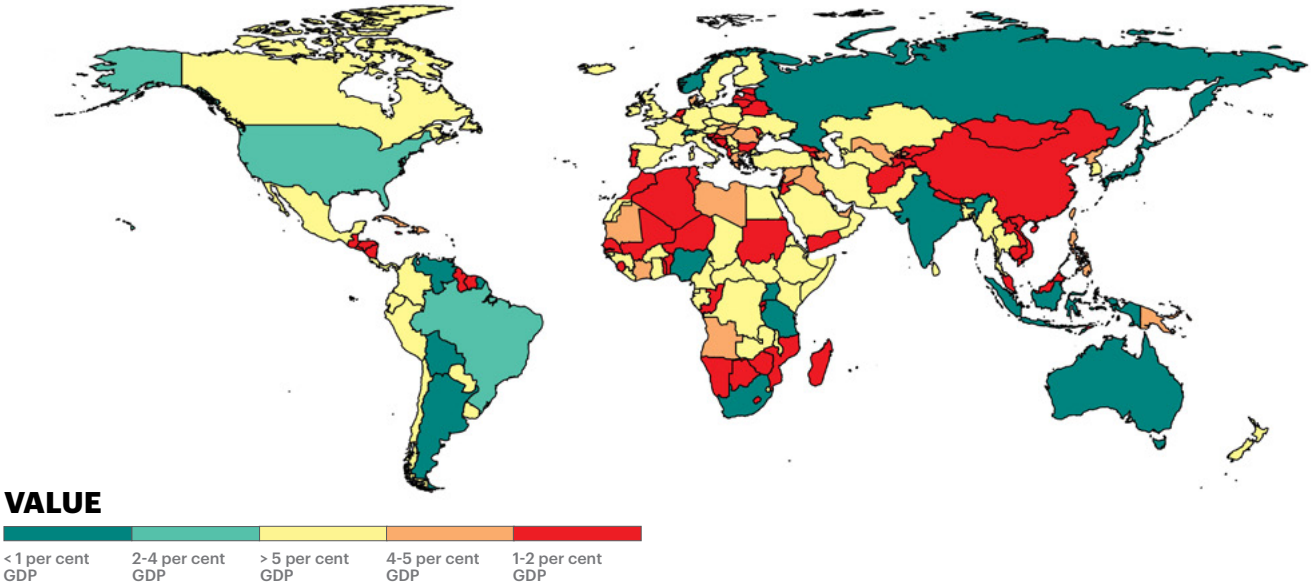


Source: FAO; IEP Calculations

FIGURE 2.7

Dependence on food imports from low peace countries, 2021

The sub-Saharan African region has the most countries that rely on imports from low peace countries followed by Europe.



Source: COMTRADE; World Bank; IEP Calculations

Regionally, the countries of sub-Saharan Africa are the most exposed to global insecurity with 21 countries relying on food imports from low peace countries. Many of these countries are other African countries. This dependence places an added pressure to tackle the region's domestic food security challenges. Other regions that show high dependency on imports from unstable countries include Europe, Central America and the Caribbean, and Asia-Pacific.

China imports a large volume of oil seeds and meat products from low peace South American countries such as Colombia, Venezuela and Guyana. European countries on the other hand depend on imports of cocoa from sub-Saharan Africa, oil seeds from South America and cereals from Russia and Eurasia.

The countries that will be most affected by future instability will be the ETR hotspot countries. This is due to their low levels of resilience and high dependence on food imports, mostly from other low peace countries, are listed in Table 2.1.

> Dependence on food imports from fragile and low peace countries represents a risk to food security. Self-reliant countries are better positioned to withstand such global fluctuations.

TABLE 2.1

Hotspot countries dependent on food imports from low peace countries

Country	Percentage of food imports from low peace countries
Zimbabwe	66%
Tajikistan	44%
Republic of the Congo	39%
Democratic Republic of the Congo	39%
Burundi	32%
Uganda	32%
Nigeria	31%
Mauritania	12%

Source: COMTRADE; IEP

BOX 2.2

How global conflict makes low peace countries more vulnerable to food security

The war in Ukraine underlines how events impact food security and peacefulness. This is particularly true for low peace countries as many are dependent on a single source of agricultural income. Between 2007 and 2019, Africa's population rose by 32 per cent, and its wheat imports rose from 27.3 million tons to 47 million tons.[10] Countries within the African continent consistently produce less than half, and often as little as one-third, of the wheat it consumes. Following the outbreak of war in Ukraine the Ukrainian conflict between seven to ten million people became food insecure in West Africa.[11] Moreover, the region is a net agricultural exporter, compounding its food insecurity.[12] When war broke in Ukraine, several African countries faced interrelated crises. The price of wheat rose, driven by the blocking of key ports such as Odessa, with 20 million tons of wheat unable to be exported.

Additionally, the price of oil increased exponentially, with compounding effects including transportation costs. The cost of fertiliser also increased, significantly impacting the agriculture industry.[13]

Egypt has also felt the impact of the Ukrainian conflict. Egypt imports around 13 million tons of wheat annually, making it amongst the largest importers of wheat globally. Despite this, Egyptian wheat farmers have are producing record yields. However, local wheat farms are unable to keep up with population growth in Egypt, with around 40 per cent of Egyptian calorie intake per person being wheat-based.[14]

Water Security

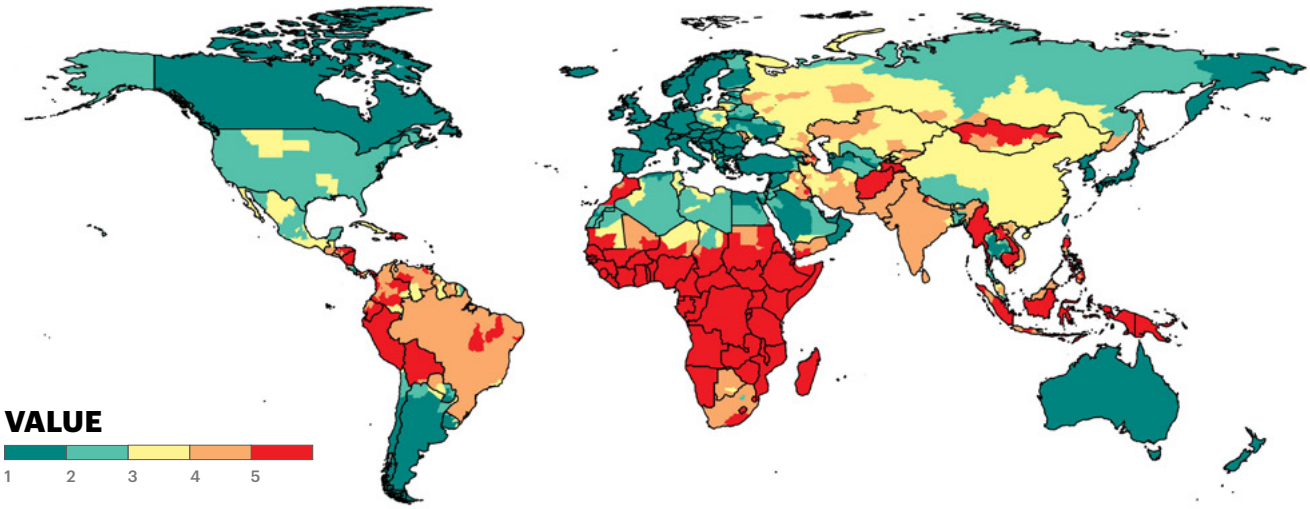
More than 1.4 billion people globally are exposed to extreme levels of water stress. In such countries, 20 per cent of the population do not have access to clean drinking water. Sub-Saharan Africa, South Asia and Latin America suffer from the worst water stress. Water stress impedes economic development and food production, which further compromises the nourishment, health and well-being of the population. It can also lead to social tension, conflict and displacement.

While most sub-Saharan countries face extreme water stress, some countries also have to contend with water disparities within their own borders. This presents a governance challenge now and into the future. For example, eight of the nine provinces in South Africa suffer from either high or extremely-high water stress, exposing almost 38 million people or 65 per cent of the population to this ecological risk, as highlighted in Box 2.3. Meanwhile the Gauteng province, containing both the nation's capital Pretoria and its largest city Johannesburg, has abundant water and low levels of water stress, highlighting that countries can face varying challenges within their borders.

FIGURE 2.8

Countries by level of water risk, 2022

Countries in sub-Saharan Africa are the countries most at risk of catastrophic water stress.



Source: WRI; IEP Calculations

BOX 2.3

Cape Town and 'Day Zero'[15]

In 2018, Cape Town faced the prospect of its residents having no access to water. In order to conserve fresh water for critical services, the taps were to be switched off on 'Day Zero,' as the six city dams reached a storage level of 13.5 per cent. Thankfully, rains arrived just prior to the shutdown.

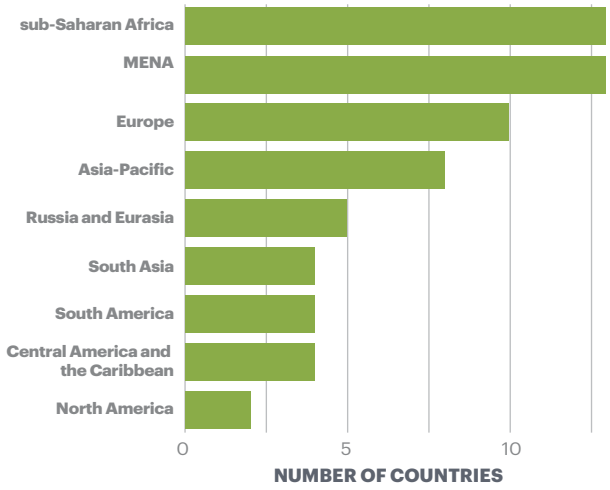
Day Zero serves as a reminder of Cape Town's precarious water situation. Cape Town's predicament rose out of a prolonged drought. Additionally, the city's water infrastructure had not been maintained and was in poor condition. Without efficient policies this predicament is likely to occur again.

Projections from the World Resources Institute show that water stress is expected to increase to extremely high in 63 countries by 2040 from 17 currently.[16] Figure 2.9 shows that regionally, the majority of these countries are in sub-Saharan Africa and MENA. Europe is the region with the next highest level of exposure, with increased water stress expected in Albania, Estonia, Greece, Italy, Macedonia, the Netherlands, Portugal, Romania, Turkey and Kosovo.

FIGURE 2.9

Number of countries with municipalities projected to be severely water stressed in 2040

By 2040, MENA is projected to have the same water stress as sub-Saharan Africa.



Source: WRI; IEP Calculations

TABLE 2.2

Hotspot countries that will face the most increased water stress by 2040

Eight of the 14 hotspot countries that will face most increase in water stress in 2040 are located in sub-Saharan Africa.

Country	Region
Haiti	Central America and Caribbean
Iraq	MENA
Sudan	MENA
Yemen	MENA
Venezuela	South America
Afghanistan	South Asia
Angola	sub-Saharan Africa
Eritrea	sub-Saharan Africa
Mali	sub-Saharan Africa
Mauritania	sub-Saharan Africa
Nigeria	sub-Saharan Africa
Somalia	sub-Saharan Africa
Chad	sub-Saharan Africa
Zimbabwe	sub-Saharan Africa

Source: WRI; IEP

WATER AND CONFLICT

As scarcity intensifies, water will become more relevant as a stressor of social unrest and cause of disputes and violence. Figure 2.10 shows that water-related violent incidents on average have increased threefold since 2000. An incident is included where water is listed as a trigger for conflict and resulted in fatalities.

These incidents vary in their level of severity. Some incidents, such as protests over water shortages or water prices, are demonstrations without violence. However, other incidents result in extreme levels of violence. For example, a series of massacres occurred in Mali throughout 2019, exacerbated by feuds over water that displaced 50,000 people.[17] The countries with the largest increases in water-related conflicts over the last two decades are listed in Table 2.3.

While the Arab Uprising is recognised as one of the triggers for the Syrian Civil War, the pre-conflict context provides an example of how water stress can contribute to underlying social stresses within a country.[18] Prior to 2010, Syria suffered from poor water resource management stemming from weak and compartmentalized governmental institutions which lacked the influence to enforce regulations.[19] This meant that the distribution of water was largely unregulated, leading to volatility in food pricing and an over-dependence on aquifers for irrigation.[20] Such usage overstretched groundwater resources in many areas, leaving farmers unable to support crops and livestock.[21]

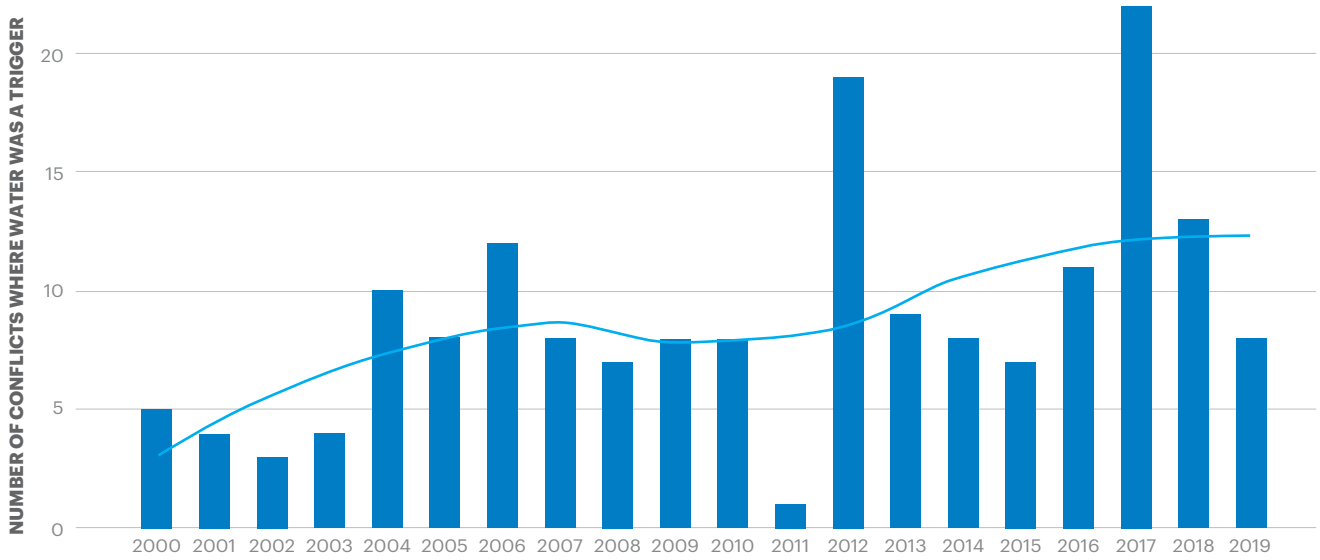
Additionally, a severe drought between 2006 and 2010 exemplifies the impact that water stress has on conflict.[22] Lack of rain slowed the output of the Euphrates and increased the rate at which Turkey withdrew water from the parts of the river that flowed through its territory.[23] Additionally, devastating dust storms upset topsoil and contributed to the destruction of crop yields.[24] These weather events meant that the proportion of arable land in Syria decreased substantially over a short period of time, causing the deaths of up to 85 per cent of all livestock in northeast Syria, and almost halving the total output of cereal production in the country.[25] At the time agriculture was Syria's largest industry, employing approximately 17 per cent of the population and accounting for 20 per cent of GDP. The economic and social repercussions of the drought were severe and multi-pronged.[26] Fleeing the environmental and agronomic degradation of the rural regions, over 1.5 million Syrians migrated to urban areas by 2010.[27] Syria's urban centres were, however, already overwhelmed with some 1.2 million Iraqi refugees who had fled to the country between 2003 and 2007 after the fall of Baghdad.[28] These extreme periods of demographic change placed increased pressure on already struggling public services and contributed to volatile inflation on the price of basic goods (such as food and oil).[29] Increased competition in the non-agricultural labour market saw unemployment rise from 8.2 per cent in 2006 to 11.5 per cent in 2011. The Syrian health system was unable to cope, leading to an increase in morbidity rates.[30] Those Syrians who had remained in rural areas suffered perhaps an even greater diminishment in their living standards than their urban counterparts; with almost 30 per cent of the remaining 10 million citizens falling into extreme poverty.[31]

Water can also be the focus of terrorism due to this resource's strategic value. Reportedly, in the early 2000s al-Qaeda operatives searched for information on remotely controlling water storage and distribution systems, as well as pipelines, in the California Bay Area.[32] The Taliban targeted Afghanistan's Minister of Water

FIGURE 2.10

Trend in water-related violent incidents, 2000–2019

The average annual numberof incidents where water was a trigger for fatal conflict has increased by 300% since 2000.



Source: Pacific Institute; IEP Calculations

TABLE 2.3

Countries with the largest increases in water-related conflicts, 2000–2019

Country	No. of Conflicts, 2000–2009	No. of Conflicts, 2010–2019	Difference	No. of Catastrophic Threats	Population (2020)
Yemen	1	10	9	4	30,245,000
India	4	10	6	0	1,383,198,000
Honduras	0	4	4	1	9,719,000
Iran	0	3	3	1	83,587,000
Peru	0	3	3	2	33,312,000
Sudan	3	6	3	2	43,541,000
Somalia	5	8	3	4	16,105,000
Turkey	0	3	3	1	83,836,000
Tanzania	0	3	3	2	62,775,000
South Africa	0	3	3	1	58,721,000

Source: Pacific Institute; UNDESA

and Energy, Mohammad Ismail Khan, several times.[33] In 2014, when al-Shabaab faced increased pressure from the African Union Mission to Somalia (AMISOM), its fighters deliberately cut water sources compelling Somalis to fetch water from areas controlled by the group.[34] In 2017, the Taliban destroyed the Shorabak dam in Kandahar Province, flooding agricultural lands.[35]

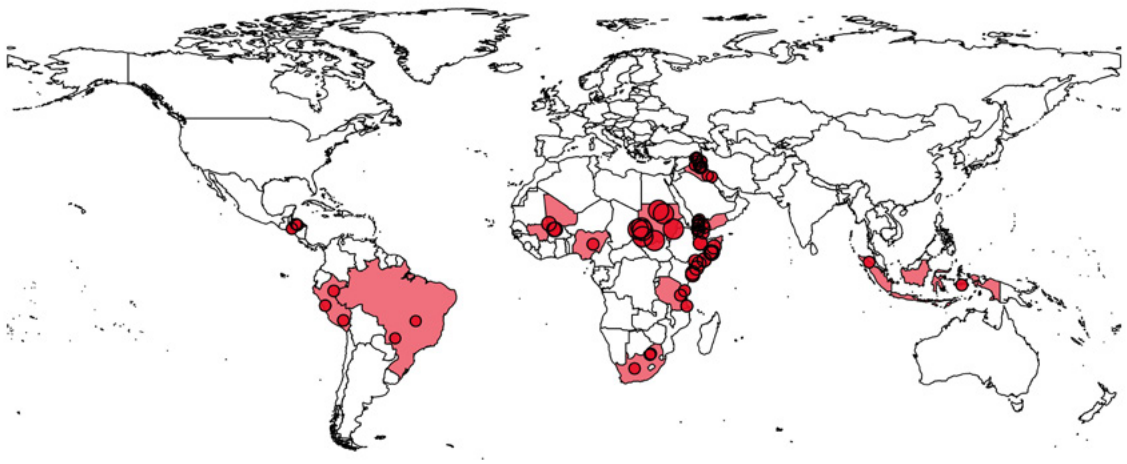
The combination of a history of water conflict and levels of stress assist in identifying countries most likely to incur future water conflict. Figure 2.11 shows the 14 countries that currently have catastrophic levels of water stress, are projected to have increasing water stress to 2040, and have a history of water-triggered conflict. Iraq has the highest number of historical conflicts over water followed by Somalia, Yemen and Sudan.

