Analysing ecological threats, resilience & peace

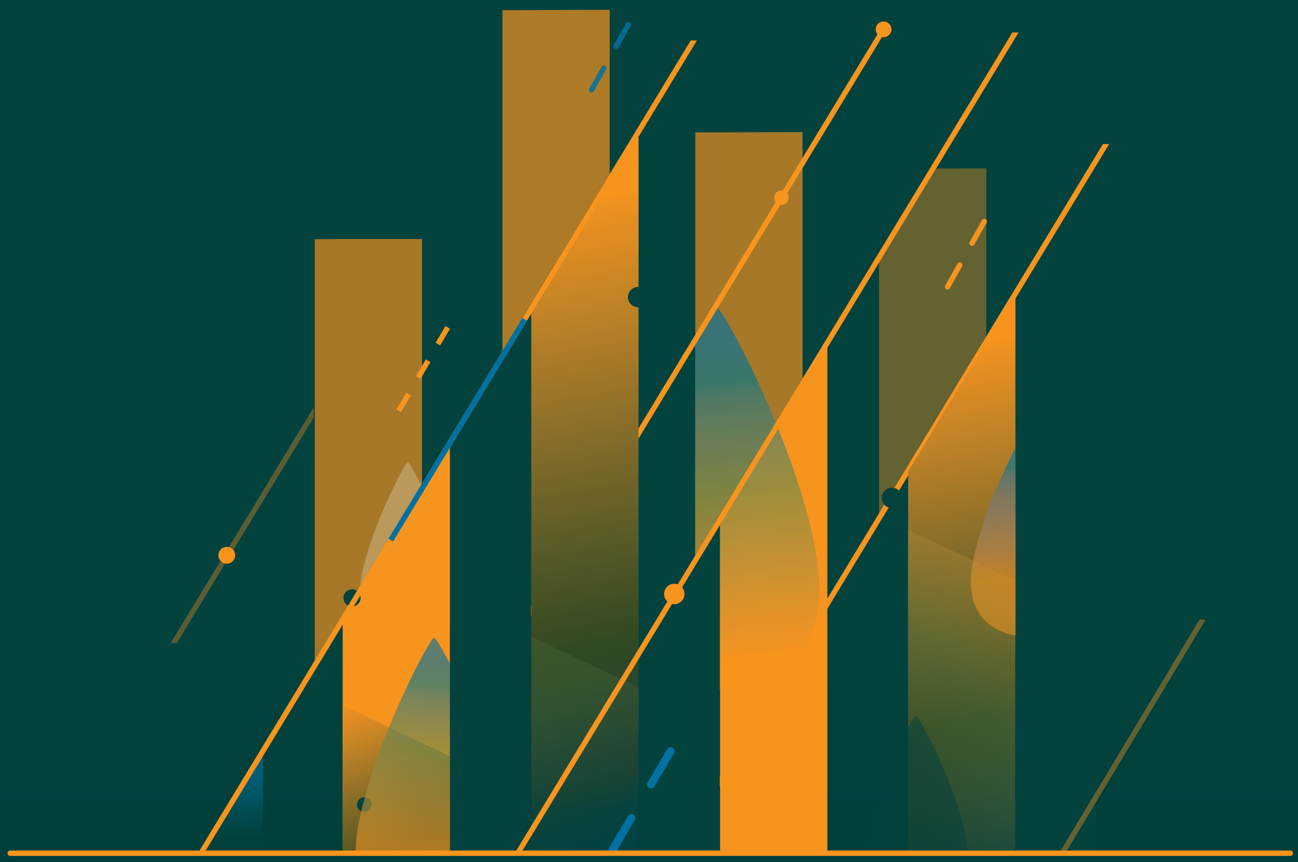
Ecological Threat Report 2024

Global Results

Water Risk

Non-State Conflict

Food Security



IEP Institute for Economics & Peace

IEP

Quantifying Peace and its Benefits

The Institute for Economics & Peace (IEP) is an independent, non-partisan, non-profit think tank dedicated to shifting the world's focus to peace as a positive, achievable, and tangible measure of human well-being and progress.

IEP achieves its goals by developing new conceptual frameworks to define peacefulness; providing metrics for measuring peace; and uncovering the relationships between business, peace and prosperity as well as promoting a better understanding of the cultural, economic and political factors that create peace.

IEP is headquartered in Sydney, with offices in New York, Brussels, The Hague, Mexico City and Nairobi. It works with a wide range of partners internationally and collaborates with intergovernmental organizations on measuring and communicating the economic value of peace.

For more information visit www.economicsandpeace.org

Please cite this report as:
Institute for Economics & Peace. Ecological Threat Report 2024: Analysing ecological threats, resilience & peace, Sydney, October 2024. Available from: http://visionofhumanity.org/resources (accessed Date Month Year).

Contents

EXECUTIVE SUMMARY

Ecological threats, including climate change, food insecurity, and water scarcity, are increasingly recognised as significant factors that affect the dynamics of armed conflict. This fifth annual edition of the Ecological Threat Report (ETR) surveys current ecological risk levels. It takes an in-depth look at the impact of water scarcity and analyses the potential of improving water capture to mitigate multiple ecological threats in some of the world's worst-affected areas.

The report finds that countries with higher levels of ecological threat are more likely to have higher levels of conflict, and lower levels of societal safety and security. Without concerted international action, ecological degradation will continue to accelerate, intensifying a range of social issues, including malnutrition and forced migration. When combined with further stressors, such as demographic pressure and poor governance, the likely result will be an increase in conflict. However, with appropriate action, involving micro water capture, enhanced agricultural yields and better local governance, the effects can be substantially mitigated.