“
The combination of a history of water conflict and levels of stress assist in identifying countries most likely to incur future water conflict.

FIGURE 2.11

Historical water conflicts in countries that are expected to have increasing water stress to 2040

Iraq, Somalia, Yemen and Sudan are most likely to have continued conflicts over water.



Source: Pacific Institute; WRI

TABLE 2.4

Number of water conflicts in countries expected to have increased water stress in 2040

Country	Number of Conflicts
Iraq	25
Somalia	13
Yemen	11
Sudan	9
Ethiopia	8
Colombia	5
Honduras	4
Mali	3
Peru	3
Tanzania	3
South Africa	3
Indonesia	2
Cote d' Ivoire	1
Nigeria	1

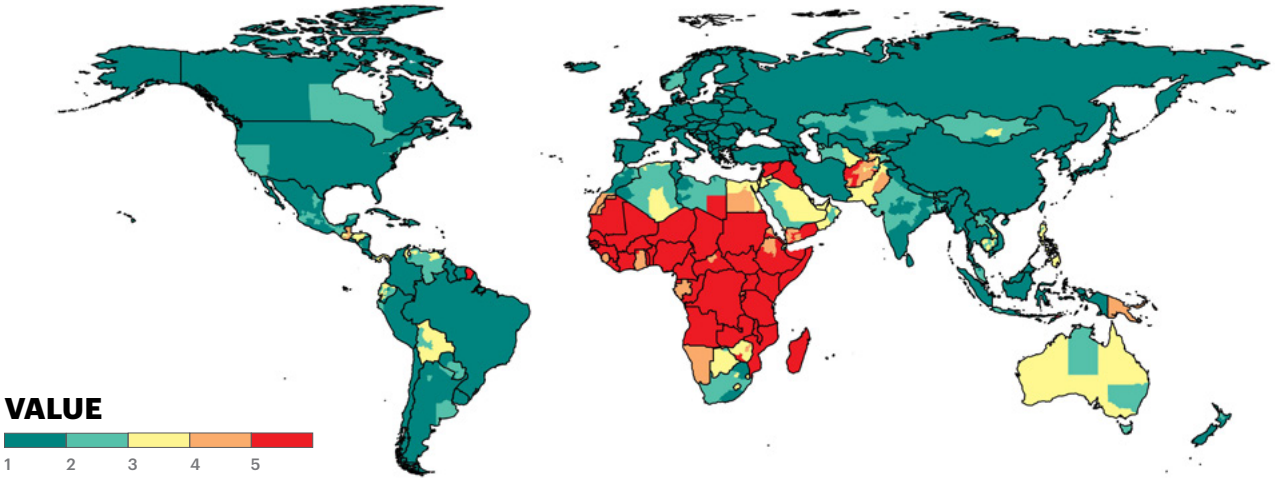
Source: Pacific Institute

Population Growth

FIGURE 2.12

Countries by population increase, 2020–2050

The sub-Saharan African region is expected to experience the highest population increase globally by 2050.



Source: UNDESA

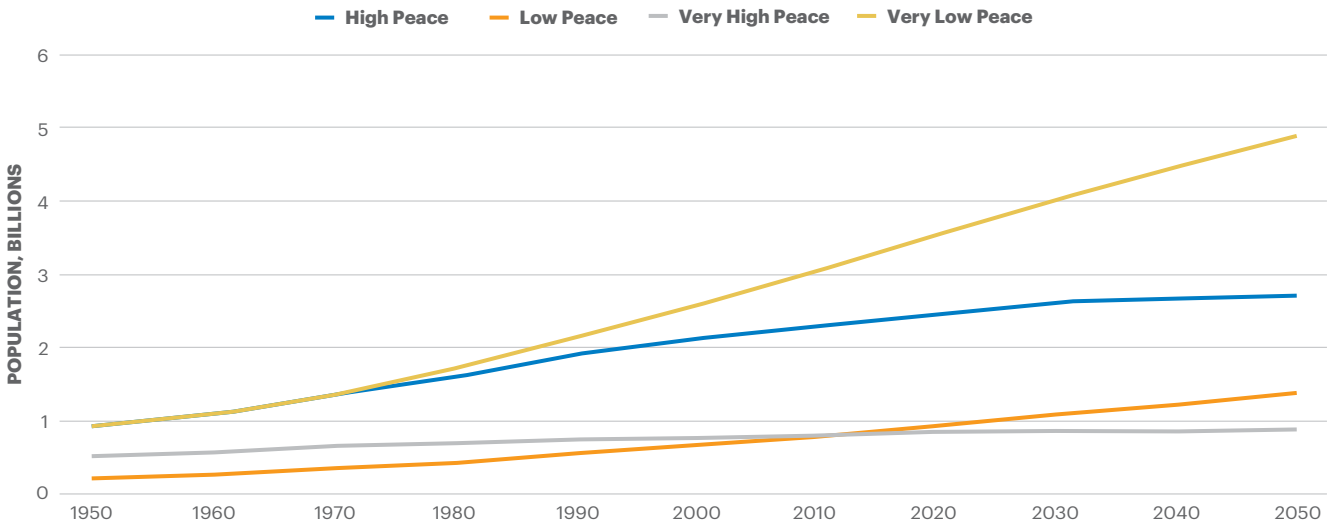
Most of the world's population growth occurs in the least peaceful countries. The 40 least peaceful countries will have an additional 1.3 billion people by 2050, accounting for almost half of the world's population or 49.6 per cent. This growth will pose major challenges for both development and peacefulness. Moreover, the population growth is unlikely to be uniform. Whether across countries or regions, by levels of development or peacefulness, certain areas will experience greater hardship than others. With resources becoming scarcer, the likelihood of conflict will increase. Figure 2.12 shows where population growth is expected to occur globally.

Projections indicate that the populations of Europe, Russia and Eurasia will increase by less than one per cent, whereas sub-Saharan Africa and MENA will see substantial increases. Figure 2.13 displays the population projections by level of peace, highlighting that most of the population increases will occur in very low peace countries.

FIGURE 2.13

Projections of global population, by peace level, 1960–2050

The population is projected to increase by 37 per cent by 2050 in very low peace countries compared to an increase of less than one per cent in very high peace countries.



Source: IHME

Table 2.5 contains a list of the 15 countries with the highest projected growth in their population for 2050. All 15 countries are located in sub-Saharan Africa.

Niger is projected to have the largest percentage increase in its population with an estimated population growth rate of 184 per cent by 2050, the highest rate of any country. The level of population growth in Niger is expected to outpace economic development, leading to a decline in living standards and greater competition for economic resources. This is followed by Angola, which is expected to record a population growth rate of 132 per cent by 2050. The global growth rate is projected to be 16 per cent, significantly less than that of Niger and Angola.

Europe, Russia and Eurasia are expected to record population growth rates of less than one per cent. Some countries such as Bulgaria, Latvia and Moldova are expected to fall by almost 20 per cent each by 2050. Only 14 of the 42 European countries are expected to record a positive population growth rate based on current trends.

TABLE 2.5

The countries with the fastest population growth, 2020–2050

The 15 countries projected to record the highest percentage increase in their populations are all located in sub-Saharan Africa.

Country	2020 Population (Millions)	2050 Population (Millions)	% Change	GPI 2022 Rank	PPI 2022 Rank
Niger	24.1	68.5	184%	140	133
Angola	32.8	76.0	132%	78	136
Uganda	47.2	105.7	124%	121	138
Somalia	16.1	35.9	123%	156	163
Democratic Republic of the Congo	89.5	197.4	121%	158	158
Tanzania	62.8	138.1	120%	86	102
Zambia	18.7	41.0	120%	56	112
Mali	20.3	44.0	117%	150	137
Burundi	11.9	25.8	116%	131	151
Mozambique	32.3	67.8	110%	122	125
Burkina Faso	20.9	43.2	107%	146	99
Chad	16.3	33.6	107%	136	159
Malawi	20.3	41.7	106%	65	117
Republic of the Congo	5.7	11.5	102%	111	145
Equatorial Guinea	1.4	2.8	102%	59	150

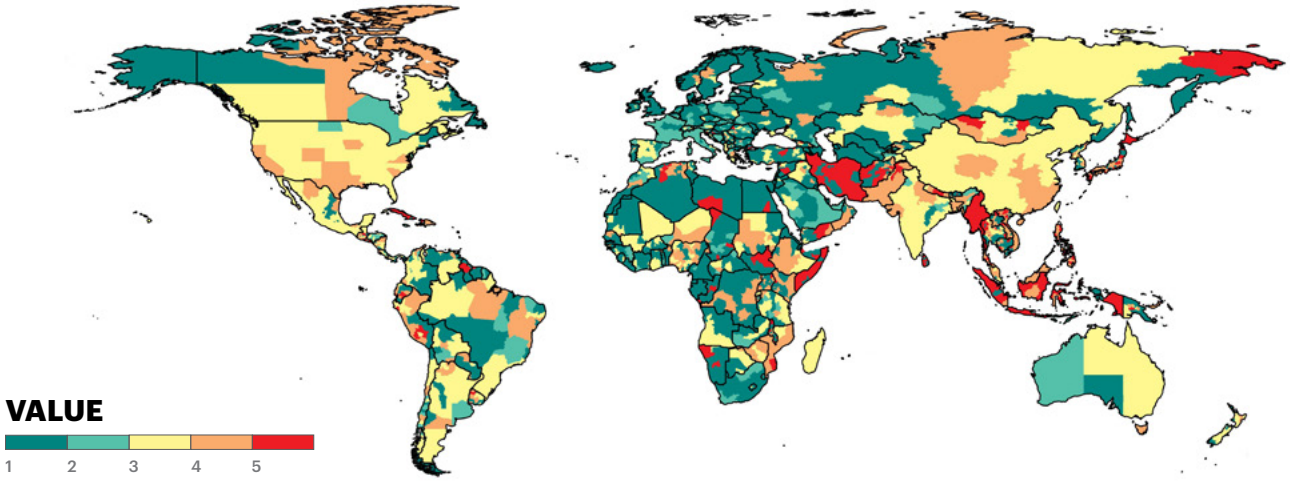
Source: UNDESA

Natural Disasters

FIGURE 2.14

Countries most impacted by natural disasters, 2021

Asia-Pacific is the most impacted region by natural disasters, followed by sub-Saharan Africa and Central America and the Caribbean.



Source: IHME

Natural disasters lead to losses of human life, destruction of property and infrastructure, and hinder future development, especially in underdeveloped regions of the world. Changes in weather patterns worldwide have led to a rise in the number of floods, as well as more frequent and longer droughts.

Figure 2.14 shows the regions most affected by natural disasters. Of these, Asia-Pacific is the most impacted region, followed by sub-Saharan Africa and Central America and the Caribbean.

TRENDS IN NATURAL DISASTERS

Since 2018, natural disasters have been on the rise, with temperatures rising to 40°C in the UK for the first time, while flooding in Pakistan left a third of the country under water.[36] The cost of natural disasters has also risen from $50 billion per year in the 1980s to $200 billion per year in the last decade.[37] Hydrological events that result in sharp and harmful changes, either in the quality of the earth's water or its distribution (in aquifers, rivers, cyclones or floods), have had the largest increase since 1980. Figure 2.15 displays the trend in the number of natural disasters over the last 40 years.

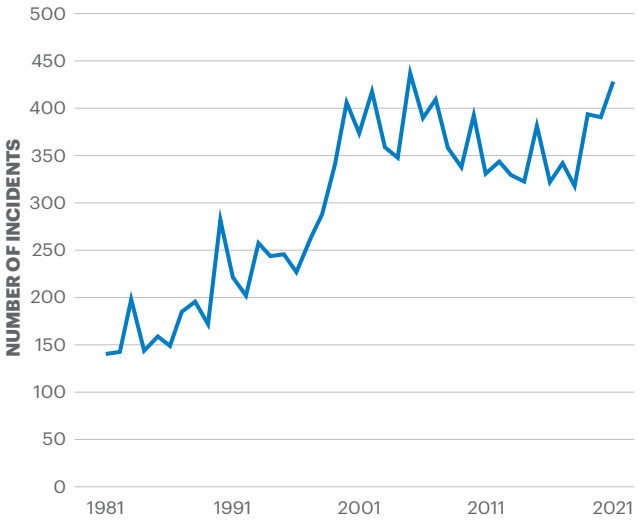
The largest number of natural disasters occurred in 2005, with 441 incidents.[38] The negative impacts of natural disasters depend on the intensity of individual incidents. Natural disasters can be of low intensity and occurring frequently, or they can be one-off catastrophic events. For instance, the 2004 Indian Ocean tsunami that affected numerous countries in Southeast Asia represents a one-off catastrophic incident that had substantial impacts. It was responsible for over 200,000 deaths and widespread destruction felt as far away as East and South Africa.

Flooding is the most common natural disaster since 1981 with 5,079 incidents recorded over the period. This was followed by

FIGURE 2.15

Trend in the number of natural disasters, 1981–2021

The global number of natural disasters has tripled over the past 40 years.



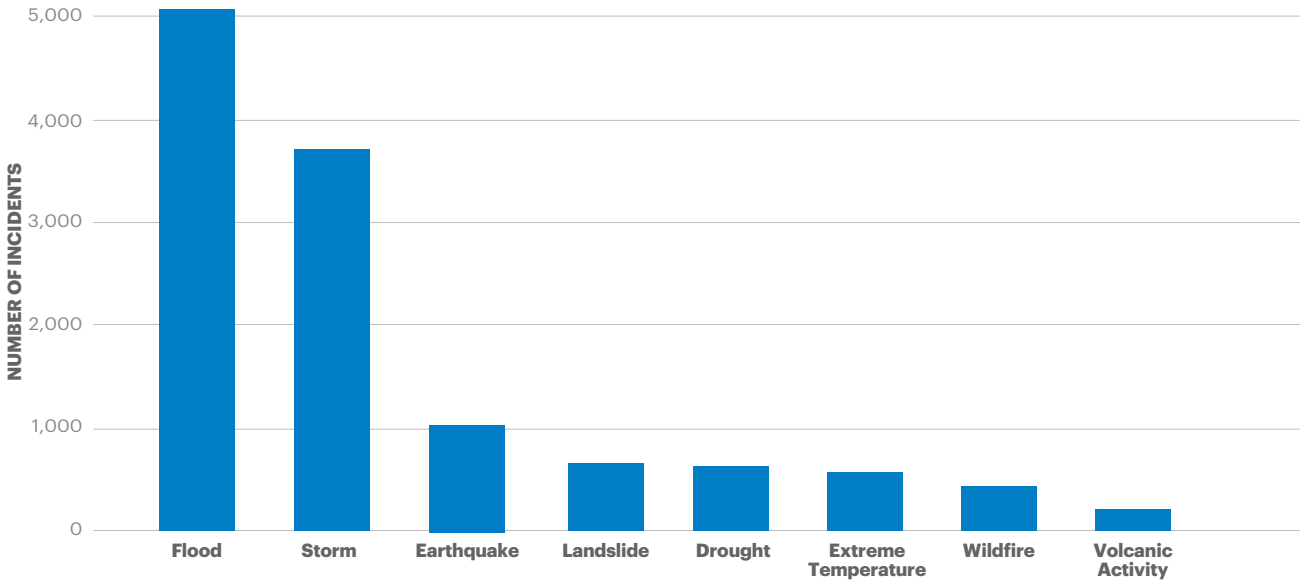
Source: EMDAT

different types of storms including cyclones, hurricanes, tornadoes, blizzards and dust storms at 3,709 incidents. Figure 2.16 shows the number of incidents by disaster type from 1981 to 2022. Floods and storms account for 71 per cent of the disasters that have occurred since 1990.[39]

FIGURE 2.16

Total number of disasters globally by disaster type, 1981–2022

Globally, floods and storms account for 71 per cent of the natural disasters that occurred between 1981 and 2022.



Source: EMDAT

TABLE 2.6

Countries by number of natural disasters, 1981–2021

Country	Total Between 1981–2021
US	909
China	883
India	532
Philippines	511
Indonesia	469
Bangladesh	254
Mexico	240
Japan	240
Vietnam	225
Australia	195
Pakistan	191
Brazil	185
Iran	182
France	170
Afghanistan	169
Columbia	166
Russia	162
Peru	148
Thailand	144
Italy	127

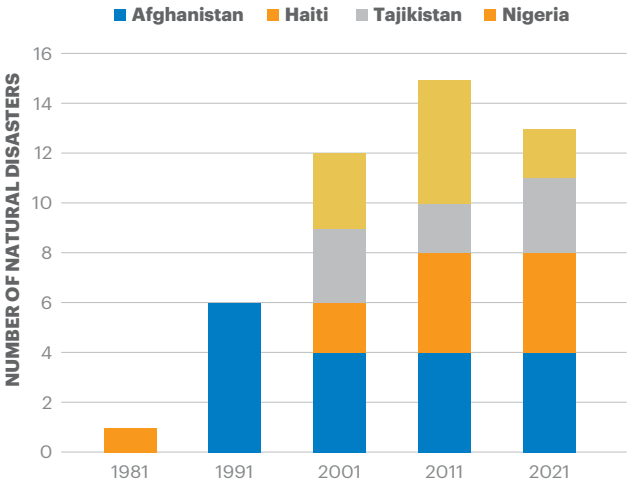
Source: EMDAT

The US, China, India and the Philippines recorded in excess of 500 natural disasters since 1981. Of the 27 ETR hotspot countries Afghanistan, Haiti, Tajikistan, Nigeria and Mali were also in the list of countries with the biggest increases since 1981.

FIGURE 2.17

Worst 5 hotspot countries by number of natural disasters, 1981–2021

Of the hotspot countries, Afghanistan, Haiti, Tajikistan and Nigeria recorded the most natural disasters, peaking in 2011 with a total of 15.

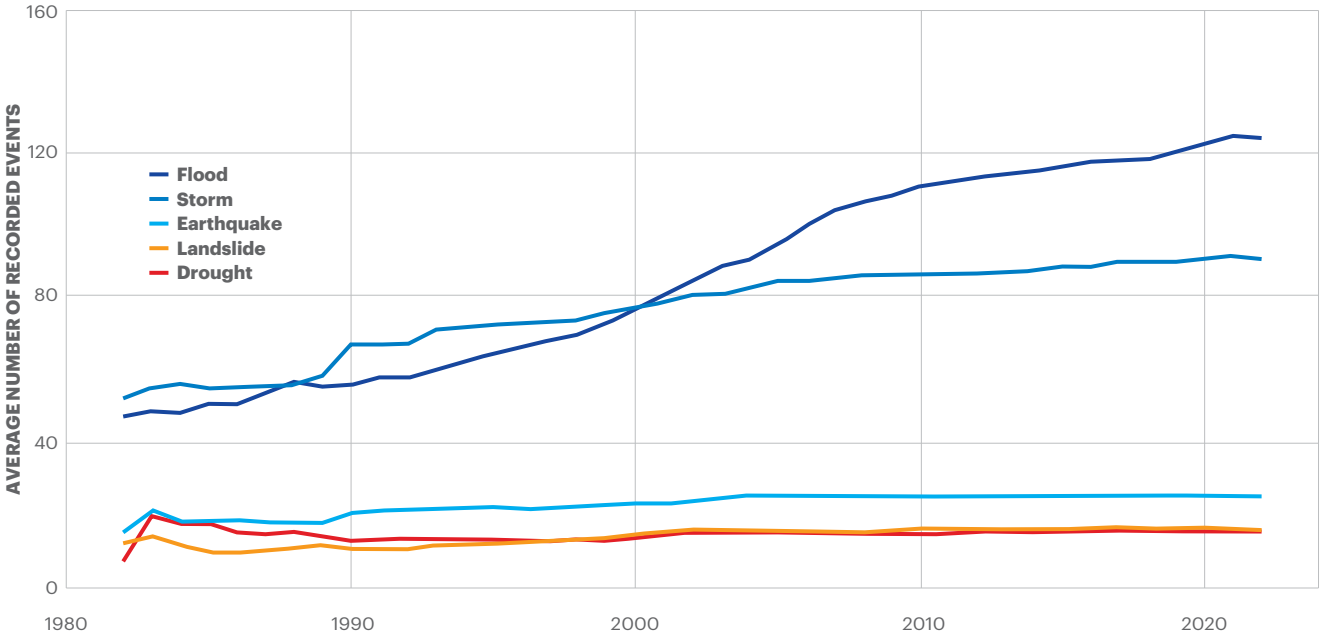


Source: EMDAT

FIGURE 2.18

Average number of incidents per year, 1981–2022

The average numbers of floods and storms continues to increase and currently stands at around 91 and 125 records per year respectively.



Source: EMDAT; IEP Calculations

Figure 2.18 shows that between 1981 and 2022, the average number of droughts and landslides recorded plateaued at around 15 per year. There are roughly 25 recorded earthquakes annually. The average numbers of floods and storms however continues to increase and currently stands at around 91 and 125 per year, respectively.

While this could be due to improved recoding techniques over the period, there are scientific studies that provide evidence that the number of instances are rising, which only serves to emphasise the need for mitigation and adaption policies.[40] If natural disasters are to become more frequent, communities will struggle to recover fully before the next one occurs, creating a cascading effect over time. This is shown in Figure 2.19.

Such effects may not only be felt in the location of the natural disaster, but also in surrounding regions. In 2021, around 23.7 million internal displacements were recorded as a result of natural disasters. Internal Displacement Monitoring Center (IDMC) estimates that providing each IDP with support for housing, education, health,security and loss of income would have an average cost of $370 per person for each year of displacement.[41] At this level, the cost to accommodate the current level of internal displacements for one year would be $8.7 billion. However, this figure is highly conservative and does not include longer-term economic consequences or the financial impacts on host communities or communities of origin. If these costs were accounted for, the financial estimates would be significantly higher.[42]

FIGURE 2.19

The country disaster loop

Disaster and Conflict Displacement

KEY FINDINGS

- UNHCR estimates in 2021 there were 89.3 million forcibly displaced people. This includes internally and refugees and excludes displacements from the Ukrainian war which is currently estimated to be between 12 and 14 million.
- There is growing recognition of the links between climate change, ecological threats, migration, and conflict.
- In 2021, the countries that had the highest levels of internal displacement from both conflict and natural disasters were Syria, Ethiopia, DRC, Afghanistan and South Sudan.
- The countries that received the most refugees from these countries included Lebanon, Jordan, Turkey, and Uganda.
- Sweden, Austria, Greece and Germany have accepted over a million refugees from these countries.

In 2021, UNHCR estimated in 2021 the number of forcibly displaced people now totals 89.3 million, with over 27.1 million refugees.[43] In 2020, the number of people forcibly displaced by violence rose by 3.7 per cent from the previous year —an additional 2.9 million people. These figures exclude displacements from the Ukrainian war which is currently estimated to be between 12 and 14 million. See Text Box 2.3 for further information.

In 2020, the majority of forcibly displaced people were categorised as:

- 55 million people were displaced internally,[44,45]
- another 5.7 million people were Palestine refugees under UNRWA's mandate,
- Over four million were asylum seekers,
- 20.7 million were refugees under UNHCR's mandate,[46]
- 3.9 million were Venezuelans displaced abroad.[47]

BOX 2.3

Ukraine displacements 2022

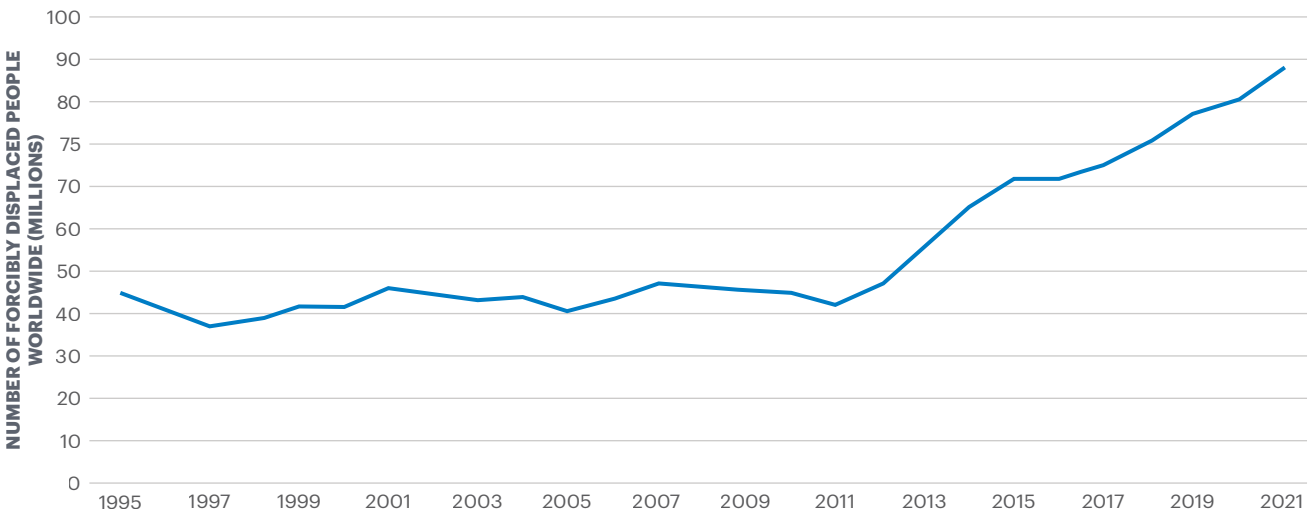
The data on displacements currently only report to the end of 2021. However, since the start of the Russian invasion of Ukraine, estimates of forced displacements range from 12 to 14 million. Of these seven million people are thought to be displaced inside Ukraine itself,[48] More than five million have left for neighbouring countries. Recipient countries include:

- Russia
- Poland
- Moldova
- Slovakia
- Hungary
- Belarus

FIGURE 2.20

Trend in the number of forcibly displaced people globally, 1995–2021

The number of forcibly displaced people has increased consecutively over the last ten years.



Source: UNHCR; IDMC

CLIMATE, ECOLOGY AND CONFLICT

There is a growing recognition of a link between the changing climate, forced migration and conflict.

By 2050, it is estimated that climate change will lead to the internal displacement of tens of millions of people in sub-Saharan Africa, Latin America and South Asia.[49] According to projections, over 143 million people could be internally displaced due to increasing ecological threats due to a changing climate. The poorest and most climate vulnerable areas will be hit the hardest. It is likely that rising sea level will push people to abandon some coastal area. as weather patterns become increasingly unpredictable and storms worsen in severity and onset.[50]

Migration in such numbers will have an impact on recipient countries and regions. Mass migration can increase pressures on existing infrastructure, creating grievances within the local communities.

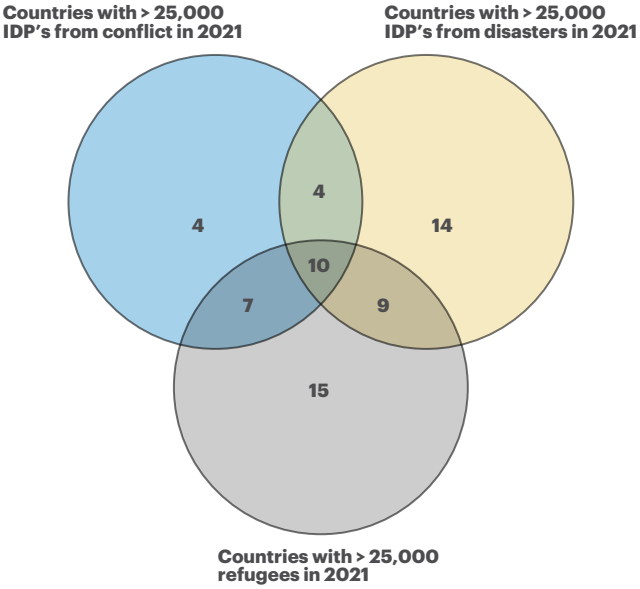
The term "Climate-Security Nexus" has risen in prominence to describe the link between climate change, ecological threats, security and migration. The ecological threats that are currently evident will accelerate due to the multitude of factors covered in this report. Figure 2.21 illustrates potential causal pathways between climate change, ecological threats, security and migration.

Countries most vulnerable to such dynamics will be those experiencing high levels of internal displacement from conflict and natural disasters. These will also be countries that many of their citizen will seek either temporary or permanent refuge. Figure 2.22 shows that in 2021, there were 10 countries that had more than 25,000 displacements in each category.

FIGURE 2.22

Countries with significant conflict and disaster displacements in 2021

There are 10 countries in 2021 that experienced significant internal and external displacements.

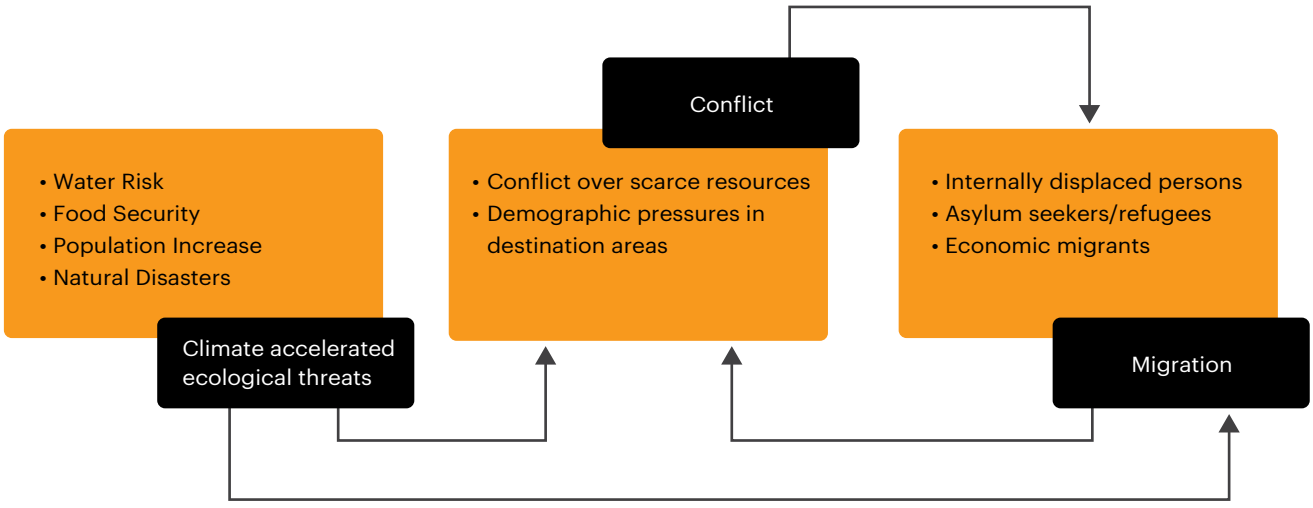


Source: UNHCR; IDMC

FIGURE 2.21

Relationships between ecology, climate, conflict and migration

Potential causal pathways between ecological threats, conflict and migration.[51]



Source: Abel et al. 2019

Table 2.7 lists the 10 countries with the largest number of displacements across all three categories. The five countries with the largest displacements from conflict and natural disasters include Syria, Ethiopia, the DRC, Afghanistan and South Sudan.

TABLE 2.7

Ten countries with the largest climate-security nexus displacements 2021

Country	Conflict IDPs	Natural Disaster IDPs	Refugees	Total
Syria	456K	79K	7M	7M
Ethiopia	5M	240K	149K	6M
Democratic Republic of the Congo	3M	888K	908K	5M
Afghanistan	723K	25K	3M	3M
South Sudan	429K	506K	2M	3M
Myanmar	448K	158K	1M	2M
Somalia	549K	271K	777K	2M
Sudan	442K	99K	825K	1M
Yemen	377K	84K	38K	499K
Colombia	134K	32K	116K	281K

Source: UNHCR; IDMC

In 2021, the countries that received the most refugees from the countries in Table 2.7 include Lebanon, Jordan, Turkey, and Uganda. In Europe, the countries that received the most from these countries were Sweden, Austria, Greece and Germany.

TABLE 2.8

Twenty recipient countries by refugees per 100,000 in 2021

Country	Refugee Intake 2021	Country Population	Refugees per 100,000
Lebanon	842K	6M	14K
Jordan	678K	10M	7K
Turkey	4M	84M	4K
Uganda	1M	49M	3K
South Sudan	331K	14M	2K
Chad	376K	17M	2K
Djibouti	23K	1M	2K
Sudan	957K	45M	2K
Nauru	177	11K	2K
Sweden	159K	10M	2K
Austria	115K	9M	1K
Germany	827K	83M	1K
Malta	4K	435K	949
Iran	778K	84M	925
Cyprus	11K	1M	924
Kenya	471K	55M	859
Pakistan	1M	212M	703
Greece	76K	11M	688
Burundi	81K	12M	656

Source: UNHCR; IDMC

3 Ecological Changes & Megacities

KEY FINDINGS

- By 2050, 70 per cent of the world's population will live in cities, up from 54 per cent in 2020.
- The past 70 years have seen the rise of "megacities," which are cities with a population of 10 million people or more. Over 60 per cent of these cities are in low peace countries.
- There are currently 33 megacities, predicted to rise to 47, with a combined increase in population to 213 million people by 2050. Eight of the 13 predicted megacities have high levels of ecological threats, low levels of societal resilience and low levels of peace.
- The most unsustainable cities are Kinshasa, Nairobi, Lagos, Dhaka, Baghdad, Lahore, Kolkata and Delhi. These cities are projected to have high population growth of over 50 per cent. This, combined with high levels of pollution, poor sanitation, high homicide rates and substantial ecological threats are likely to make these cities unsustainable.
- The cities with the greatest population growth are in sub-Saharan Africa. These include Dar es Salaam and Nairobi, who are predicted to grow their population by more than 100 per cent within the next 30 years. Kinshasa, Lagos and Khartoum are likely to increase their population by more than 80 per cent.
- Three megacities are expected to decrease in size between now and 2050: Osaka, Tokyo and Moscow.
- Megacities in low peace countries have the highest population growth rates. These cities also have low coping capacities and will likely struggle to provide jobs, security and manage their ecological threats.
- The high population growth rates in cities will create increasing challenges for peacefulness especially in terms of violent crime, organised crime and civil unrest.
- Nine cities have more than 20 times the WHO recommended maximum air pollution level. These cities include Lahore, Kabul, Delhi and Agra. The highest number of polluted cities are in South Asia and China.
- In 2019, the World Bank estimated that pollution was responsible for economic losses totalling $8.1 trillion, or 6.1 per cent of global economic output.
- It is possible to address the issue of air pollution, as was seen in Beijing where air quality in 2013 was 90 times higher than the WHO's recommended daily level; by 2021, it was only 7 times higher.
- A number of megacities are sinking, creating long-term issues of viability. For instance, parts of Mexico City are sinking by 50 centimetres per annum while North Jakarta is sinking by 4.9 centimetres per annum.
- Cities could have been responsible for as much as 70 per cent of global CO2 emissions in 2021, causing around 9 million premature deaths annually.
- A 2017 UN Human Development report estimated that $57 trillion in global infrastructure investment would be required to provide adequate housing for the 1 billion people living in sub-standard housing. This figure would be higher now.

Introduction

The historical trend of rural to urban migration is projected to continue and may accelerate. Figure 3.1 shows that current projections for the proportion of the world's population living in cities is set to increase from 54 per cent in 2022, to 70 per cent by 2050. This increase means that approximately 2.5 billion people will live in cities.

Since the 1950s a new type of city has emerged called the 'megalopolis', which is home to 10 million people or more. In the 1950s there were only two megalopolises: New York and Tokyo. However, with high levels of population growth and industrialisation, urbanisation has intensified giving rise to the "megacity." There are currently 33 megacities, which will increase to at least 47 by 2050.

Urban living offers many benefits and is often associated with increased job opportunities, higher incomes, greater use of technology and advanced levels of education. Businesses in urban areas can enjoy lower input costs, greater collaboration, and more innovation opportunities.

Countries that are more urbanised are usually more developed; they exhibit low population growth and are generally sustainable. Large populations residing in close proximity provide further benefits, as population diversity helps to increase levels of tolerance, learning is enhanced by accessibility to teaching establishments, and creativity is heightened by diverse ideas and talent. There are also a range of benefits to government, including lower service delivery costs and greater accessibility for residents.

However, urbanisation – especially if it is rapid – also brings challenges. Local governments and policymakers must plan for and manage the impacts of urbanisation on inequality, employment, services, transport, ecological threats and politics.

Many of today's cities were not designed to accommodate the large populations who now live in them. Many have not addressed or are prepared for the ecological, environmental, infrastructure and security challenges that arise from rapid urbanisation. Some of the fastest growing cities are in sub-Saharan Africa and in parts of South Asia. Open sewers, poor or no refuse collection and a lack of safe drinking water are common. They are more likely to experience high levels of petty crime, as well as organised crime and corruption.

Urbanisation has also exacerbated existing environmental, social, political and economic issues including higher concentrations of pollution, increasing socio-economic differences, and putting pressure on infrastructure. This is evident in many South Asian and African megacities, where those who can afford it, live in well-serviced neighbourhoods, while many live in over-crowded and under-resourced slums.[1] These issues could directly impact societal and personal peacefulness as lack of job opportunities, hygiene, food and water, create a breeding ground for dissatisfaction which can stoke conflict.[2]

There are various reasons for migration to cities. Many of the originating factors in rural areas are identified in the ETR, ranging from environmental degradation and resource scarcity to conflict. Rapid population growth has meant that farm sizes become untenable as land inheritances shrink the size of a working lot; this is especially noticeable in parts of Africa.

In these environments, city authorities face a complex set of challenges. There is a persistent flow of people, as seen in Dhaka where 1,500 to 2,000 people migrate to it daily, but the infrastructure and employment opportunities to accommodate them are not present.

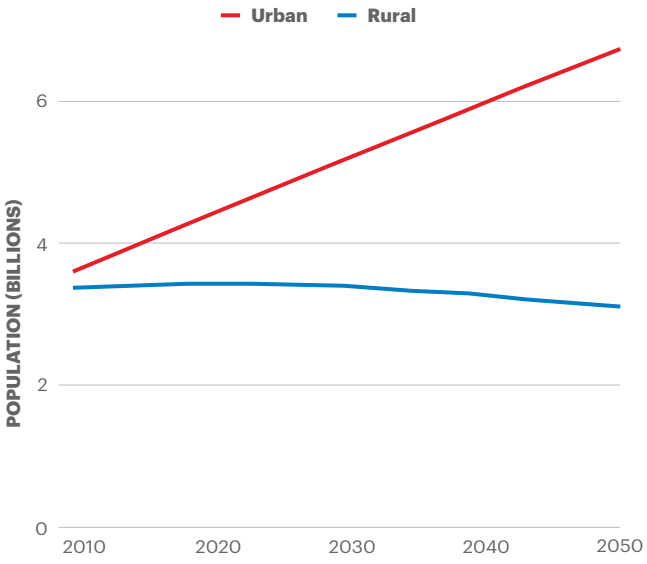
These challenges are compounded by a lack of financial capacity, as most high growth megacities are situated in lower income countries who often lack the ability to fund the necessary infrastructure.