The ETR covers 207 countries and territories, of which 50 face high or very high levels of ecological threat. IEP estimates almost two billion people will live in these countries by 2050. At present, they are home to just under 1.3 billion, and seven in ten of these people reside in countries with low levels of societal resilience, highlighting that whole-of-system approaches are needed to rectify the deteriorating situation. The resilience of many of these at-risk communities is already being tested: global food prices remain almost 25 per cent higher than pre-pandemic levels.

Sub-Saharan Africa faces the most acute ecological threats of any region. This is driven by its high levels of food insecurity, related issues of water stress, large increases in population, and poor governance. Moreover, although many countries around the world have stable or shrinking populations, sub-Saharan Africa's population is projected to increase by more than 70 per cent by 2050, placing further pressure on already strained food and water supplies.

One of the key findings of this year's report is that, through improvements in water capture for food production, an economically viable model can be developed that shows attractive returns on investment. This has the potential to reduce hunger and poverty and substantially boost economic activity in sub-Saharan Africa. For sub-Saharan Africa to meet its basic food needs by 2050, it will need to more than double its production of cereals, which represent the foundation of the region's diet.

Ecological threats are strongly correlated with peacefulness. If multiple ecological threats related to food insecurity, water risk and demographic pressure occur simultaneously, they can converge and amplify each other, causing a multiplier effect. Improvements in water and food security will also improve a range of other factors, including health, development, and societal resilience. Combined with improvements in local governance, the likelihood of future conflict can be substantially lessened.

IEP uses a multi-dimensional analysis of food insecurity, the impact of natural events, demographic pressure, and water risk, broken down into 3,518 sub-national areas covering 99.9 per cent of the global population, to derive a score for ecological threat levels.

The analysis identifies 27 ecological "hotspots", which are countries facing high ecological risks that intersect with low societal resilience. Seventeen of these countries are in sub-Saharan Africa, six are in the Middle East and North Africa, and just four are in all other regions.

Although much of this report focuses on sub-Saharan Africa, the lessons are applicable to other regions. Climate change is going to stress water resources in the glacier-fed ecosystems of South Asia and South America, rising sea levels are going to increase salinity in some of the world's most fertile agricultural regions, particularly in Southeast Asia, and more extreme weather in China and India will make it harder to feed the 2.8 billion people who live there.

Water availability can also affect international relations, as in the case of rivers that flow through multiple countries, giving upstream areas greater control over the resource. For example, the damming of the Nile in northeastern Africa and the Mekong River in Southeast Asia have severely affected the livelihoods of tens of millions of people in downstream communities.

Sub-Saharan Africa has both unused arable land and large and under-utilised water resources. The World Bank says that sub-Saharan Africa has 200 million hectares of unused land suitable for agriculture. Moreover, there are nearly 35 million hectares of cropland with untapped irrigation potential.

Expanding farmland comes with significant social and ecological trade-offs. However, by focusing on improving productivity on existing agricultural land, substantial gains can be made in the volume of food produced across the region.

Africa can substantially increase its food production. Global annual yield for rainfed maize averages about 5.4 tonnes per hectare. In sub-Saharan African countries, it averages about 1.9 tonnes per hectare. Moreover, with the application of irrigation, appropriate and carefully managed fertilisers, and best farming practices, the assessed potential for maize yields across the region is about 14 tonnes per hectare, a difference of more than 600 per cent.

IEP estimates that an investment of US$15 billion annually to 2050 in irrigation systems, improved farming practices and inputs, and expanded grain storage infrastructure could help the region raise its cereal production by more than 50 per cent. This type of investment in water capture and distribution would produce on average nearly a threefold annualised increase in yield, with initial investment costs being recouped within four to seven years.

Water risk is not strongly correlated with the overall availability of water resources. The greatest obstacle to increased water utilisation for agriculture in sub-Saharan Africa is the lack of infrastructure to effectively capture and distribute water, particularly during dry seasons. Currently, only two per cent of the region's renewable water resources are used in agriculture, less than one third of the global rate of 6.7 per cent and substantially less than the 47.7 per cent used in the Middle East and North Africa.

Water risk is more closely correlated to weak governance and poor infrastructure than low rainfall. Countries with strong institutions and infrastructure, such as the United Arab Emirates, manage to mitigate water risks despite having limited natural water resources. In contrast, countries like Yemen, with more abundant water resources but weaker governance, face severe water risks.

In relation to armed conflict, the combination of ecological threats and weak governance is deadly. The Sahel – the transition zone between the Sahara Desert and the rest of Africa – accounts for 6.8 per cent of the total population of Africa, but just under 16 per cent of total conflict deaths.

Shocks to food systems, whether due to ecological or natural disasters, political instability, or economic disruptions, can lead to increased civil unrest, forced migration, and a higher likelihood of conflict. These cascading effects highlight the importance of addressing the root causes of food insecurity through comprehensive, multi-faceted approaches that consider the broader ecological and socio-political context.

This report finds that, while climate change and environmental pressures are not direct causes of violence, they act as "threat amplifiers" that can intensify ongoing conflicts, particularly in transition zones like the Sahel Regions with historical ethnic borders have a 27 per cent higher probability of conflict compared to non-border areas, highlighting the significance of ethnic divisions in conflict dynamics.