The rapid growth of cities also has a direct effect on surrounding areas. Cities are generally strategically located close to transport routes and high-quality farming land. As they expand, they tend to take over the agricultural land, reducing availability for food production. A 2016 study projected that by 2030, urban expansion will result in a 1.8 to 2.4 per cent loss of global croplands, with about 80 per cent of this loss occurring across Asia and Africa. The most affected areas in Asia are likely to be the Bohai Economic Rim, the Yangtze River Delta in China, and Java Island in Indonesia. In Africa, the region surrounding the Lake Victoria Basin in Eastern Africa appears most vulnerable to the loss of farmland.[3] In countries with food security issues, such a move can compound existing problems.

FIGURE 3.1

Projected population growth 2010–2050, urban versus rural

The world's population is projected to continue to rise, with the growth occurring in cities, while rural areas will marginally decline.



Source: IEP; OWID; Masanobu Kii 2021

> Urbanisation exacerbated existing environmental, social, political and economic issues including higher concentrations of pollution, increasing socio-economic differences, and putting pressure on infrastructure.

Megacities

In 2022, 33 cities had a population of over 10 million.[4]

Megacities face distinct challenges with regards to peacefulness and climate change, as some of these cities are larger than many countries. In 2022, the world's five biggest megacities were Tokyo (37.3 million), Delhi (32.3 million), Shanghai (28 million), Sao Paulo (22.5 million) and Mexico City (22.1 million).

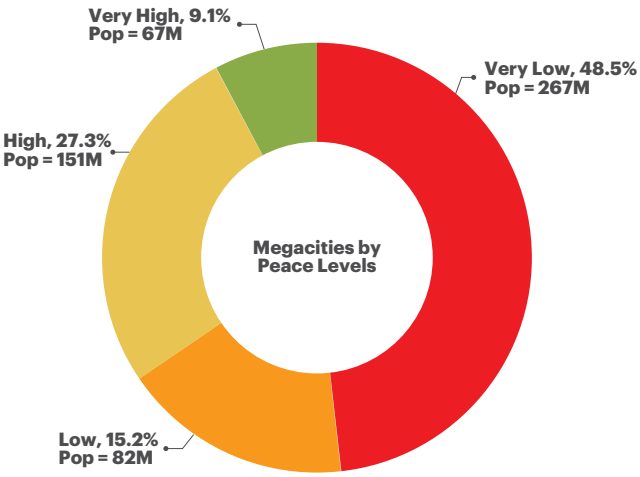
Categorised by GPI levels, Figure 3.2 shows that more than half of the megacities are located in low peace countries. Cities with low peace generally have the highest population growth and low per capita income. They are the cities most likely to suffer from increased violence, crime (both petty and organised) and civil unrest as the cities grow.

Table 3.1 shows population projections for the world's largest cities. Some of these cities, such as Tokyo, are projected to see a decline in their population due to a decrease in birth rates. Such falls are more common in highly industrialised, high-income countries. However, in Africa and Asia, urbanisation is projected to increase significantly, placing enormous pressure on the cities that are already located in low peace countries, as these areas are also where ecological threats are greatest.

FIGURE 3.2

Proportion of megacities by peace levels

More than 60 per cent of the world's current megacities are located in low peace countries.



Source: POPSTAT; IEP

TABLE 3.1

Megacities population projections 2050

The number of megacities is projected to increase from the current 33 to 47 by 2050. Cities with an asterisk are projected to become megacities by 2050.

City	Country	Region	Pop 2022	Pop 2050	Percentage Increase in Population	ETR	GPI	PPI	Air Quality	Expected Climatic Changes
Dar es Salaam*	Tanzania	sub-Saharan Africa	7.5M	16.4M	118%	Extremely High	Low	Low	Unhealthy for Sensitive Groups	Wetter
Nairobi*	Kenya	sub-Saharan Africa	5.2M	10.4M	101%	Extremely High	Very Low	Low	Unhealthy for Sensitive Groups	Drier
Kinshasa	Democratic Republic of the Congo	sub-Saharan Africa	15.8M	29.0M	84%	Extremely High	Very Low	Very Low	Unhealthy for Sensitive Groups	Drier
Lagos	Nigeria	sub-Saharan Africa	15.5M	28.2M	82%	Extremely High	Very Low	Very Low	Hazardous	Hotter, Wetter
Khartoum*	Sudan	MENA	6.2M	11.2M	80%	Extremely High	Very Low	Very Low	Unhealthy	Hotter, Drier
Baghdad*	Iraq	MENA	7.6M	13.0M	71%	Extremely High	Very Low	Very Low	Unhealthy for Sensitive Groups	Hotter, Wetter
Luanda*	Angola	sub-Saharan Africa	9.0M	14.6M	62%	Extremely High	Low	Very Low	Hazardous	Wetter
Karachi	Pakistan	South Asia	16.9M	26.6M	57%	High	Very Low	Very Low	Unhealthy	Hotter, Wetter
Lahore	Pakistan	South Asia	13.6M	21.4M	57%	High	Very Low	Very Low	Unhealthy	Hotter
Surat*	India	South Asia	7.9M	12.0M	54%	High	Very Low	Low	Unhealthy	Wetter, Hotter
Ahmedabad*	India	South Asia	8.5M	13.0M	54%	High	Very Low	Low	Unhealthy for Sensitive Groups	Hotter
Hyderabad	India	South Asia	10.6M	16.2M	54%	High	Very Low	Low	Unhealthy	Wetter, Hotter
Kolkata	India	South Asia	15.2M	23.4M	54%	Medium	Very Low	Low	Unhealthy	Drier

Mumbai	India	South Asia	21.0M	32.4M	54%	High	Very Low	Low	Unhealthy	Hotter, Wetter
Chennai	India	South Asia	11.6M	17.8M	54%	High	Very Low	Low	Unhealthy for Sensitive Groups	Wetter
Delhi	India	South Asia	32.3M	49.6M	54%	High	Very Low	Low	Unhealthy	Hotter
Pune*	India	South Asia	7.0M	10.8M	54%	High	Very Low	Low	Unhealthy	Wetter
Bangalore	India	South Asia	13.3M	20.4M	54%	High	Very Low	Low	Moderate	Hotter, Wetter
Dhaka	Bangladesh	South Asia	22.6M	34.6M	53%	High	Low	Very Low	Unhealthy	Wetter
Manila	Philippines	Asia-Pacific	14.5M	22.0M	52%	Extremely High	Very Low	Low	Moderate	Wetter
Cairo	Egypt	MENA	21.8M	32.6M	49%	Medium	Low	Low	Unhealthy for Sensitive Groups	Hotter, Drier
Ho Chi Minh City*	Vietnam	Asia-Pacific	9.1M	13.0M	42%	Medium	High	High	Unhealthy	Wetter
Bangkok	Thailand	Asia-Pacific	10.9M	14.4M	32%	High	Low	High	Unhealthy	Hotter, Wetter
Jakarta	Indonesia	Asia-Pacific	11.1M	14.2M	28%	Extremely High	High	Low	Hazardous	Wetter
Lima	Peru	South America	11.1M	13.4M	21%	Extremely High	Low	High	Unhealthy	Hotter, Drier
New York City	United States	North America	18.9M	22.8M	21%	Medium	High	Very High	Unhealthy for Sensitive Groups	Drier, Hotter
Chicago*	United States	North America	8.9M	10.8M	21%	Medium	High	Very High	Moderate	Drier, Hotter
Los Angeles	United States	North America	12.5M	15.0M	21%	High	High	Very High	Unhealthy	Hotter, Colder, Wetter
Istanbul	Turkey	Europe	15.7M	18.4M	18%	Medium	Very Low	Low	Moderate	Colder, Drier
Mexico City	Mexico	Central America and Caribbean	22.1M	25.8M	16%	Low	Very Low	High	Unhealthy	Colder, Drier
London*	United Kingdom	Europe	9.6M	10.8M	14%	Very Low	Very High	Very High	Moderate	Colder, Drier
Buenos Aires	Argentina	South America	15.4M	17.4M	14%	Low	Low	High	Unhealthy	Drier
Tehran*	Iran	MENA	9.4M	10.6M	13%	Medium	Very Low	Low	Unhealthy for Sensitive Groups	Wetter, Hotter
Paris	France	Europe	11.2M	12.4M	12%	Low	Very High	Very High	Moderate	Wetter
Guangzhou	China	Asia-Pacific	14.0M	15.6M	11%	High	High	High	Unhealthy	Hotter, Wetter
Chongqing	China	Asia-Pacific	17.0M	18.8M	11%	Medium	High	High	Unhealthy	Drier
Nanjing*	China	Asia-Pacific	9.5M	10.4M	11%	Medium	High	High	Unhealthy	Wetter, Hotter
Shenzhen	China	Asia-Pacific	12.9M	14.2M	11%	High	High	High	Unhealthy for Sensitive Groups	Hotter, Drier
Shanghai	China	Asia-Pacific	28.7M	31.6M	11%	Medium	High	High	Very Unhealthy	Wetter, Hotter
Beijing	China	Asia-Pacific	21.4M	23.6M	11%	Medium	High	High	Very Unhealthy	Hotter, Wetter
Chengdu*	China	Asia-Pacific	9.5M	10.6M	11%	Medium	High	High	Unhealthy	Hotter
Tianjin	China	Asia-Pacific	14.1M	15.6M	11%	Medium	High	High	Very Unhealthy	Hotter, Wetter
Sao Paulo	Brazil	South America	22.5M	24.0M	7%	High	Very Low	High	Unhealthy	Wetter
Rio de Janeiro	Brazil	South America	13.7M	14.6M	7%	Medium	Very Low	High	Moderate	Wetter
Moscow	Russia	Russia and Eurasia	12.7M	12.2M	-3%	Low	Very Low	High	Unhealthy for Sensitive Groups	Colder, Drier
Tokyo	Japan	Asia-Pacific	37.3M	32.6M	-12%	High	Very High	Very High	Unhealthy	Hotter, Drier
Osaka	Japan	Asia-Pacific	19.0M	16.8M	-12%	High	Very High	Very High	Unhealthy for Sensitive Groups	Wetter, Hotter

Source: IEP; University of Toronto;[5] Copernicus Satellite; World Air Quality Index[6]

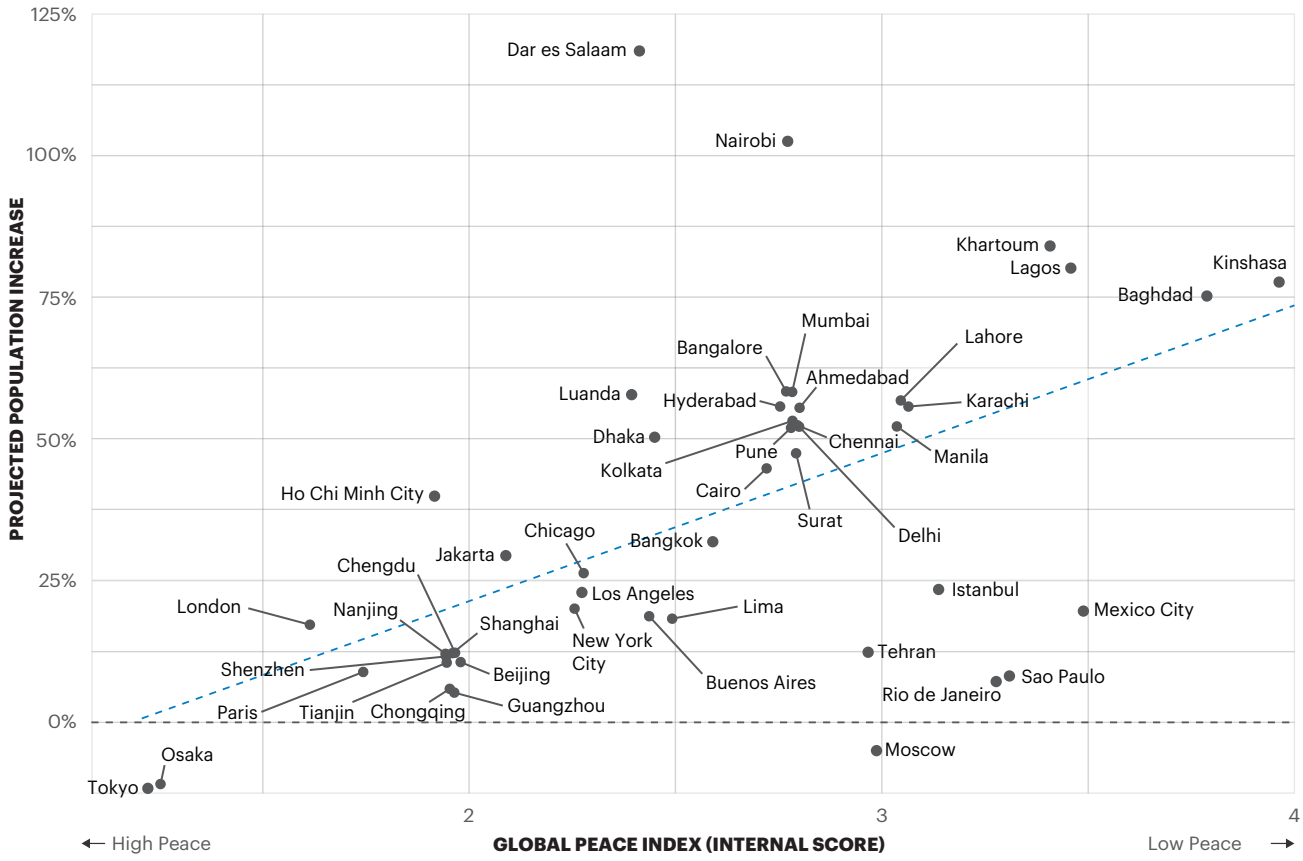
The projected 47 megacities will increase their population by 213 million people by 2050.

Figure 3.3 shows that the largest population projections in large cities occur in countries with the lowest scores in the GPI and those facing the most severe ecological threats. This is significant, as the increase in population places an additional pressure on stretched resources. These countries generally have lower levels of resilience, have less financial capacity, and less developed infrastructure. This combination of issues could create a backdrop for substantial reductions in peacefulness.[7]

FIGURE 3.3

Projected populations in large cities correlated with GPI scores

Largest population projections in large cities occur in countries with the lowest scores in the GPI.



Source: IEP

Most Challenged Megacities

Some cities face more challenges than others. High per capita income cities with low population growth are likely to be better placed to deal with ecological threats over the next 30 years. Other cities with less resources, but strong societal resilience, should also be capable of navigating the next 30 years. However, cities with high population growth, low societal resilience and substantial ecological threats are of most concern.

The following table takes several criteria into account to determine which cities are most likely to face future sustainability and security issues. The criteria include population growth, current coping abilities, number and intensity of ecological threats, ranking on the GPI, and various measures of violence.

TABLE 3.2

20 cities and projected megacities most at risk

City	Overall Rating	Pop 2050	Population Increase	Population Increase Rating	ETR Rating	GPI Score	PPI Score	Homicide Rating	Terrorism Rating	Violent Demonstration Rating	Pollution Rating	Traffic Congestion Rating	Expected Climatic Changes
Kinshasa	4.36	29.0M	84%	5	5	3.95	4.31	5	1	5	5	5	Drier
Nairobi*	4.15	10.4M	101%	5	5	2.79	3.54	4	5	4	4	4	Drier
Lagos	4.03	28.2M	82%	5	5	3.44	3.84	5	1	3	5	5	Hotter, Wetter
Dhaka	3.81	34.6M	53%	4	4	2.46	3.81	5	2	5	3	5	Wetter
Baghdad*	3.77	13.0M	71%	5	5	3.79	4.1	5	5	4	1	1	Hotter, Wetter
Lahore	3.75	21.4M	57%	5	4	3.05	3.74	4	4	4	4	2	Hotter
Kolkata	3.67	23.4M	54%	4	3	2.78	3.22	3	3	5	4	5	Drier
Delhi	3.67	49.6M	54%	4	4	2.78	3.22	3	1	5	5	5	Hotter
Karachi	3.64	26.6M	57%	5	4	3.05	3.74	4	5	4	2	2	Hotter, Wetter
Dar es Salaam*	3.55	16.4M	118%	5	5	2.41	3.5	3	4	1	4	4	Wetter
Luanda*	3.47	14.6M	62%	5	5	2.41	3.84	4	1	3	5	2	Wetter
Mexico City	3.4	25.8M	16%	2	2	3.48	3.12	5	2	5	5	3	Colder, Drier
Khartoum*	3.29	11.2M	80%	5	5	3.42	4.21	4	1	4	1	2	Hotter, Drier
Jakarta	3.25	14.2M	28%	3	5	2.07	3.22	1	4	4	5	2	Wetter
Mumbai	3.22	32.4M	54%	4	4	2.78	3.22	2	1	3	4	5	Hotter, Wetter
Lima	3.17	13.4M	21%	3	5	2.49	3	5	1	3	2	4	Hotter, Drier
Manila	3.16	22.0M	52%	3	5	3.05	3.4	4	3	1	2	4	Wetter
Sao Paulo	3.14	24.0M	7%	1	4	3.29	2.98	5	1	5	5	1	Wetter
Hyderabad	3.11	16.2M	54%	4	4	2.78	3.22	3	1	3	3	4	Wetter, Hotter
Chennai	3.11	17.8M	54%	4	4	2.78	3.22	3	1	3	3	4	Wetter

Source: University of Toronto; POPSTAT; IEP; UNODC; TerrorismTracker; ACLED; Air Quality Index; TomTom; IMF; Copernicus Satellite
Note: Cities with an asterisk are projected to become megacities by 2050

Ecological Challenges for Cities

Urbanisation in low-income countries with high population growth is problematic. There is a real danger that without substantive and systemic reform, some of these cities will become unsustainable. This is especially true for cities already suffering from water shortages, unreliable food supply chains, civil unrest, positioned on flood plains or facing subsidence.

In some cases, the issues are so great that cities will need to be abandoned, and new ones created. For example, Indonesia is building a new capital, Nusantara, because parts of Jakarta are sinking at a rate of between 1.8 to 10.7 centimetres per annum.[8]

Islamabad, the capital of Pakistan, is an example of a city that attempted to plan for urbanisation. Constantinos Doxiadis, who laid out the city's master plan during the 1960s, had wanted to balance the perfect urban space - not only by ensuring that the environment is protected - but also supported.[9] However, because of large unplanned increases in its population, Islamabad is today facing a myriad of short and long-term ecological challenges, ranging from catastrophic flooding to sanitation issues, a lack of clean water and food insecurity.[10] Similar issues are evident in Cairo, another megacity dealing with severe water stress and food insecurity.

POPULATION INCREASES

The migration of millions of people to the cities is largely driven by the search for security and employment, as regional areas become increasingly unsustainable and over-populated.

Large increases in the population of cities are one of the major factors driving poor living conditions. Most cities, because of limited financial resources, can only provide infrastructure for a certain number of new migrants. When too many migrants arrive, resources become overwhelmed leading to slum conditions, poor sanitation, poor air quality, reduced security and potentially increased conflict. This is a difficult situation for authorities to fix, as the push factors causing migration are often beyond the government's control. The underlying cause is unsustainable population growth, with realistic solutions requiring a systemic approach.