The Sahel region has seen a rise in agro-pastoralist conflicts, affecting over 50 million people who rely on livestock for their livelihoods. In such areas, existing tensions can sometimes be exploited by other actors, such as transnational jihadist groups. These groups have increasingly co-opted local grievances, particularly those of nomadic pastoralist populations, to mobilise fighters and escalate conflicts.

> Water risk is more closely correlated to weak governance and poor infrastructure than low rainfall

However, the majority of interactions between farmers and herders remain peaceful. The effectiveness of conflict prevention in agro-pastoralist communities is strongly linked to the strength of local governance structures, with community-based approaches proving to be effective. Respecting and working with the local power structures and social norms can be leveraged for stronger community engagement and more effective outcomes.

Identifying and addressing low-level conflicts before they escalate can prevent them from becoming larger, and more intractable, particularly in regions with high ecological threats and historical grievances. More international attention is needed for conflict resolution and peacebuilding. In the 2010s, only four per cent of conflicts finished with a peace agreement, compared to 24 per cent in the 1970s.

Looking ahead, climate change is expected to act as a threat multiplier, exacerbating existing ecological pressures and potentially leading to increased competition and tension over scarce resources. The report emphasises the importance of resilience-building measures to mitigate the impacts of these threats. Without significant intervention, the compounding effects of population growth, environmental degradation, and weak governance could lead to a cycle of increasing instability, particularly in regions already prone to conflict.

KEY FINDINGS

Section 1: Results

- Of the 207 countries and territories in the Ecological Threat Report (ETR), 50 face high or very high levels of ecological threat. Just under 1.3 billion people live in these 50 countries, a number which is expected to grow to almost two billion by 2050.
- There are 62 countries which face a very high threat for at least one of the four ETR indicators.
- There are 27 countries that are ecological threat “hotspots”, meaning that they have very high levels of ecological threat combined with low levels of societal resilience, as measured by the Positive Peace Index (PPI). These countries are especially at risk from ecological-related shocks.
- Only four of the 27 hotspot countries are outside the sub-Saharan Africa and the Middle East and North Africa regions.
- Ecological threat is strongly correlated with peacefulness, as measured by the Global Peace Index (GPI). Countries with higher levels of ecological threat are more likely to have higher levels of conflict, and lower levels of societal safety and security.
- The number of people facing food insecurity, defined as insufficient or uncertain daily food consumption, may reach 1.7 billion by 2050. Global food prices remain almost 25 per cent higher than their pre-pandemic levels.
- Water risk is not strongly correlated with water resources. Many countries have high levels of water resources per capita but lack the resilience and strong institutions to provide adequate clean water for their civilians.
- The impact of natural events is felt throughout the world. There are areas in almost every global region that face high or very high levels of risk from natural events. This impact is likely to increase as the effects of climate change become more prominent.
- By 2050, sub-Saharan Africa's population is predicted to rise to 2.1 billion, an increase of over 70 per cent, which will dramatically increase pressure on existing food and water supplies.

Section 2: Non-State Conflict and Ecological Threats

- Climate change alone does not directly cause violent conflict; it acts as a threat amplifier, exacerbating existing tensions in areas with a history of conflict, weak institutions, and low resilience.
- In sub-Saharan Africa, regions with high water stress are more likely to experience communal violence, particularly in areas where local institutions are weak and public trust is low.
- Regions with historical ethnic borders have a 27 per cent higher probability of conflict compared to non-border areas, highlighting the significance of ethnic divisions in conflict dynamics.
- Ecological threats often exacerbate tensions in regions with significant ethnic diversity, particularly where these groups have historically contested access to natural resources such as water and arable land.
- The Sahel region has seen a rise in agro-pastoralist conflicts, driven by climate variability, adverse government policies, rapid population growth, and disruption of traditional mobility routes, affecting over 50 million people who rely on livestock for their livelihoods.
- Despite the prevalence of agro-pastoralist conflicts, most interactions between farmers and herders remain peaceful, with cooperation over shared resources being the norm rather than the exception.
- The effectiveness of conflict prevention in agro-pastoralist communities is strongly linked to the strength of local governance structures, with community-based approaches proving more successful than external interventions.
- Empowering existing community systems and traditional conflict resolution methods has been identified as the most effective way to reduce conflict in agro-pastoral regions, particularly in response to climate-induced stressors.
- Low-level conflicts, particularly those involving non-state actors, can be instrumentalised by national or transnational actors, leading to broader and more intense violence, as seen in the Central Sahel region.
- In areas like the Sahel, transnational jihadist groups have co-opted local grievances, particularly those of nomadic pastoralist populations, to mobilise fighters and escalate conflicts.
- Identifying and addressing low-level conflicts before they escalate can prevent them from becoming larger, more intractable issues, particularly in regions with high ecological threats and historical grievances.
- Regions with a history of conflict that are currently facing high ecological threats, particularly in the domains of water stress and food security, may be at an elevated risk of conflict recurrence.
- In countries like Sierra Leone and Liberia, where conflicts have been inactive for decades, the combination of high level of ecological threat and historical conflict could signal a need for renewed focus on ecological resilience and conflict resolution.

Section 3: Towards Food Security in Sub-Saharan Africa

- Two out of every three people in sub-Saharan Africa are food insecure, and the population of the region is expected to nearly double by 2050, significantly increasing the pressure on food systems.
- By 2050, 58 per cent of sub-Saharan Africa's population will live in urban areas, up from 44 per cent today.
- To meet its basic food needs by 2050, sub-Saharan Africa will need to more than double its production of cereals, which represent the foundation of the region's diet.
- Regional improvements in agricultural output relative to inputs, as measured by the total factor productivity (TFP), have lagged efficiency gains in other parts of the world. While global agricultural TFP has increased by about 84 per cent since the 1960s, in sub-Saharan Africa it has only increased by about 27 per cent.
- Sub-Saharan Africa faces agricultural productivity challenges and large yield gaps. The region's average cereal yield is 1.7 tonnes per hectare, less than half the global average of 3.8 tonnes per hectare.
- The region's yield gaps are in part a result of lack of irrigation. Sub-Saharan Africa has the lowest irrigation rates in the world, with only 1.8 per cent of cultivated land being irrigated.
- Despite the severe stresses on water access in sub-Saharan Africa, the region has large and relatively untapped water resources. The region could irrigate all its lands with irrigation potential using less than six per cent of its renewable water resources.
- Advances in irrigation technology will make water use in agriculture more efficient, in contrast to many current practices which can result in substantial water wastage. In low- and middle-income countries, the amount of irrigated land is expected to increase by 34 per cent by 2030, but total agricultural water usage is expected to increase by only 14 per cent.
- According to FAO data, sub-Saharan Africa has about 34.2 million hectares of land with untapped irrigation potential, meaning it has substantially underutilised productive capacity. IEP estimates that providing adequate water to fully utilise these lands would cost about US$9.2 billion per annum and result in average yield increases of about 80 per cent, which would have a total annual value of at least US$12.3 billion.
- Innovative water capture projects at the local level will be critical to expanding irrigation in Africa's arid and semi-arid regions that currently have little to no irrigation potential.
- This report outlines how a water-driven, integrated yield-boosting project of this kind would cost around US$99,000 over 25 years and would generate an additional 24.5 tonnes of cereals per year on the surrounding croplands. Against a median cereal price of about US$450 per tonne across the region, this would result in around US$276,000 in added revenue for farmers over 25 years.
- Sub-Saharan Africa has the lowest chemical fertiliser usage globally, applying less than one-sixth of the global median of nitrogen fertiliser per hectare.
- While overuse of chemical fertilisers can pose serious risks to soil fertility, there is a strong correlation between increased fertiliser use and higher cereal yields. Globally, every 10 additional kilograms of nitrogen fertiliser per hectare corresponds with a yield increase of approximately 0.3 tonnes.
- IEP estimates that annual investments totalling about US$15 billion by 2050 in irrigation systems, new water capture projects, increased use of fertilisers, and expanded grain storage infrastructure could help the region increase its cereal production by more than 50 per cent.

50

Of the 207 countries and territories in the ETR, 50 face high or very high levels of ecological threat. Just under 1.3 billion people live in these 50 countries, a number which is expected to grow to almost two billion by 2050.

62

There are 62 countries which face a very high threat for at least one of the four ETR indicators.

27

There are 27 countries that are ecological threat “hotspots”, meaning that they have very high levels of ecological threat combined with low levels of societal resilience, as measured by the Positive Peace Index (PPI). These countries are especially at risk from ecological-related shocks.

1.7 billion

The number of people facing food insecurity, defined as insufficient or uncertain daily food consumption, may reach 1.7 billion by 2050.

The impact of natural events is felt throughout the world. There are areas in almost every global region that face high or very high levels of risk from natural events. This impact is likely to increase as the effects of climate change become more prominent.

+70%

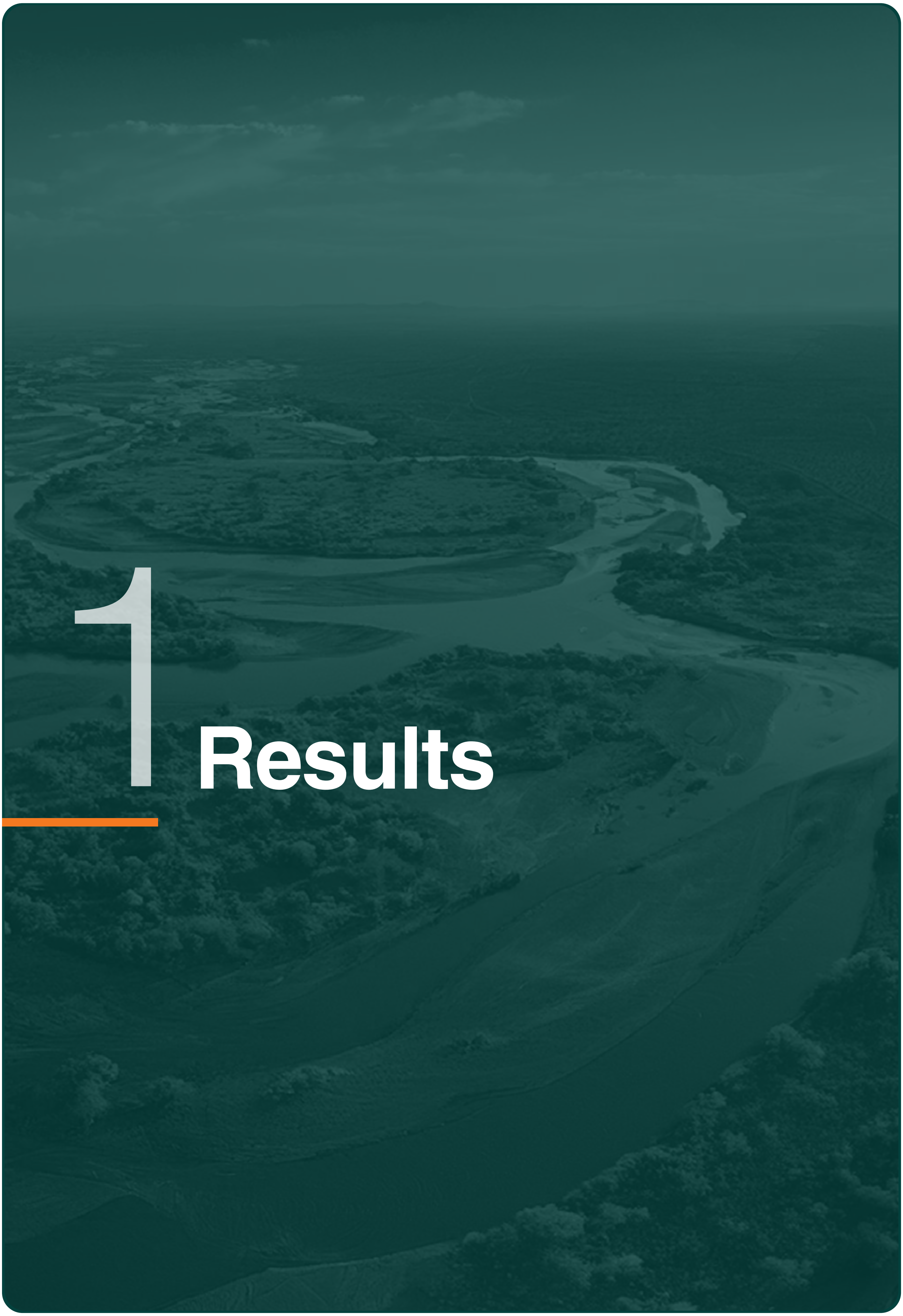
By 2050, sub-Saharan Africa's population is predicted to rise to 2.1 billion, an increase of over 70 per cent, which will dramatically increase pressure on existing food and water supplies.