The growth of cities in areas vulnerable to ecological threats mean authorities must explore better and systemic ways to maintain peacefulness.[13] In addressing the underlying drivers of peacefulness, authorities will have difficulties assessing and providing for basic needs (such as water and food) as well as infrastructure (including roads, electricity, security and policing).

FOOD AND WATER SECURITY

Seventy per cent of the planet is covered in water, but less than three per cent of it is fresh water.[14] These statistics highlight the challenge some cities will face due to limited access to fresh water.[15] These cities will confront the same challenge that Cape Town did in 2018, when 4 million residents faced the prospect of turning their taps on and having no water. The city's authorities responded by getting residents to reduce their water consumption, moving from 780 to below 550 mega litres per day.

Mexico City highlights a different challenge, which is subsidence. It is the fifth biggest megacity, currently home to over 20 million people - although this is expected to increase to 26 million by 2050. The city was built on top of Lake Texcoco, from which it draws much of its water. The withdrawal of water has left large cavities, which subsided, leading parts of the city to sink at a rate of around 50 centimetres per year. As more people migrated to the city, the surrounding freshwater lakes were drained to accommodate the new migrants, which has led to the city importing about 40 per cent of its water from far away sources. These actions, alongside bad management and poor investment in infrastructure (including issues with rainwater collection), have led the city to lose significant amounts of water due to leakage and the mixing of fresh water and sewage. Consequently, one in five inhabitants can only access tap water for a few hours during the day.[16] Cairo is another megacity facing a similar reality.

Lack of access to water and food, coupled with the inability of authorities to provide immediate solutions to these shortages, creates a fertile ground for civil unrest.[17] From IEP's database of over 40,000 cities, 25 per cent are classified as having high water stress according to the ETR. In such cities, the potential for civil unrest is significant. Of the 33 megacities today, 12 are in highly water-stressed regions. Following the current trend, this will increase to 19 by 2050. To address the immediate needs of the population, authorities can look to build dams and wells to store water.[18]

In Bangalore, authorities have drastically increased the digging of wells to capture water. Despite the city having ample rainfall, it is facing water shortages because of substantial leakage due to poor infrastructure. The closest major water source is the Kaveri River, approximately 100 kilometres from the city, but the river is at full capacity in terms of water provision to the city.[19] In Chennai, Pali, Kerala and other cities and districts also within India, water trains have been required to travel hundreds of kilometres to make deliveries when these areas have run out of water.

International rights to water are becoming increasingly contentious, as more of the great rivers of the world are dammed. The Grand Ethiopian Renaissance Dam has caused Ethiopia friction with Egypt and Sudan, as the two countries depend on the Nile River for water, with an acceptable agreement proving difficult to negotiate. The Mekong Delta is another area affected by damming, as the river feeds into multiple countries that include China, Myanmar, Thailand, Vietnam and Cambodia. China has erected multiple dams and is planning on adding more, with Laos also planning to build dams. There are 65 million people dependent on the waters of the lower Mekong Delta. The agreements appear ineffective in managing the broader issues related to the river's flow.

INFRASTRUCTURE CHALLENGES FROM RISING URBANISATION

Rapid urbanisation places a strain on a city's infrastructure. One study estimated that by 2030, about $57 trillion in global infrastructure investment would be required to provide adequate housing for one billion people, who in 2017 were living in sub-standard housing.[20] These infrastructure challenges are most

obvious in Africa and Asia, where urbanisation has given rise to informal urban settlements[21] and the destruction of farmland and green spaces.[22]

Depending on the rate of growth and urban planning, it is likely there will be insufficient public facilities and institutions (such as libraries, schools and health providers) for new migrants.[23] Additionally, the high rates of migration make urban planning difficult, as the areas chosen by migrants will change depending on availability and appeal. However, even with good planning, many high-growth megacities do not have the financial resources or skills necessary to build and manage the growth.

South Africa provides insight into the effects of rapid urbanisation. About one quarter of South Africa's urban population live in informal settlements which have limited basic amenities and infrastructure. These informal settlements also tend to be situated in areas prone to natural disasters, such as floods.[24]

Two major issues arising out of rapid urbanisation are congestion and overcrowding. Many of the world's cities have transportation systems that cannot carry the required number of people. For example, Mumbai's rail system transports daily over three times the number of passengers it was meant to carry at peak times. The overcrowding leads people to take risks, which includes riding between carriages or on top of carriages, leading to many accidents. Congestion also means that people waste long hours in traffic. Additionally, as the ETR shows, congestion generates air pollution which the OECD predicts will be responsible for between 6 to 9 million premature deaths annually by 2060.[25]

RISING TEMPERATURES

Cities in the tropics or in deserts are particularly at risk from rising temperatures. There are indications that extremely high temperatures can lead to interpersonal violence, civil conflict and a fall in economic activity.[26] Unless action is taken to reverse rising temperatures, many cities could experience a warming of 4 degrees Celsius by the end of the twenty-first century.[27]

The proliferation of people and infrastructure in cities can lead to what is known as the 'heat island' effect. This dangerous ecological threat occurs when a city or megacity becomes significantly warmer than its surrounding rural area. The increased temperatures can damage roads, placing additional stress on the transportation system, which in turn affects food, health and communication.[28] The primary cause of the 'heat island' effect is the generation of heat through manufacturing processes, car usage, lighting and the concentration of greenhouse gas emissions. The concrete sector is a good example of how the traditional way to build up cities affects the environment. The process begins with the manufacturing of cement as kilns are heated to temperatures over 1400 degrees Celsius, which requires large amounts of energy. Concrete, which is 80 per cent cement, also absorbs heat - it is estimated that the concrete sector is responsible for about 8 per cent of total global carbon dioxide emissions.[29]

As the climate changes and temperatures rise, the experience of living in a city where the temperature reaches 50 degrees Celsius is becoming more common. This gives rise to extreme heat, defined as a period of high heat and humidity - with temperatures rising above 32 degrees Celsius for at least two to three consecutive days.[30] One study indicated that since 1987, urban exposure to extreme heat has increased by nearly 200 per cent.[31] Recently Nawabshah, Pakistan recorded 50.2 degrees Celsius; Basra 53.9 degrees Celsius; while both Kuwait City and Doha have had several days where it was 50 degrees Celsius.[32]

PROXIMITY TO THE COAST

Several megacities are located within 100 kilometres of coastal areas, and under 50 metres elevation from the coast. These urban centres are likely to face challenges from rising sea levels and storm swells. Rising sea levels affect the ecosystems on which many of the cities rely. These urban centres must not only contend with the usual challenges non-coastal megacities face, but also distinct threats such as subsidence caused by dense building, the increasing intensity of storms, rising seas levels and excessive groundwater extraction.

Coastal megacities in Africa and Asia face distinctive challenges because many of the new migrants to these centres are amongst the world's poorest people. These individuals tend to build their homes in areas vulnerable to ecological threats, as these areas are less regulated and cheaper.[33] Additionally, these cities tend to focus on large construction projects, looking to provide housing for the new migrants. However, lack of capital and resource means these constructions are less regulated, leading to disasters as seen in Lagos where 24 buildings collapsed between January and July 2022.[34]

Megacities can also facilitate overexploitation of resources and unsustainable pollution to the environment, through the use and release of toxic chemicals into soil and groundwater reserves.[35] This is evident in Lagos State, where more than 400,000 tons of fish are collected annually from the Lagos Lagoon, but which has become increasingly polluted due to substantial damage to the ecology that surrounds the lagoon and the Gulf of Guinea.[36]

POLLUTION IN CITIES

The concentration of large populations in urban centres substantially increases pollution. This not only impacts local residents, but also increases global pollutants through the movement of air and water. Estimates indicate that in 2021 cities could have been responsible for as much as 70 per cent of global CO2 emissions.[37] This is significant, as air pollution is expected to be responsible for between 6 to 9 million premature deaths annually.[38]

In 2019, air pollution was responsible for economic losses totalling $8.1 trillion, or over 6.1 per cent of global economic output, with over 90 per cent of pollution-related deaths occurring in low-income and middle-income countries.[39] These countries experience air pollution more acutely than high-income countries because they lack the resources and capacity to bring about change.

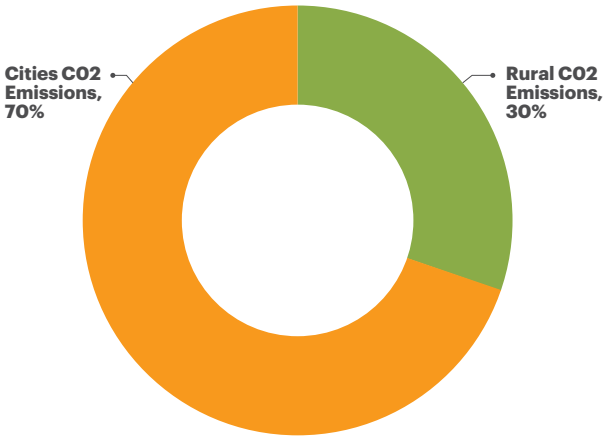
In 2019, the five most air-polluted cities all had readings of more than 22 times the WHO recommended annual limit of 5 micrograms per cubic metre. Five Asian cities recorded well above this rate with Lahore 25 times, Kabul 24 times, Hetian Shi 23 times, Hapur 22 times, and Agra 21.9 times the WHO limit.

Table 3.3 shows the 20 cities with the highest levels of pollution. Of these cities, half are in India, and a further seven are in China. China demonstrates the migratory trend and challenges many urban centres in low-income countries face, as they look to industrialise. China's drive to urbanise has been strong, rising from 16.2 per cent of people living in cities in 1960, to 61 per cent in 2020. This urbanisation drive highlights why the country is

FIGURE 3.4

Cities versus rural communities and their respective CO2 emissions in 2019

Cities generate more than double the CO2 emissions of rural areas.



Source: UN

home to at least 15 megacities and over 110 cities with a population of one million or more.[40] It is also evident that these cities face many challenges in adapting to ecological threats, as it is not only what the city does to address the changing climate, it is also what is taking place in the surrounding areas.

In 2021, the presence of hazardous airborne particles (PM2.5) in Beijing was seven times the WHO recommended levels and a 13 per cent reduction from the previous year. Even though the air quality is below recommended levels, the improvement is profound as in 2013 the level of pollution was 90 times higher than the WHO's recommended daily level. This improvement is due to an aggressive program beginning in 1998, aimed at reversing Beijing's poor air quality. Actions taken by city authorities included using cleaner natural gas, the planting of a 'Green Wall' (the Three-North Shelter Forest Programme), and the imposition of stringent fuel standards on cars. This is an example for other megacities that with the right policies and investment it is possible to make substantial improvements in air quality. The challenge however for Beijing and the areas surrounding it, are that they are in dire need of ecological repair, as toxins have saturated the soil.

TABLE 3.3

Pollution by cities, 2019

City	Country	Population (estimate)	PM2.5 (microns/m3)	Level Above WHO Recommendations
Lahore	Pakistan	11.1M	123.88	24.8
Kabul	Afghanistan	4.3M	119.77	24
Hetian Shi	China	1.3M	112.3	22.5
Hapur	India	242.9K	111	22.2
Agra	India	1.6M	109.67	21.9
Noida	India	225.1K	105.25	21.1
Delhi	India	31.9M	105	21
Muzaffarpur	India	333.2K	101	20.2
Ghaziabad	India	2.4M	100.67	20.1
Baghpat	India	386.0K	92	18.4
Kashgar	China	506.6K	90.23	18
Zhanhe Qu	China	905.9K	89.6	17.9
Shunhe Huizuqu	China	5.4M	88.27	17.7
Muzaffarnagar	India	10.8K	86.5	17.3
Dhaka	Bangladesh	22.6M	86.48	17.3
Xinfu District, Xinzhou	China	3.1M	83.39	16.7
Dongchangfu Qu	China	88.5K	82.12	16.4
Asansol	India	563.9K	81	16.2
Chuzhou Shi	China	3.9M	80.79	16.2

Source: WHO

Case Studies

This section examines four cities from different regions of the world – sub-Saharan Africa, South Asia and Asia Pacific. The megacities selected show a broad range of challenges with recurring themes including water stress, air pollution and susceptibility to ecological threats. These cities are from medium to low per capita countries and are not necessarily the most challenged, but rather represent the issues faced by many high growth cities.

Kinshasa

ETR Domain	Rating
Water Stress	Extremely High
Population Increase	Extremely High
Food Security	Extremely High
Natural Disasters	High

The Democratic Republic of the Congo (DRC) is a low peace country facing many challenges including political instability, social vulnerability, food insecurity and mass poverty. The country, and specifically Kinshasa, are projected to face increasing pressures from high population growth, specifically in water and food security. The city is projected to grow from its current population of 16 million people to 29 million by 2050, a growth rate of 84 per cent. This will place extreme pressure on infrastructure including roads, electricity, schools, medical centres and transport, as well as government services such as security and policing.

The country is likely to experience higher temperatures, more extreme weather events, and changes in total precipitation and rainfall variability. These are likely to have a detrimental impact on the population, many of whom rely on agriculture.

The DRC has most of the known global cobalt reserves in the world, making Kinshasa the financial, political, and social centre of the country. Kinshasa suffers from regular flooding; and for low peace countries flooding is particularly harmful as it tends to paralyse the transportation network. The damage to Kinshasa from severe floods can cause major physical destruction to roads, leaving them unusable.[41]

Kinshasa has undergone dramatic changes, transitioning from a fishing and trading town into a huge metropolis of geostrategic importance, due to the province's mineral wealth. This has also led to the presence of a large diplomatic community, and headquarters for foreign and local mining companies. The city lies about 500 kilometres from the sea, but its location at the Congo Basin means it is sensitive to pluvial and fluvial flooding, made worse by poor urban planning.[42] It is one of the DRC's 26 provinces, covering an area of 9,965 square kilometres, much of which is rural.[43]

The unplanned development of Kinshasa has taken place because of migration from the rural areas of the country. There are many factors driving the migration, including violence and general lack of security, the presence of criminal groups, lack of policing, and ecological degradation. There are also too many people for the available agricultural land.

Many of Kinshasa's infrastructure problems stem from poor or no urban planning. It is estimated that only six per cent of the city has planned and well-serviced neighbourhoods.[44] The lack of planning has affected the city's ability to establish appropriate infrastructure and institutions, including schools, medical facilities or policing, which explains the rise of kulunas – young gangs – that are now integrated into the city's communities.[45] Another major challenge for Kinshasa is that the city is unable to process the 9,000 tons of waste that it produces annually.[46]

Recognising Kinshasa's vulnerability, the World Bank in 2021 signed a $500 million infrastructure project, with the intention of improving roads, mitigating flood risks, fighting erosion, and developing public spaces across the capital.[47]

BOX 3.1

Kinshasa, cobalt and geopolitics

Approximately 70 per cent of the world's cobalt is found in the DRC. An estimated 3.4 million metric tons of cobalt, a key mineral in the production of batteries for smartphones, personal computers and electrical vehicles (EVs). The reserves are mainly located in Southern Congo. In 2021, the automotive sector consumed 59,000 tonnes of cobalt, which amounted to 34 per cent of total demand.

The DRC is expected to supply over 73 per cent of cobalt in the global market in 2023. Most EVs have a lithium-ion battery and a key mineral for these batteries is cobalt. The production of cobalt is projected to increase by 585 per cent by 2050 to accommodate the shift towards electrical batteries, as increasingly countries introduce measures to replace the use of diesel and petrol vehicles. In 2020, China accounted for 66 per cent of global refined cobalt output and is the major importer of DRC's cobalt.

Dhaka

ETR Domain	Rating
Water Stress	Low
Population Increase	Low
Food Security	High
Natural Disasters	High

Bangladesh consistently rates as one of the most affected countries by flooding and cyclones. Much of the country is about six metres above sea level, though its coastal areas are much lower. Depending on the rates of sea level rise, an estimated 15 to 30 million Bangladeshis could be displaced from coastal areas. It has been shown that approximately 90 million Bangladeshis live in "high climate exposure areas," with around 53 million subjected to "very high" exposure.[48] The UNDP, other UN agencies and NGOs have looked to support Bangladesh with initiatives including resilience-building, emission reductions from fossil fuel based power, and better flood-preparedness.[49]

Dhaka, a city of 22.6 million people, is affected by ecological changes in several ways. The city is located on an area of just 360 square kilometres, making it one of the more densely populated cities in the world (with 29,000 inhabitants per square kilometre).[50] This high density, combined with rapid urbanisation, means a third of the city's population cannot rely on piped water.[51] Many residents end up in informal settlements, with the Korail slum growing from 40,000 inhabitants in 2011 to around 150,000 in 2021.[52]

The city is impacted by regular floods, which are only likely to increase.[53] As it is low lying it may be affected by sea level rises, while also coping with infrastructure problems particularly in transport, water, waste and energy. Dhaka struggles to provide good living conditions to its residents due to its inability to deal with waste. The city generates approximately 5,000 tons of waste a day, but only half is properly collected and disposed of.[54]

Dhaka has been one of the fastest growing cities in the world; between 1990 and 2005 the city's population doubled from 6 million to 12 million. The city's population is further expected to increase, rising to 35 million from its current population of 23 million, an increase of 53 per cent. One reason for this growth is that about 2,000 people move to the city daily.[55]

Dhaka's rapid urbanisation highlights its central role in Bangladesh's drive to move from being a low-income to a middle-income country. The city generates around one-fifth of Bangladesh's total economic output and provides more than 40 per cent of its formal sector jobs.[56]

Delhi

ETR Domain	Rating
Water Stress	High
Population Increase	Low
Food Security	Medium
Natural Disasters	Medium

Delhi, which in 1947 had barely a million inhabitants, is described as one of the most polluted cities in the world,[57] leading the Indian Supreme Court in 2021 to order millions of people to stay at home due to poor air quality.[58] Many of the problems Delhi faces, as experienced in other low and middle-income countries, are due to lack of planning and rapid urbanisation.

In 2021, Delhi's most significant ecological threat was air pollution, made worse by the dust that is a constant feature of the city. Delhi generates between a third and 56 per cent of the harmful pollutants in its atmosphere, with the rest mainly originating from other parts of India.[59]

Several interrelated factors explain Delhi's poor air quality,[60] some of which are beyond the city's control. Firstly, the city cannot regulate the environment that surrounds it, which means it attracts pollutants from brick kilns and construction needed to accommodate this growing metropolis. Additionally, the size of the city and its weak infrastructure (including the regulatory and enforcement regimes) cannot address pollutant sources in the city. This is most obvious with respect to the construction sector, which lies at the heart of Delhi's growth. Cement contributes 10 per cent of the coarse pollutants in Delhi's air.[61] The poor public transport system compels car usage, whereas poverty encourages the burning of wood and cow-dung cakes to keep warm.

The unfavourable geographic location and regional meteorology results in low humidity and episodic dust events from the surrounding environment. Delhi is also affected by regional trends, such as stubble burning in the Punjab and Haryana states, which although banned continue.[62] These activities and other outside activities account for 30 to 40 per cent of Delhi's air pollution between October and November.[63]

The interconnectedness between geography, population growth and ecological threats is visible when one considers how densely populated Delhi is and will continue to be. More people, lack of efficient public transport and poor road construction mean that the congested traffic conditions persist into the evening. This is a problem as the cooler temperatures keep the emissions that are generated during the day closer to the ground.[64] The poor regulatory and enforcement regimes, allow polluters to escape scrutiny.

There have been attempts to address Delhi's air quality, including developing an action plan that aligns with the principles and guidelines of the National Action Plan on Climate Change. The first attempt at developing a plan stalled as stakeholders spent seven years negotiating, meaning it expired a year after formal adoption as it was only meant for a decade.[65]

Delhi has looked to cut car usage in the city through an 'odd-even' alternate days approach. The city has also looked to introduce buses that run on natural gas, instead of the more polluting diesel. In 2016, the government introduced regulations for cleaner motor fuel and vehicle emission standards.[66] There has also been a move to transition away from coal-fired power plants.[67]

Jakarta

ETR Domain	Rating
Water Stress	High
Population Increase	Low
Food Security	Low
Natural Disasters	Extremely High

Jakarta is home to around 11.1 million people and is a relatively new megacity, growing at an annual rate over the last three years of around 1.4 per cent.

The population is projected to increase to 14.2 million by 2050, a 28 per cent increase. The city is located on the northwest coast of Java, at the mouth of the Ciliwung. The Jakarta Metropolitan Area (Jakarta, Bogor, Depok, Tangerang, Bekasi and Cianjur) is home to close to 29 million people, spanning 4,384 square kilometres, with a population density of 3,000 people per square kilometre.[68]

The growth that took place between 1980 and 2002 resulted in about a quarter of the land area of Jakarta being converted from mainly agricultural or wetlands to urban use for industry, commerce and housing.[69]

Despite being a relative newcomer to the megacity club, Jakarta experiences many of the ills seen in other large urban centres specifically massive traffic congestion, informal settlements, flooding, lack of clean water, ineffective waste management and land subsidence.

The two major challenges that Jakarta faces, beyond the other ecological threats, are land subsidence and sea level rise. A 2021 study by the National Research and Innovation Agency (BRIN) found that without drastic measures, approximately 25 per cent of the capital area will be under water by 2050, as the city sunk between 1.8 centimetres and 10.7 centimetres annually between 2019 and 2020.[70]

The reasons for Jakarta's subsidence and water stress began with the overuse of groundwater by home drilling. In 2011, around 7.2 cubic million metres of water had been extracted from 4,231 wells, but four years later the figure rose to 8.9 million cubic metres of water taken from 4,473 wells.[71] This process has a double impact on the city, not only can it not regulate how much fresh water has been used but overuse leads to empty spaces underground that leads to subsidence.

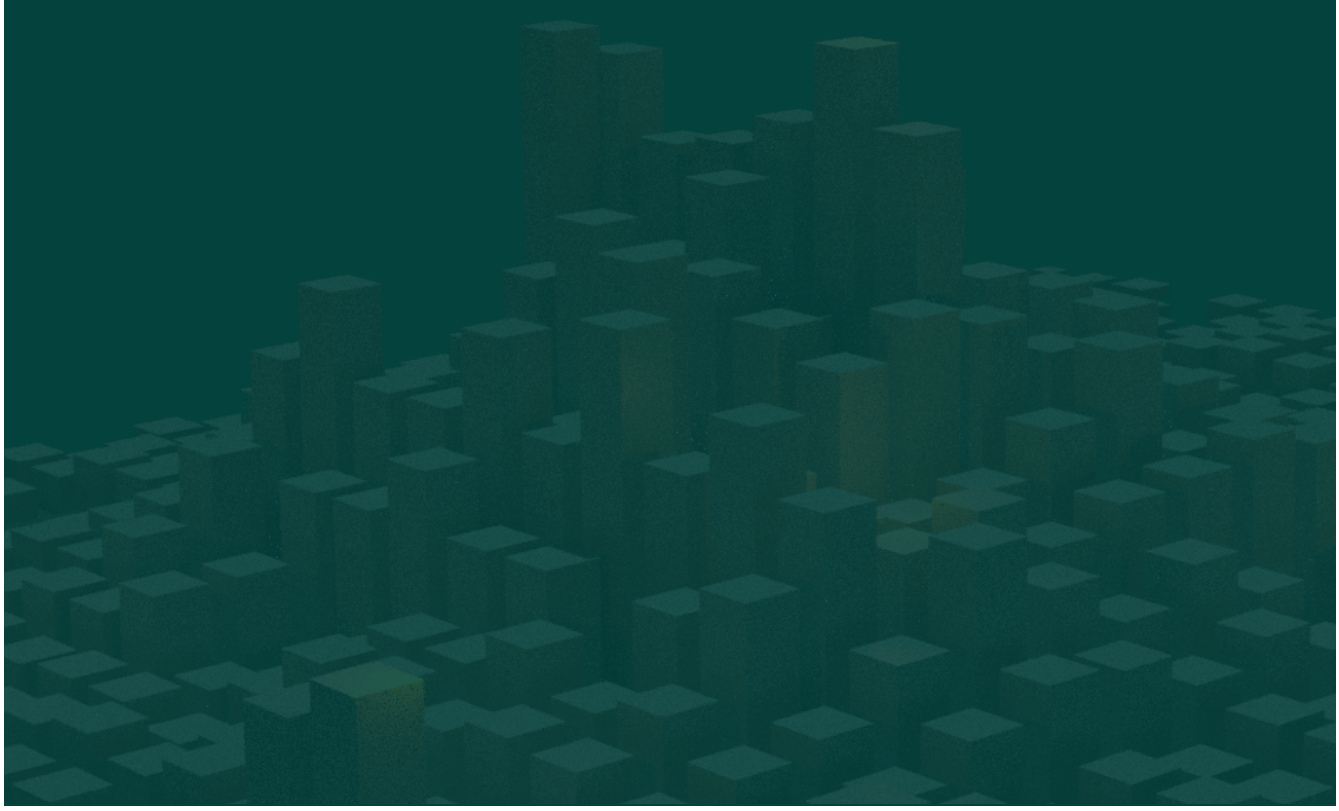
The loss of the mangrove ecosystem has been particularly problematic. Although initially it was urbanisation that led to their destruction it is increasingly the rising storm swells, ferocity of the waves bringing copious amounts of rubbish, and massive fluvial floods that are reducing the salinity and harming the mangroves.[72]

With a population of around 11 million people, one would not have expected Jakarta to be at one point the worst city in the world for traffic jams. The large number of vehicles, around 20 million trips a day, and poor infrastructure mean drivers must stop and start their cars approximately 33,000 times per year on the road.[73] This has led to the claim that the average Jakartan spends 10 years of their life in traffic, with the average speed about 8.2 kilometres per hour.[74] Such congestion explains the substantial rise in motorcycle use and the decline in bus use.[75] The high level of traffic is also a reason why Jakarta is known for its poor air quality,[76] which causes 1.3 million absences at schools, 2.8 million lost work days, 9,000 hospitalizations and at least 6,500 premature deaths per year.[77]

Jakarta has taken a multi-pronged approach to the threat of rising sea levels. In 2011, it began to construct a barrier across the bay of Jakarta to convert the bay into a water reservoir, so water could be pumped back to the sea reducing flooding. There was also a plan to build 17 artificial islands off the coast of Jakarta. However, only three were constructed before the plan was cancelled. A separate solution has involved the building of a natural ecosystem, mainly mangroves, to absorb the waves and prevent flooding.

In 2019, seeing how massive the ecological challenge was, the government proposed creating a new capital.[78] This purpose-built $35 billion city, to be called Nusantara (meaning 'archipelago' in Sanskrit), will be on the island of Borneo more than 1,000 kilometres away from Jakarta.[79] In addition, in 2019 Jakarta adopted a regeneration plan that looks to reduce emissions, as well as adopt efficient energy production and waste management, while strengthening its adaption policies. Key to the plan is an improved public transportation system, aimed at reducing congestion and emissions.[80]

4 Policy Recommendations



ECOLOGICAL THREAT POLICY SEMINARS

In 2021, IEP held a series of six policy seminars with 60 leading experts from governments, think tanks, military institutions and development organisations to explore policy options to address increasing ecological threats. A series of key themes emerged that spanned action from the local to the international level. These are summarised as follows:

Building resilience. Resilience building is *holistic*, involving all aspects of a societal system. Part of this holistic approach is recognising the multilayered links between ecological change, sustainable development, human security and global action. Faced with such complexity, international agencies need to develop a common understanding on the meaning of 'resilience.'

Broaden the range of actors involved. Stronger multilateral cooperation with a wider group of actors is also required for *interventions based on systems thinking to be successful*. Modern global governance is characterised by an increase in non-state actors, who in many cases, form a large part of programme implementation. It is therefore important that proposed solutions ensure their inclusion and input.

Security and development. In states with the worst threat levels and lowest societal resilience, ecological challenges will act as a 'threat multiplier' and worsen instability. This can cause increased conflict and encourages spill-over into neighbouring countries and regions. Some of these effects include new conflicts and population displacement, even into other regions as well as economic dislocation. Focus should be on mitigating interventions that reduce the risk of conflict.

The scope of the problem is beyond the budget capabilities of all the international agencies combined. As institutional funding decreases, it is clear that private sources need to be leveraged to reduce reliance on taxpayer resources. The sum of all national governments' income is 15 per cent of world GDP.[1] Only a small proportion of government income can be directed towards ecological adaptation and development. Therefore, these issues must be faced with not only governments and NGOs, but also the private sector. For example, if global pension funds were to allocate just one per cent of their assets to ecological threat resilience building programs, the investment would constitute around $500 billion. This is more than three times the OECD's annual allocation in official development assistance (ODA) and would go a long way towards averting more serious humanitarian crises and economic disruptions.

Solutions to ecological problems require short-term costs with long-term benefits. Adapting to increasing ecological shocks requires sectoral reallocations. As with any budgetary restructure, there will be winners and losers. For example, decarbonisation to mediate long-term temperature change means moving away from carbon-intensive sectors, which many countries heavily depend on. As sectoral reallocations will negatively impact certain workers, businesses and investors, there needs to be further analysis on its effect on these groups (for instance coastal farmers and coal miners).[2] In regions with already low resilience, the ability to successfully navigate this transition will be further hindered by tight budgets.

Many of the solutions to ecological problems can generate income, such as the provision of water which can then be used to grow food. If business can clearly see how to garner a profitable return from ecologically positive investments, funds will naturally flow towards ecological solutions.

Develop community cooperatives. Due to the strong bonds within communities, cooperatives can work well. Cooperatives provide a mechanism for the pooling of resources and sharing of costs. Many examples exist including shared water resources, seed and fertiliser banks, and micro-manufacturing plants.

A key overarching implication of these discussions is **the need to empower local communities to address the contextual challenges they face**. Community-led approaches to development and human security lead to better programme design, easier implementation and more accurate evaluation. Initiatives that are led by locals usually benefit from more accurate local knowledge, deeper awareness of local sensitivities and usually enjoy greater community buy-in. Thus, such initiatives tend to run more smoothly and at lower research and implementation costs than others. They also avoid the "one size fits all" approach of top-down interventions. Designed effectively, these bottom-up approaches can work in tandem with programmes initiated at a higher level by governments and multilateral organisations.

SYSTEMS PLANNING: THE HALO APPROACH

While successful developmental programs can be implemented in isolation, a better outcome can be achieved when a well-planned set of interventions is developed from a systems perspective. Programs will yield better outcomes if the successes of each are designed to underpin the success of the others. The resulting system of projects will yield results greater than the sum of each of the projects. For a successful fully systemic approach many other aspects would need to be considered, including security responses, governance initiatives and community engagement.

Further, in creating systemic change, smaller "nudges" are preferable to large scale interventions. A large scale mistake is difficult to recover from, whereas minor changes can be undone more easily, even if they are numerous. In addition, drastic changes – even those in the right direction – can be disruptive and, in extreme cases, destabilising for the system. In defining interventions, it is better to attempt to do many small nudges, rather than large, fundamental changes to the status quo.

What has emerged from the IEP Policy Seminars is that in most cases governments, multilaterals and other institutions engaged in societal development initiatives do not address their initiatives systemically. This can create unforeseen consequences and lead to only partially successful outcomes, since there is not a wider understanding of the dynamics of that society. If institutions themselves are not set up systemically it can lead to issues including inefficiencies, partial solutions, inter-organisational disagreements and duplication.

To achieve systemic and sustainable outcomes, there needs to be a common understanding of how the system currently operates and what the desired change is. Currently there is no agreed holistic process for stakeholders to conduct a collective mapping system of operation.

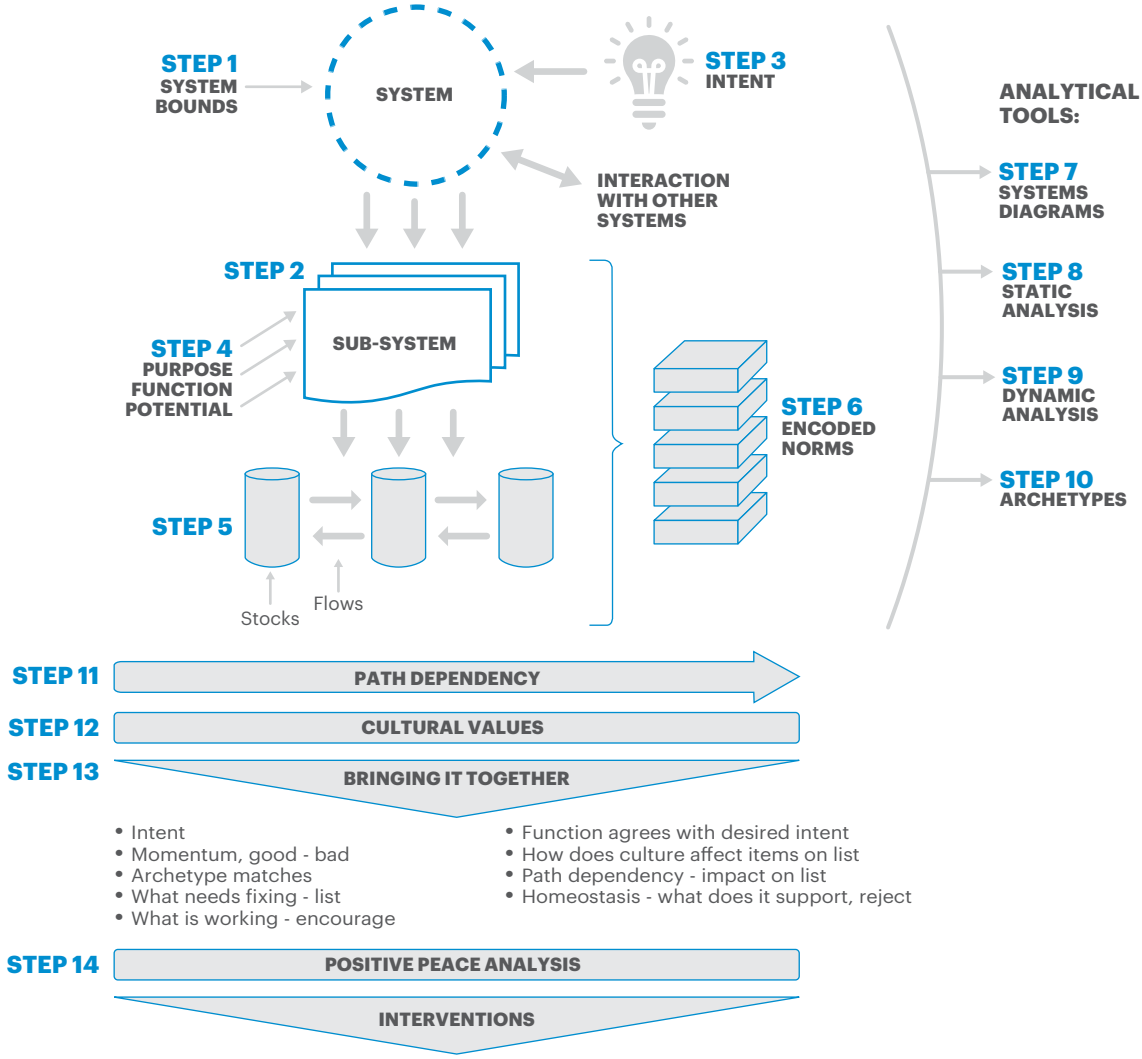
In recognition of this gap, in 2021 IEP developed and published a process to allow practitioners to build a more holistic systems picture of societal issues. Called HALO, it presents a set of 24 building blocks for the analysis of societal systems and the design of resilience-building programs. It guides the user through 14 steps as shown in Figure 4.1. This allows for an adaptive approach that can be uniquely tailored based on dependencies including the size of the societal system and the sophistication required in the analysis.

HALO workshops and programs can be as short as two days or as long as one year using this building block approach. Different building blocks can be utilised depending on the strengths of the design team, what may suit the project best, and the length of time allocated for the analysis.

FIGURE 4.1

Schematic illustration of IEP's HALO systems analysis

This stylised summary depicts the key attributes of a system and helps analysts map each attribute to a real-world scenario that is under analysis.



Source: IEP

A full HALO systems analysis provides knowledge to help design the interventions that need to be performed to rectify the imbalances within the system and set it on a new course. For a more detailed explanation of the HALO approach, please consult the 2022 Positive Peace Index.[3]

INNOVATIVE DEVELOPMENT

This section provides a series of localised programs that have had success in building resilience against ecological threats. These include addressing ecological rehabilitation, improving water sources, managing population growth and building local industry. Some of these projects have been implemented by IEP's sister organisation The Charitable Foundation (TCF).

Countries more vulnerable to resource scarcity have lower coping capacities to manage resource scarcity shocks. These countries also tend to have unsustainable population growth, low or volatile economic growth, high rates of poverty, lack of societal resilience and greater prevalence of food insecurity. With this in mind, there is a clear need for building more resilient and sustainable food and water systems in communities vulnerable to resource scarcity. This can look like more efficient water capture infrastructure or community-based programs connecting smallholder farmers to finance systems or mobile apps that inform farmers of changing weather patterns.

FOSTERING WATER RESILIENCE

Sand Dams

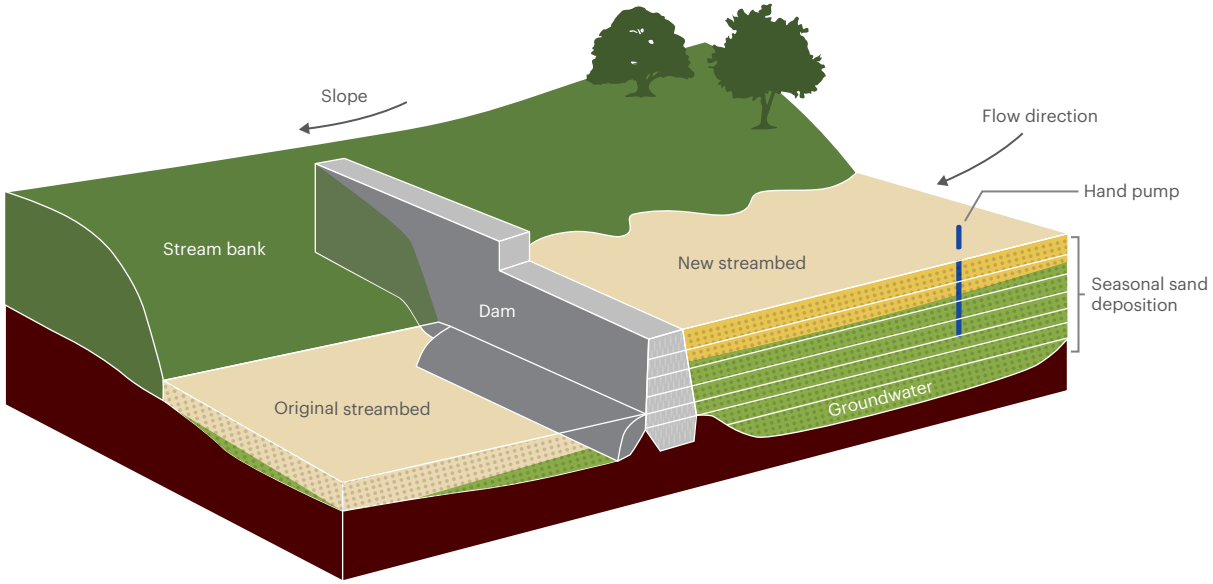
Abstraction of water from sandy seasonal riverbeds is an ancient practise where natural dikes capture the water stored in the sand. Subsurface dams and sand dams are artificial enhancements to natural dikes, which if constructed carefully last for an exceptionally long period of 50 to 100 years.