Water risk is not strongly correlated with water resources. Many countries have high levels of water resources per capita but lack the resilience and strong institutions to provide adequate clean water for their civilians.

Ecological threat is strongly correlated with peacefulness, as measured by the Global Peace Index (GPI). Countries with higher levels of ecological threat are more likely to have higher levels of conflict, and lower levels of societal safety and security.

2.1 billion

By 2050, sub-Saharan Africa’s population is predicted to rise to 2.1 billion, an increase of over 70 per cent, which will dramatically increase pressure on existing food and water supplies.



1 Results

Overview

The Ecological Threat Report (ETR) is a comprehensive, data-driven analysis covering 3,518 subnational areas across 207 countries and territories. It covers 99.9 per cent of the world's population and assesses threats relating to food insecurity, water risk, demographic pressure, and hazardous natural events.

This report identifies countries that have the highest risk, both now and in the future, of suffering from major disasters due to the ecological threats they face, lack of societal resilience, and other factors. These countries are also the most likely to suffer from conflict.

The 2024 ETR aims to provide an impartial, data-driven foundation for the debate about ecological threats facing countries and subnational areas and to inform the design of resilience-building policies and contingency plans.

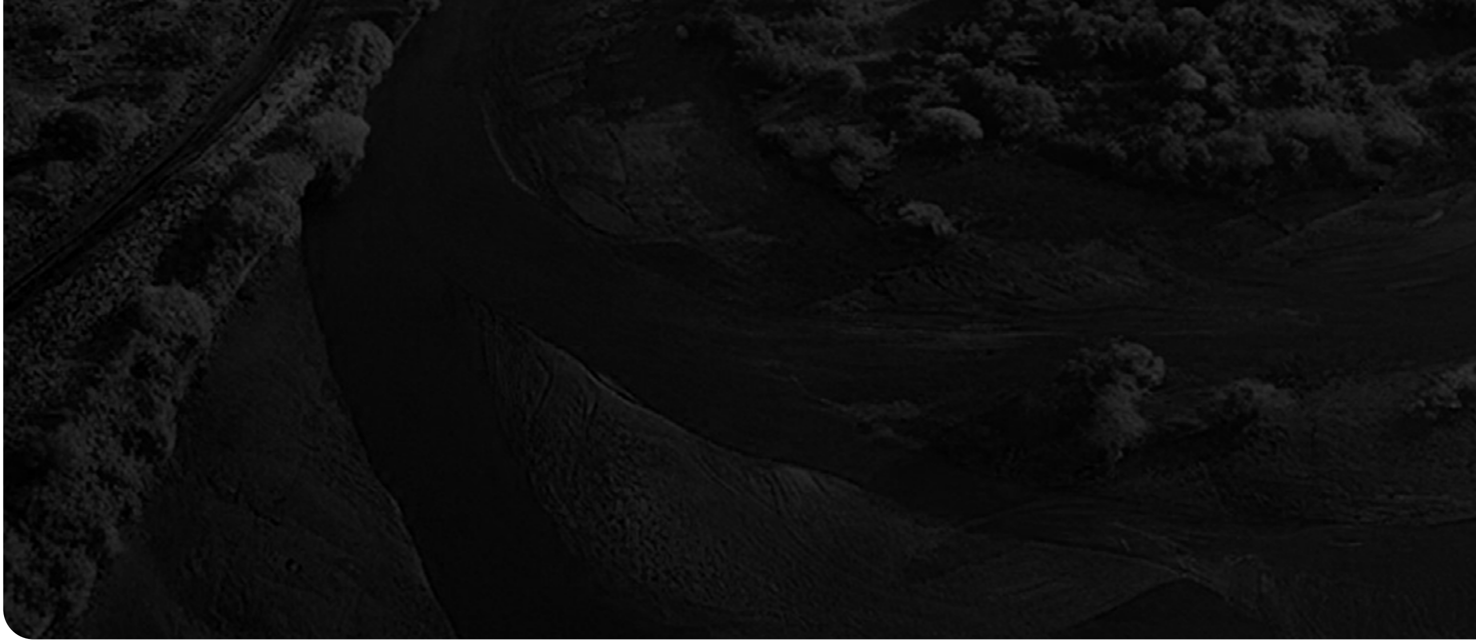
The global population is projected to reach 9.7 billion by 2050, an approximate 20 per cent increase over the current population. This growth will place added pressure on the planet's finite resources, and the balance between human activity and the ecology will come under increasing stress. As many as 1.9 billion people currently live in areas with limited access to clean drinking water, which is projected to rise to 2.9 billion by 2050. In many places, water shortages, food insecurity, and the impact of natural disasters are likely to substantially increase.