A sand dam is a dam built in a seasonal dry riverbed onto bedrock or an impermeable layer. It is constructed across the river channel to block the subsurface flow of water through the sand. The upstream reservoir of such a dam can be composed of 40 per cent water when made up of coarse sand. The water can then be retrieved for multiple uses including domestic purposes, livestock and irrigation. The captured water also seeps into the banks of the river increasing the vegetation and biodiversity. The cost to build one of these dams is approximately $50,000.

FIGURE 4.2

Schematic diagram of a sand dam in Kenya

For the cost of $50,000, a Sand Dam can produce water to the value of $180,000.



A very large sand dam can hold 71,000 cubic metres of water (71 million litres) which when amortised over 10 years will yield water for 29c per thousand litres. Large dams can yield 400 tonnes of produce. Based on World Health Organisation (WHO) estimates, this is enough for 2,790 people's fruit and vegetable requirements. A study done on sand dams in Kenya estimates the value of 400 tons of produce to be around 20 million shillings ($180,000).

The return on investment will vary depending on the crops and price of staples at the time. TCF has conducted a detailed feasibility study which is publicly available.

In many locations of TCF projects, little or no agriculture was being undertaken before the installation of the sand dam. Subsequent agricultural activity has been central to uplifting the regions.

TCF has built 30 sand dams in Kenya and they are exploring ways of scaling the benefits through establishing the business case for investing in the construction of sand dams.

Dispensers for Safe Water in Zomba, Malawi

This project was developed by Evidence Action to install chlorination dispensers at water collection points, to make the water so safe that it reduces the need for boiling the water. This was then recognised as a carbon emission reduction program and monetised to help finance the maintenance of dispensers and refilling them with chlorine.

As such, they have succeeded in obtaining carbon credits. Evidence Action has now managed to secure carbon credits for its dispensers in Uganda, Kenya and for TCF funded dispensers in Malawi. The aim is to expand the program to reach an additional 1 million people. While carbon credits provide an important revenue source, it has become clear this alone will not make the program self-sustaining. The revenue from the sale of 720,000 carbon credits accounted for 39 per cent of Dispensers for Safe Water's budget, with a service-for-fee approach covering the remaining costs of the project.

Sustainable Water Sourcing Through Engineered Wetlands

A community-based initiative in the Chinese villages of Xiadong and Lixi in the Dongjiang River Basin, developed a project with Conservation International funding to make their water system more sustainable. The community constructed a water treatment system that mimics wetlands[4].

These engineered wetlands facilitate the flow of contaminated water through traditional infrastructure such as shallow septic tanks, and into natural ecosystems such as marshes, plants and soil that absorb pollutants and filter water. The engineered wetlands in the two villages treat on average up to 9,000 tons of sewage annually, before the water returns to the river.

This project creates freshwater infrastructure while providing habitat for local frog, fish, insect, waterfowl and other species. The maintenance of the wetland is provided by local villagers, who also take part in testing water quality, cleaning leaves and branches, and patrolling along the river.

This brings economic benefits to the local community, providing water stability which fosters economic growth. The watershed has also created an increase in tourism, stimulating the domestic economy. As part of the program, Conservation International helped train a group of villagers as guides to showcase the wetlands, and offered educational tours of the apiaries where beekeepers harvest honey, native herb and bamboo forests, and orange orchards. A portion of the revenue from the tours goes to a community water fund, which was set up to support the wetlands' maintenance.

The success of this program has caused Conservation International and partners to expand the program to other areas through the '100 Village Initiative,' which aims to improve freshwater health in 100 villages along the Dongjiang River. This project will be transformative for the Dongjiang River system, which provides drinking water for 40 million people, and can serve as an example for other communities looking to make their water systems more sustainable through a program led by the local community for the local community.[5,6,7]

BUILDING RESILIENT FOOD SYSTEMS

Farmer Managed Natural Regeneration (FMNR)

Farmer Managed Natural Regeneration (FMNR) is a low-cost land restoration technique developed by Tony Rinaudo from World Vision. Rinaudo pioneered FMNR in Niger during the 1983 famine and is regarded as the leading expert in the technique worldwide. FMNR promotes water harvesting techniques as the planting includes a micro-catchment which traps surface run-off, makes the soil and water settle down, and feeds the plant at a microsite.[8]

In practice, FMNR involves the systematic regrowth and management of trees and shrubs from felled tree stumps, sprouting root systems or seeds. This process is low-cost because participants look to re-sprout tree stumps, undertake rootstock or recruit seeds that are present in the soil or are dispersed into the field. The farmers prune, mulch and engage in active protection. The regrown trees and shrubs help restore soil structure and fertility, inhibit erosion and soil moisture evaporation, rehabilitate springs and water tables, and increase biodiversity. Some tree species also impart nutrients such as nitrogen into the soil.[9]

Since the early 1990s, Southern Niger has perhaps experienced the most rapid, farmer-managed re-greening in human history. Over five million hectares of mosaic have been restored through the regrowth of 'underground' trees.[10] Niger is now greener than northern Nigeria – although it has less rainfall.

The success of the World Vision project in Humbo, Ethiopia has led to the Government of Ethiopia calling for a 15-million-hectare scale-up. The Global Ever Greening Alliance is now promoting the FMNR and related re-generation mechanisms across the Sahel and drylands in other parts of the world. TCF is implementing an FMNR project among pastoralists in Longido in Northern Tanzania to complement the land use planning and pasture regeneration projects it has been running there. A 2018 World Bank study investigating crop modelling, FMNR and drought impact reduction, found that when native species are added to the other productivity-enhancing technologies then the projected number of poor, drought-affected people living in drylands in 2030 falls by 13 per cent with low-density tree systems and by more than 50 per cent with high-density tree systems.[11]

Farmer-managed natural regeneration programmes look to improve a community's agro-ecological conditions by reversing the environmental damage that occurs when trees are lost, either due to natural causes or human behaviour. By restoring vegetation and trees these programmes reduce fuelwood scarcity, increase building materials and forage for animals, which are essential to sustain the ecosystem.

The regeneration has specific benefits to particular members, such as women and girls tasked with searching for and collecting fuel wood, cooking food and gathering wild fruits. Additionally, as FMNR looks to reverse wood scarcity and improve the general environment; this can aid in reducing tensions and possibly conflict as individuals need not fight over resources. This development could be significant, as the Global Terrorism Index highlighted, because violent extremists look to capitalise and exploit environmental harm, poverty and hardship in their recruitment drives.

FMNR could help limit and prevent resource-driven conflict because it looks to promote more robust land use and land access rights (including preventing and reversing land erosion). By doing so, FMNR aids local communities to move away from subsistence farming and facilitates income generation. In Humbo, Ethiopia, it is estimated that some $160,000 of fuelwood will be harvested from the project. This is in addition to creating both temporary and permanent employment.

By regenerating trees and ensuring communities recognise these finite resources require protection and nourishment, communities gain a sustainable fuelwood supply. This helps reduce insecurity, as women and girls who are often tasked with finding fuel, need not venture too far from the community. FMNR also involves the protection of fragile water catchment areas and the restoration of water, which is key as many places in sub-Saharan Africa face water stress and scarcity.

FMNR could play an important role in promoting adaption policies across Africa, where droughts are becoming more frequent and millions must deal with water shortages. African countries must invest more in adaption policies, something that many middle and high-income countries are already doing. However, many low-income countries are unable to as adaption policies require enormous investment and infrastructure restructuring, because existing structures are only suitable for an environment that no longer exists.

Improving food yields in Kisii, Kenya

The absence of volcanic rejuvenation, cycles of weathering, erosion and leaching on the continent over the years has left soil in sub-Saharan Africa inherently low in nutrients. This has also resulted in a wide diversity of soil types that differ dramatically in their ability to retain and supply nutrients to plants, hold or drain water, withstand erosion or compaction, and allow root penetration.

One project funded by TCF and implemented by One Acre Fund (OAF) in Kisii in Western Kenya focuses on crop yields. The model is simple and provides high quality seeds and fertilizer on credit, along with high quality extension advice on planting, weeding and harvesting. After harvest, the farmers are assisted to market their produce. With the realised yield and productivity increase, the farmers are able to repay the input and training received, while earning a higher profit than before. The seed and fertilizer bank is maintained by a cooperative.

One Acre Fund now serves more than a million farmers in the Sahel who all realise a higher profit.

Food Security Through Sustainable Aquaculture

By implementing programs that support sustainable aquafarming practices, smallholder farmers can increase their efficiency and production all while reducing their ecological impact. Currently, half of all seafood consumed today is farmed and one-third of the world's wild fisheries are depleted because of overfishing, pollution and the effects of long-term temperature changes. Populations of fish like cod and salmon are decreasing, as they are being fished faster than they can reproduce. It is projected that aquaculture production must double by 2050 to meet growing demand.[12] When smallholder aquafarmers attempt to meet growing demand by participating in deforestation and destruction of wetlands, food systems are compromised. Unsustainably sourced fish feed depletes species that local communities rely on in the aquafarming sector.

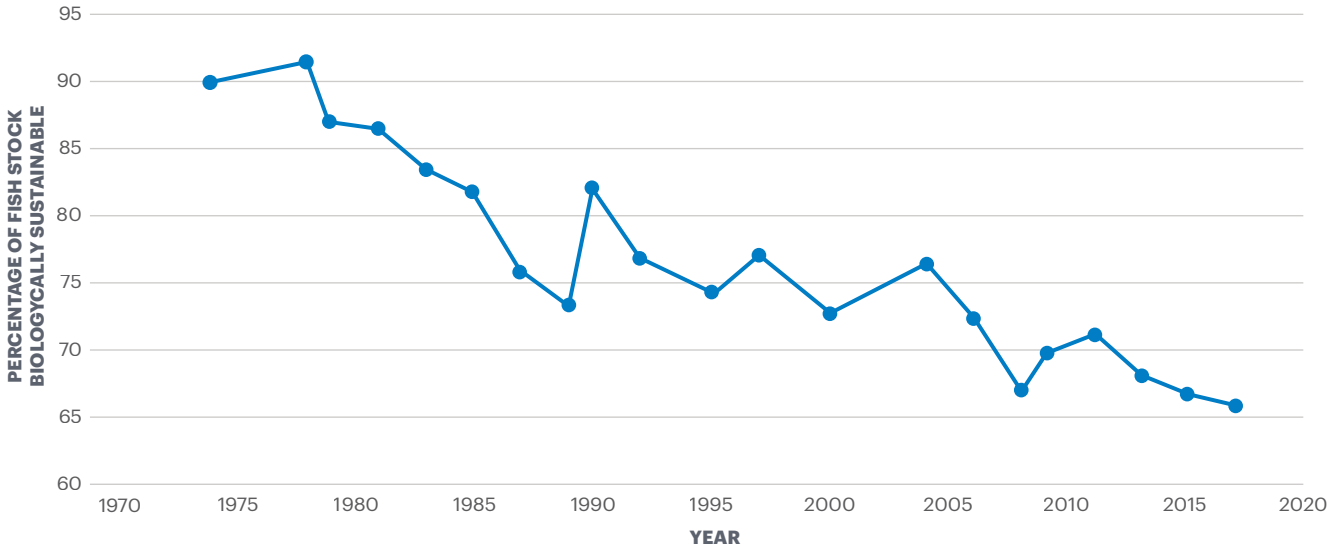
While there can be massive ecological impacts from unsustainable fishing practices, they are practices that increase production without coming at the expense of environmental degradation.[13,14,15]

Sustainable aquaculture practices increase efficiency and while there is an upfront cost, the payoff is substantial. Sustainable fish food is more cost effective with a much lower cost over time. Making aquaculture more sustainable includes practices like avoiding deforestation, filtering the water on aquafarms before releasing it into surrounding ecosystems, limiting the use of antibiotics, investing in disease management, using low impact fish feed, selective breeding, and more.

FIGURE 4.2

Percentages of stocks fished at biologically sustainable levels, 1974–2017

Sustainable fish stocks have decreased by 24 percentage points since 1975.



Source: FAO

Hyperlocal Tropical Weather Forecasting

Designed with the goal of providing farmers in tropical areas with a tool to increase the efficiency of their farm, Ignitia works with development agencies, NGOs, agri-input businesses and other global industries that are affected by weather variability in the tropics to deliver SMS text messages to local farmers with reliable weather predictions.

Storms in tropical areas are characteristically smaller than in non-tropical regions with a quick onset, which makes general weather predictions insufficient for tropical areas. Global models in the tropics are correct only about 39 per cent of the time.[16] By developing a weather prediction system specifically designed to predict tropical weather patterns on a hyperlocal level, Ignitia is able to deliver forecasts to West African farmers in partnership with mobile network operators to truly help farmers anticipate weather.

Weather patterns in the region are becoming increasingly erratic and unpredictable, so farmers benefit greatly from having a tool to help them adapt their farming practices to anticipated weather. In the tropics within Africa, 96 per cent of the agriculture is rain-fed, meaning that weather prediction has a largely positive impact on their ability to farm productively. Most farmers in Africa have access to a phone and the SMS text format is designed to be inclusive to areas with low-literacy rates.

Farmers using the service only pay a few cents per day, less than two per cent of their annual input costs. Ignitia is partnering with larger agencies, such as UNDP, to provide free access to certain vulnerable communities.[17] The pilot test in Northern Nigeria with 2SCALE was successful and saw 1,400 farmers benefitting from the project. These farmers saw an improvement in their yield compared to the previous season, and 90 per cent reported they were satisfied or very satisfied with the Iska weather forecasts. Meanwhile 88 per cent reported that they used the weather forecasts to improve their farming practices leading to a yield increase.[18]

RURAL DEVELOPMENT

The programs with the most impact in building resilient communities and sustainable food systems, provide farmers with tools that reduce obstacles faced by local farming communities. Smallholder farmers supply food for 70 per cent of the developing world. Rising populations, low crop yields, inadequate infrastructure and lack of access to formal finance are just a few of the obstacles smallholder farmers face. By reducing these obstacles, local farms can increase their productivity while promoting sustainable agricultural practices.

In the interest of sustainable development and to help alleviate the obstacles faced, investment should focus on smallholder farmers. Many programs showcase the ability of private enterprise to play a positive role in building resilience as shown by the following four program examples.[19]

The Coffee Farmer Resilience Initiative (CFRI)

The CFRI's objective was to help farmer resilience. In this program, coffee companies supported smallholder farmers to address the spread of a disease that affects coffee crops by providing technical assistance on rehabilitation, renovation and climate-smart agricultural practices (e.g.,[20]. The CFRI was funded through the Coffee Farmer Resilience Fund, a financing mechanism.[21])

Impact Terra's Golden Paddy Digital Platform

This program facilitated access to the finance sector for smallholder farmers in Myanmar, where the lack of access to finance hampers smallholder productivity. Thanks to the access to mobile phones in these rural areas, digital service providers have the opportunity to cost-effectively connect small holders with local financial institutions and agricultural service providers. Nearly two-thirds of Myanmar's population work in the agricultural sector, and despite high poverty rates 70 per cent of smallholder farmers have mobile phone access.[22] This platform was designed to increase farmers' crop productivity by providing real-time, tailored agronomic advice, weather and pest alerts, better market connections and access to improved financial opportunities. This project focusses on financial inclusion, with an objective to deliver scalable farming advice and contribute to the financial inclusion of smallholder farmers.[23]

Large-scale data analytics and crop prediction models are just two of the tools used to assist in delivering tailored advice to rural customers and service providers. This program offers financial inclusion through both a free mobile application (the Golden Paddy App) and a free web application. The mobile application provides tailored agronomic support services to smallholder farmers; with the advice primarily aimed at helping farmers increase their productivity in line with Good Agricultural Practices (GAP). The web application offers business-to-business support to financial institutions, traders and agricultural enterprises.

Beekeeping and Big Cats: Supporting Conservation and Rural Development

Creating beehives in both Tanzania and China have proven to be a cost-effective and simple way to build food resilience, create an opportunity for rural development, provide income for community members, increase native crop production and preserve resources (like sustainable forests). In areas with poor economic conditions but access to natural resources, communities often contribute to logging, deforestation and unsustainable hunting practices. Around 90 per cent of the world's food supply comes from about 100 crop species, and 71 of those crops rely on bees for pollination.[24] Beekeeping is a source of goods like honey and raw materials for various industries like beeswax candles. It is also an important income generating activity, with high potential for improving incomes, especially for communities living close to forests and woodlands. Beekeeping improves biodiversity and increases crop production, causing native plant species to flourish.[25]

An initiative led by Tanzanian women beekeepers is aiding vital conservation, rural economic development, environmental sustainability and financial literacy by strategically planting beehives in trees. Under Tanzanian law, trees holding beehives cannot be cut down and by planting beehives in certain trees, critical rangelands are protected. This preserves resources and fosters the habitat for many endangered species like lions, leopards and cheetahs. The honeybees regenerate degraded pastures and are vital for the health of native plant species. The honey produced has generated a sustainable revenue stream for rural women, aiding in rural economic development.[26]

The initiative has placed more than 1,350 environmentally friendly beehives and hosted more than 50 million bees.[27] Currently, the Women's Beekeeping Initiative has helped to protect an estimated 439,847 acres of vital rangelands. This provides habitat for lions, leopards and cheetahs which are all classified as 'Vulnerable' on the IUCN Red List of Threatened Species. One of the biggest threats these big cats face is loss of rangeland habitat. As a result of this program, an increase of big cats has been observed in the Tarangire-Manyara ecosystem.[28]

Tanzania People & Wildlife bolsters the ecological benefits from this program, by layering beehives from the Women's Beekeeping Initiative with its human-wildlife conflict and sustainable rangeland initiatives.

In a similar project, the World Wildlife Fund (WWF) donated 400 beehives to community residents in the continental tiger range in Huangnihe National Nature Reserve and provided technical training on beekeeping. Investment in beekeeping supported the production of honey and raw materials, which aided in economic rural development. Just as the Tanzanian beekeeping initiative has provided safe sustainable habitats for endangered lions, cheetahs and leopards, this project provides sustainable forests for the endangered tiger population in China. The increase in crop production, ability to hunt sustainably and improved income showed the success of this program.

Development of Cooperatives & Small Businesses

A cooperative in Kangalumira was developed to upgrade its value-added processes and equipment. This assists the farmers to gain a higher income from their small-scale farms and has developed into a revolving fund approach. These funds are leveraged into other cooperatives to develop value-added products for their crops.

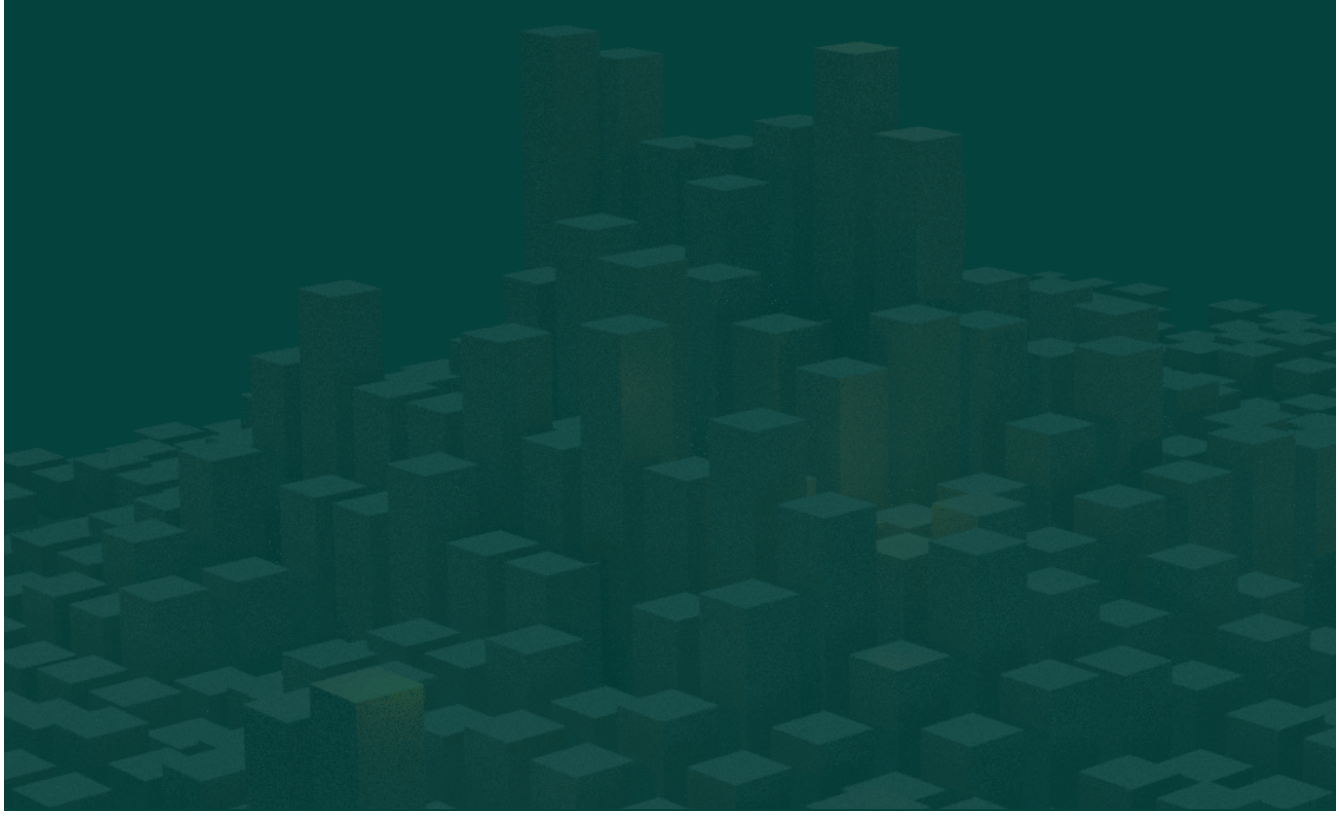
In Kangalumira, 28 farmer groups with a total of 3,250 farmers associated with the cooperative, were supported with training on pineapple growing and collective marketing. The cooperative was assisted with equipment, in the form of solar driers to produce pineapple chips and juice, as well as wine processing equipment. This equipment allowed the members to add value through the cooperative to the pineapples, that had until then been exclusively sold fresh.

The cooperative and its member farmers paid 10 per cent of the equipment cost upfront and paid back the remaining 90 per cent over three years at 2.5 per cent interest per month to a revolving fund established by CESA-Uganda.

The returned funding was then reinvested in a similar project in Nazigo, where a maize and rice mill and processing facility was established as a cooperative. This allowed 450 farmers and their families to realise higher profits from communally owned, value-addition facilities. They received training on the production and marketing of the produce, and were given ongoing management support and a loan towards the equipment. Farmers were obliged to pay back their loan into the revolving fund.

A TCF project in Buusana will install a tomato processing unit. This will include a cooler and the ability to produce juice, puree, paste, ketchup, sauce and canned whole products. The project will train 1,000 farmers in tomato processing (post-harvesting storage, grading and packing) and the construction of water-harvesting technologies. The farmers will repay the money into the revolving fund.

Appendices



APPENDIX A

The ETR Indicator Sources, Definitions & Scoring Criteria

The information below details the sources, definitions, and scoring criteria of the four indicators that form the Ecological Threat Report. All scores for each indicator are banded or normalised on a scale of 1-5, whereby qualitative indicators are banded into five groupings from very low to extremely high.
The overall score for any given ADMIN1 is the **maximum of any of the indicators in the ETR**. Likewise, a country score is assigned the **maximum of any given ADMIN1**.

Natural Disaster Displacement

Indicator type	Quantitative
Data Sources	The Geocoded Disasters (GDIS) Dataset Centre for Research on the Epidemiology of Disasters' Emergency Events Database (EM-DAT) Global Burden of Disease (GBD)
Measurement period	2000 - 2019

Definition: The aggregate of the number of disasters from 2000 to 2018 weighted by the mortality over the same period.
Calculation: The mortality of disasters is calculated using the average of the total deaths from EM-DAT and the GBD mortality from disasters from 2000 to 2018. This is then divided by the population to calculate the mortality for each country per 100,000 over the period. The rate is then normalised and scaled 0 to 1 where 0 is the lowest mortality from disasters and one is the highest mortality from disasters globally.

The country level mortality scale is multiplied by the total number of disasters at the ADMIN1 level to calculate the sub-national administration unit's weighted disaster variable.

The weighted disaster variable is then normalised on a scale of 1 to 5 to determine the overall weighted disaster score indicator.

Scoring Bands:

Indicators	1 (Extremely Low)	2 (Low)	3 (Medium)	4 (High)	5 (Extremely High)
Deaths and Displacements per 100,000	< 5	5-10	10-15	15-20	> 20

Rapid Population Growth

Indicator type	Quantitative
Data Sources	Gao, J. 2020. Global 1-km Downscaled Population Base Year and Projection Grids Based on the Shared Socioeconomic Pathways, Socioeconomic Data and Applications Center (SEDAC).
Measurement period	2020 and 2050
Additional note	Future projections based on IPCC fifth assessment report. The future projections used are the shared economic pathway 370. This is considered the middle of the range of baseline outcomes.

Definition: The percentage difference between the 2020 population and the 2050 population for each admin.

Calculation: The population data is available at a 1 kilometre grid spatial resolution level. The total population of each ADMIN1 is aggregated for both 2020 and 2050. The percentage difference between the future and current population is calculated as the population growth variable. A positive value indicates that the projected population is higher than the current population.

The population growth variable is then normalised on a scale of 1 to 5 to determine the overall population growth score indicator.

Scoring Bands:

Indicators	1 (Extremely Low)	2 (Low)	3 (Medium)	4 (High)	5 (Extremely High)
Population Growth	< 20%	20%–30%	30%–50%	50%–70%	> 70%

Food Risk

Indicator type	Quantitative
Data Sources	EIU Food Security Index, Gallup World Poll
Measurement period	2019–2021

Calculation: The responses to the Gallup World Poll Question "In the past 12 months have you not been able to buy food for you family" is used as the primary indicator. To impute country gaps, the EIU Food Security Index is used as a regressor in a linear model.

Scoring Bands:

Indicators	1 (Extremely Low)	2 (Low)	3 (Medium)	4 (High)	5 (Extremely High)
Food Security	< 20%	20%–40%	40%–50%	50%–65%	> 65%

Water Risk	
Indicator type	Quantitative
Data Sources	World Resources Institute (WRI)
Measurement period	Current Baseline Estimate
Additional note	Future projections based on IPCC fifth assessment report. The future projections used are the shared economic pathway 3 7.0. This is considered the middle of the range of baseline outcomes produced by energy system models. The model used is GFDL-ESM4 developed by the National Oceanic and Atmospheric Administration (NOAA).

Definition: Water Stress is defined by percentage of population without access to clean drinking water. IEP bands the WRI categories to a scale of 1 to 5.

Scoring Bands:

Indicators	1 (Extremely Low)	2 (Low)	3 (Medium)	4 (High)	5 (Extremely High)
Water Stress percentage of population without access to clean drinking water	< 2.5%	2.5%-5.0%	5%-10%	10%-20%	> 20%

APPENDIX B

ETR Rank, Domain and Indicator Scores

Country	Rank	Ecological Threat Overall Score	Food Security	Natural Disasters	Population Increase 2020-2050	Water Risk
Burundi	1	5	5	5	5	5
Central African Republic	1	5	5	5	5	5
Republic of the Congo	1	5	5	5	5	5
Kenya	1	5	5	5	5	5
Mozambique	1	5	5	5	5	5
Malawi	1	5	5	5	5	5
Niger	1	5	5	5	5	5
Somalia	1	5	5	5	5	5
South Sudan	1	5	5	5	5	5
Chad	1	5	5	5	5	5
Uganda	1	5	5	5	5	5
Yemen	1	5	5	5	5	5
Afghanistan	1	5	4	5	5	5
Benin	1	5	5	4	5	5
Cameroon	1	5	5	4	5	5
Democratic Republic of the Congo	1	5	5	4	5	5
Comoros	1	5	4	5	5	5
The Gambia	1	5	4	5	5	5
Guinea-Bissau	1	5	5	4	5	5
Namibia	1	5	5	5	4	5
Nigeria	1	5	5	4	5	5
Zimbabwe	1	5	5	4	5	5
Angola	1	5	5	3	5	5
Ethiopia	1	5	4	4	5	5
Guinea	1	5	5	3	5	5
Haiti	1	5	5	5	3	5
Iraq	1	5	3	5	5	5
Madagascar	1	5	5	3	5	5
Mauritania	1	5	4	4	5	5
Rwanda	1	5	5	3	5	5
Sudan	1	5	4	4	5	5
Senegal	1	5	4	4	5	5
Sierra Leone	1	5	5	4	4	5
São Tomé and Príncipe	1	5	5	3	5	5
Tanzania	1	5	4	4	5	5
Zambia	1	5	5	3	5	5
Burkina Faso	1	5	4	3	5	5
Botswana	1	5	4	5	3	5
Cote d'Ivoire	1	5	4	3	5	5
Cape Verde	1	5	5	4	3	5
Ecuador	1	5	4	5	3	5
Ghana	1	5	4	3	5	5
Guatemala	1	5	4	5	4	4
Cambodia	1	5	4	5	3	5
Laos	1	5	4	5	3	5

Country	Rank	Ecological Threat Overall Score	Food Security	Natural Disasters	Population Increase 2020-2050	Water Risk
Lesotho	1	5	5	4	3	5
Mali	1	5	4	3	5	5
Philippines	1	5	4	5	3	5
Solomon Islands	1	5	2	5	5	5
Syria	1	5	5	5	5	2
Togo	1	5	4	3	5	5
Tajikistan	1	5	4	3	5	5
Timor-Leste	1	5	2	5	5	5
Venezuela	1	5	5	4	3	5
Djibouti	1	5	3	5	3	5
Eritrea	1	5	5	1	5	5
Equatorial Guinea	1	5	5	1	5	5
Honduras	1	5	4	4	3	5
Liberia	1	5	5	1	5	5
Libya	1	5	3	5	5	3
Myanmar	1	5	4	5	2	5
Mayotte	1	5	5	1	5	5
Nepal	1	5	4	5	2	5
Pakistan	1	5	3	5	4	4
Peru	1	5	3	5	3	5
Papua New Guinea	1	5	2	5	4	5
Belize	1	5	2	5	4	4
Bolivia	1	5	3	4	3	5
Dominican Republic	1	5	3	5	2	5
Gabon	1	5	5	1	4	5
Morocco	1	5	3	4	3	5
Mongolia	1	5	2	5	3	5
Nicaragua	1	5	4	4	2	5
Eswatini	1	5	5	2	3	5
Vanuatu	1	5	2	5	4	4
Bhutan	1	5	2	5	3	4
Egypt	1	5	3	5	4	2
Indonesia	1	5	2	5	2	5
Sri Lanka	1	5	4	5	1	4
El Salvador	1	5	4	5	1	4
Turks and Caicos Islands	1	5	3	5	3	3
Vietnam	1	5	2	5	2	5
Antigua and Barbuda	1	5	3	5	2	3
Colombia	1	5	3	4	1	5
Cuba	1	5	3	5	1	4
Algeria	1	5	2	5	3	3
Federated States of Micronesia	1	5	2	5	3	3
French Guiana	1	5	3	2	5	3
Iran	1	5	3	5	1	4
Mauritius	1	5	3	4	1	5
New Caledonia	1	5	2	5	3	3
Panama	1	5	2	3	3	5
Palau	1	5	2	5	3	3
Suriname	1	5	2	5	1	5
Tonga	1	5	2	5	3	3
Tuvalu	1	5	2	5	3	3
South Africa	1	5	3	2	3	5
Anguilla	1	5	3	5	1	3

Country	Rank	Ecological Threat Overall Score	Food Security	Natural Disasters	Population Increase 2020-2050	Water Risk
The Bahamas	1	5	3	5	1	3
Brazil	1	5	2	4	1	5
Dominica	1	5	3	5	1	3
Western Sahara	1	5	5	1	4	2
Fiji	1	5	2	4	1	5
Georgia	1	5	2	5	1	4
Guyana	1	5	2	5	1	4
India	128	4	3	4	2	4
Kyrgyz Republic	128	4	2	4	3	4
Saint Lucia	1	5	3	5	1	3
Malaysia	128	4	2	4	3	4
Paraguay	128	4	3	4	2	4
Palestine	1	5	3	1	5	3
Réunion	1	5	5	1	1	5
Russia	1	5	2	5	1	4
Saint Helena	1	5	5	1	1	5
Seychelles	1	5	5	1	1	5
Thailand	1	5	2	5	1	4
Turkey	1	5	3	5	1	3
Saint Vincent and the Grenadines	1	5	3	5	1	3
British Virgin Islands	1	5	3	5	1	3
Samoa	1	5	2	5	2	3
Bangladesh	128	4	4	4	2	2
Kazakhstan	128	4	2	4	2	4
Moldova	1	5	2	3	1	5
Northern Mariana Islands	1	5	2	5	1	3
Puerto Rico	1	5	2	5	1	3
Romania	1	5	2	5	1	3
Tokelau	1	5	2	1	5	3
Uruguay	1	5	2	5	1	3
Argentina	128	4	2	4	2	3
Australia	128	4	1	4	3	3
Barbados	128	4	3	4	1	3
Costa Rica	128	4	2	4	1	4
Jamaica	128	4	3	3	1	4
Jordan	167	3	3	3	3	3
Saint Kitts and Nevis	128	4	3	4	1	3
Mexico	128	4	2	4	2	3
North Macedonia	1	5	2	5	1	2
French Polynesia	128	4	2	4	2	3
Trinidad and Tobago	128	4	3	3	1	4
Tunisia	128	4	2	4	2	3
U.S. Virgin Islands	128	4	3	4	1	3
Albania	128	4	2	4	1	3
Azerbaijan	1	5	2	1	1	5
China	128	4	1	4	2	3
Israel	128	4	1	3	4	2
New Zealand	128	4	1	4	2	3
Oman	128	4	2	4	3	1
Saudi Arabia	167	3	2	3	3	3
Ukraine	128	4	2	4	1	3
United States of America	128	4	1	4	2	3
Uzbekistan	167	3	3	2	3	3

Country	Rank	Ecological Threat Overall Score	Food Security	Natural Disasters	Population Increase 2020-2050	Water Risk
United Arab Emirates	167	3	2	2	3	3
Armenia	128	4	2	2	1	4
Brunei	128	4	2	1	2	4
Canada	128	4	1	4	2	2
Chile	128	4	1	4	1	3
Croatia	1	5	1	5	1	1
Japan	1	5	1	5	1	1
Lebanon	128	4	3	4	1	1
North Korea	128	4	4	4	1	2
Slovenia	1	5	1	5	1	1
Bulgaria	128	4	2	4	1	1
Bahrain	167	3	2	1	3	3
Saint Barthélemy	167	3	3	1	2	3
Cayman Islands	167	3	3	1	2	3
Guadeloupe	167	3	3	2	1	3
Greece	128	4	1	4	1	2
South Korea	128	4	2	4	1	1
Norway	128	4	1	4	2	1
Serbia	128	4	2	4	1	1
Taiwan	167	3	2	3	1	3
Caribbean Netherlands	167	3	3	1	1	3
Bermuda	167	3	3	1	1	3
Switzerland	128	4	1	4	1	1
Grenada	167	3	3	1	1	3
Kuwait	167	3	2	1	3	2
Lithuania	128	4	1	1	1	4
Luxembourg	167	3	1	3	3	1
Marshall Islands	167	3	2	1	2	3
Montserrat	167	3	3	1	1	3
Martinique	167	3	3	1	1	3
Poland	167	3	1	3	1	3
Portugal	128	4	1	4	1	1
Sweden	128	4	1	4	1	1
American Samoa	167	3	2	1	1	3
French Southern Territories	167	3	2	1	1	3
Cook Islands	167	3	2	1	1	3
Czech Republic	167	3	1	3	1	2
Guam	167	3	2	1	1	3
Ireland	167	3	1	3	2	1
Nauru	167	3	2	1	1	3
Qatar	167	3	2	1	3	1
Turkmenistan	167	3	1	1	3	2
United States Minor Outlying Islands	167	3	2	1	1	3
Wallis and Futuna	167	3	2	1	1	3
Austria	167	3	1	3	1	1
Spain	167	3	1	3	1	1
Italy	167	3	1	3	1	1
Slovakia	199	2	2	2	1	2
Bosnia and Herzegovina	199	2	2	2	1	1
Belarus	199	2	2	1	1	2
Estonia	199	2	1	2	1	2
Latvia	199	2	1	2	1	2
Montenegro	199	2	2	2	1	1

Country	Rank	Ecological Threat Overall Score	Food Security	Natural Disasters	Population Increase 2020-2050	Water Risk
Åland Islands	199	2	2	1	1	1
Andorra	199	2	2	1	1	1
Belgium	199	2	1	2	1	1
Cyprus	199	2	1	2	1	1
Germany	199	2	1	2	1	1
Finland	199	2	1	1	1	2
France	199	2	1	2	1	1
Faroe Islands	199	2	2	1	1	1
Guernsey	199	2	2	1	1	1
Greenland	199	2	2	1	1	1
Hungary	199	2	1	2	1	1
Isle of Man	199	2	2	1	1	1
Jersey	199	2	2	1	1	1
Liechtenstein	199	2	2	1	1	1
Netherlands	199	2	1	2	1	1
Svalbard & Jan Mayen	199	2	2	1	1	1
San Marino	199	2	2	1	1	1
St. Pierre & Miquelon	199	2	1	1	1	2
Kosovo	199	2	2	1	1	1
Denmark	224	1	1	1	1	1
United Kingdom	224	1	1	1	1	1
Iceland	224	1	1	1	1	1
Malta	224	1	1	1	1	1
Singapore	224	1	1	1	1	1

Source: IEP

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SECTION 2: ECOLOGICAL THREATS

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