However, the expansion of human populations will not occur at equal rates in all places, with most of the world's regions and countries experiencing slowing rates of growth and some even set to experience population declines. This reality presents both challenges and opportunities, as the places experiencing the most ecological stress are often the ones projected to undergo the most significant population growth. In contrast, regions with slower population growth are likely to face shortfalls in their working-age populations in the coming decades, which can lead to economic stagnation, increased burdens on social support systems, and a reduced ability to sustain economic growth and innovation. It is therefore possible, for example, that international migration could help alleviate rising ecological pressures in areas with high population growth, while helping address labour shortage issues in areas with lower population growth.[1]

While refinements in the methodology of the ETR make it difficult to compare scores in editions of the report from previous years, some similarities and patterns persist from year to year. Many of the same countries continue to face severe ecological threats as in previous years. Across editions, sub-Saharan Africa and South Asia have consistently been the regions with the highest average ETR scores.

The world is facing many instances of instability related to ecological threats. In 2023, hazardous natural events resulted in 32.6 million people being displaced across 151 countries.[2]

Rapid population growth and food insecurity in regions such as sub-Saharan Africa and parts of the Middle East and North Africa have been stressors of socio-political instability for the past 50 years or more. For example, water scarcity and rapidly growing populations in the Lake Chad region



are exacerbating pre-existing political and social instabilities, in turn increasing stress on already scarce resources.[3] Similarly, clashes between Iran and Afghanistan regarding water distribution in the Helmand River and Hamun Lake escalated to conflict along the border in 2023.[4]

The Sahel region faces 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. Seven of the ten countries within the Sahel are classified as "hotspots", meaning they have low levels of resilience and face at least one severe ecological threat: Cameroon, Chad, Guinea, Mali, Mauritania, Niger, and Nigeria. Many of these areas are already experiencing armed conflict.

Looking forward, climate change will likely act as a threat multiplier, potentially exacerbating competition and tensions among groups and countries with inadequate resources and low resilience. The latest report from the Intergovernmental Panel on Climate Change projects more extreme fires and floods, and longer droughts.[5] These ecological disasters lead to mass displacement as individuals search for basic security.[6]

With the global population continuing to increase, rising consumption expands humanity's ecological footprint. As a result, the effects of ecological catastrophes are set to become more pronounced. While mitigation strategies are available, they require substantial funding increases in order to prevent irreversible damage.[7] These ecological factors will interact, compounding the pressures on many countries. These challenges will have an adverse effect on existing social and political structures.

Increasingly, the impacts of ecological shocks extend well beyond national and even continental boundaries. In places ranging from the Horn of Africa to North America, natural events such as droughts and wildfires have recently affected large portions of entire national communities and displaced millions of people.[8]

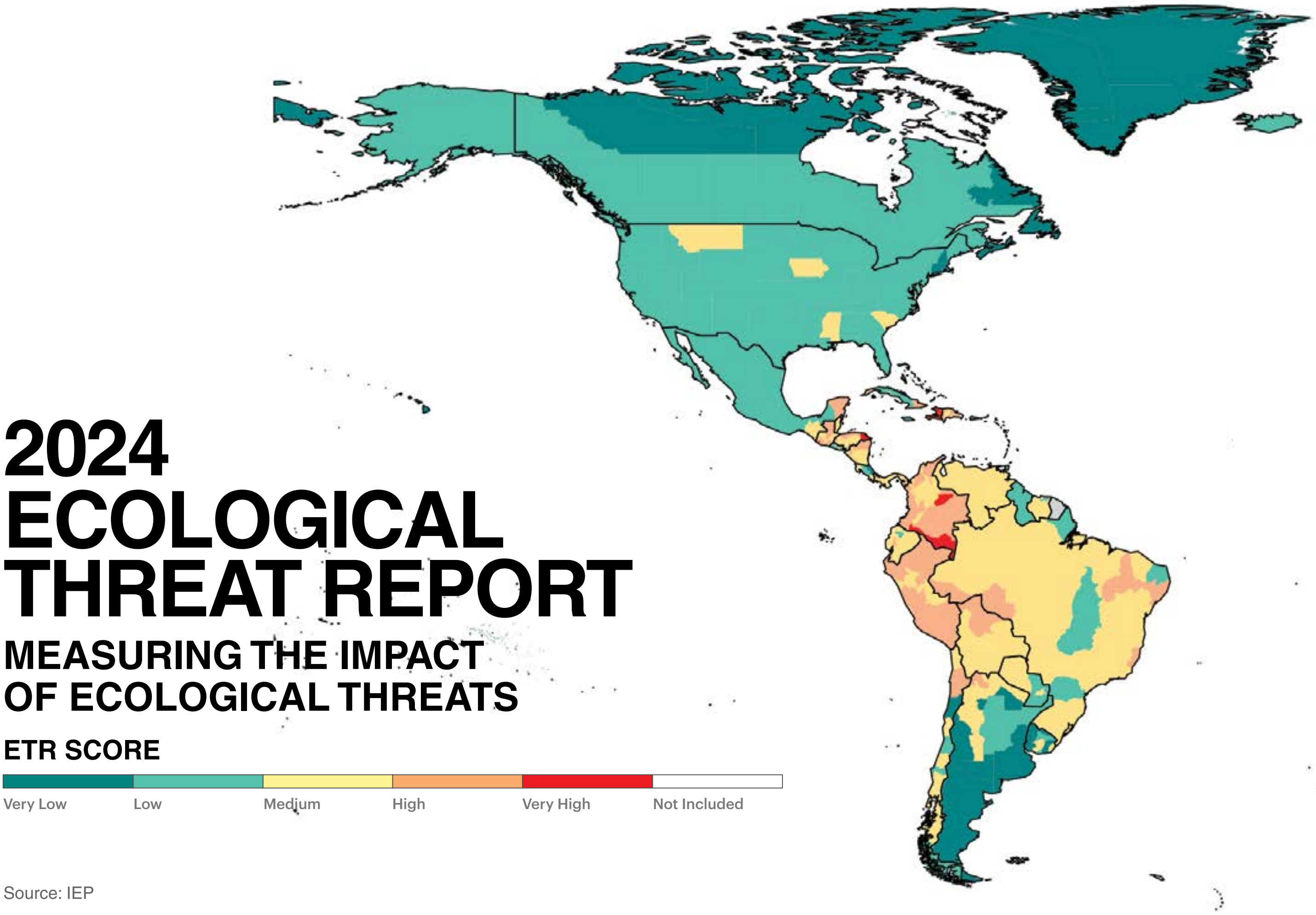
Despite this stark picture, the ecological threats the world is facing can be mitigated through focused international collaboration between governments, international organisations, businesses, and civil society. Innovations in technology and improved resource management practices, supported by strategic investments, offer substantial opportunities for progress. For example, as highlighted in the third section of the report, there is considerable potential for improvements in water management, which can lead to increased food security and economic development, especially in predominantly agricultural economies. Effective water capture techniques and continued efficiency gains in agricultural water usage can help alleviate ecological stresses directly and indirectly related to water, supporting both sustainable agriculture and economic resilience. By harnessing the collective efforts of diverse stakeholders and focusing on scalable and context-specific solutions, the global community can turn ecological challenges into opportunities for sustainable development.

Methodology and Results

FIGURE 1.1

Subnational Ecological Threat Report scores, 2024

Sub-Saharan Africa has the highest average level of ecological threat.

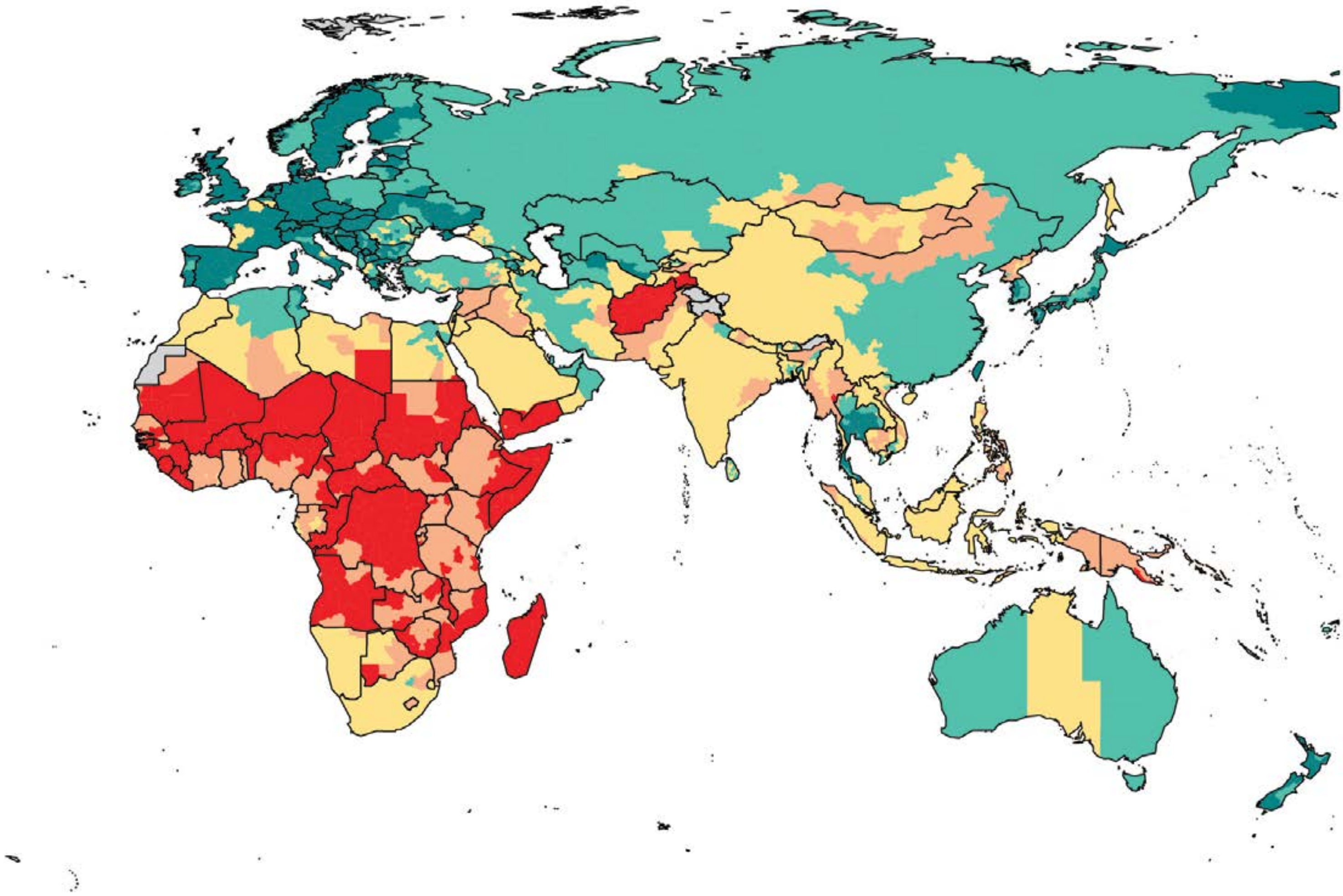


Source: IEP

The ETR focuses on four categories of threat that are directly related to drivers of conflict. These threats are classified by severity from very low to very high. A country is defined as facing a very high threat if it exceeds one or more of the following thresholds:

- **Food Insecurity:** More than 42 per cent of the population have insufficient food consumption
- **Impact of Natural Events:** More than 100 people killed or displaced by natural events on average every year for the past 20 years
- **Demographic Pressure:** More than a 40 per cent increase in population by 2050
- **Water Risk:** More than 20 per cent of the population do not have access to clean drinking water

The ETR is calculated at the sub-national administrative level of a country, according to its relative threat level on four domains. A subnational score is calculated as the weighted average it faces across all four threats.



BOX 1.1

Methodology at a glance

The ecological threats included in the Ecological Threat Report (ETR) are water risk, food insecurity, demographic pressure, and the impact of natural events. These indicators are calculated first at the subnational level and then at the national level.

The calculation of subnational scores involves two steps. In the first step, all indicators are normalised on a 1-5 scale, with a higher score representing a higher threat level. In the second step, the overall ETR score is calculated by taking the mean of the indicator scores and then adding the variance (as measured by the standard deviation) across the four scores.

This means that a subnational area with scores of 5, 5, 1 and 1 across the four indicators would have a higher overall score than an area with scores of 3,3,3 and 3. This weighting is applied to capture the disproportionate impact of severe ecological threats.

At the national level, a country's four indicator scores and its overall score are the population-weighted averages of the scores across its subnational areas.

Figure 1.1 highlights the severity of ecological threats faced by 3,518 subnational areas, with areas in red having an overall ETR score higher than 4.2 out of 5, indicating a very high level of ecological threat. It shows that the most vulnerable countries are clustered in certain geographical regions: sub-Saharan Africa, the Middle East and North Africa, and South Asia. These regions are also the least peaceful, as measured by the Global Peace Index (GPI). For a list of the 207 countries covered in the report please refer to Appendix B.

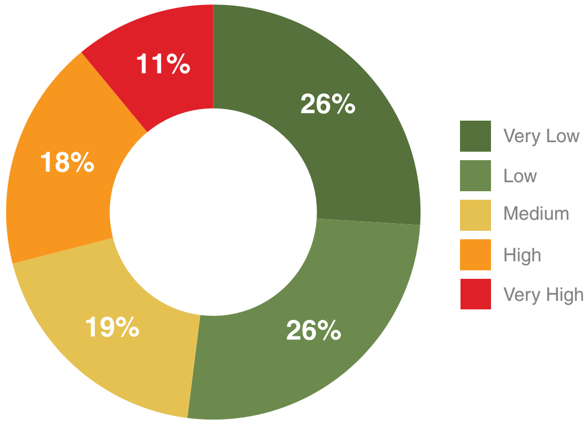
Figure 1.2 displays the distribution of subnational areas by the severity of the ecological threat they face. Of the 3,518 subnational areas in the ETR, 11 per cent face a very high level of ecological threat. These areas are home to an estimated 1.1 billion people or 22 per cent of the global population. By 2050, this figure is projected to rise to 1.5 billion people. While not all the population in these areas will suffer from the direct impact of adverse ecological conditions, the indirect impact will be widely felt. This is especially true of the areas which are in countries facing conflict, civil unrest, or poor governance. Displacement of persons and competition for food and water resources may cause the impact of the original shock to transcend national and even continental boundaries.

Despite this increased global ecological risk, countries with favourable environmental conditions and strong governance continue to mitigate ecological threats. For example, due to widespread environmental mitigation practices and investments in sustainability, Costa Rica continues to display low ecological risk despite having similar environmental conditions to neighbouring countries facing higher risk levels. In 2020, renewable energy supplied 99.78 per cent of Costa Rica's energy, largely due to hydro-electric dams,[9] indicating the country's strong water infrastructure and commitment to sustainable development. The success of these projects puts Costa Rica at the forefront of sustainability and offers an example of the pathway to ecological security that could be replicated and improved upon by other countries.

FIGURE 1.2

Distribution of ETR threats at the subnational level, 2024

Eleven per cent of subnational areas face a very high level of ecological threat.



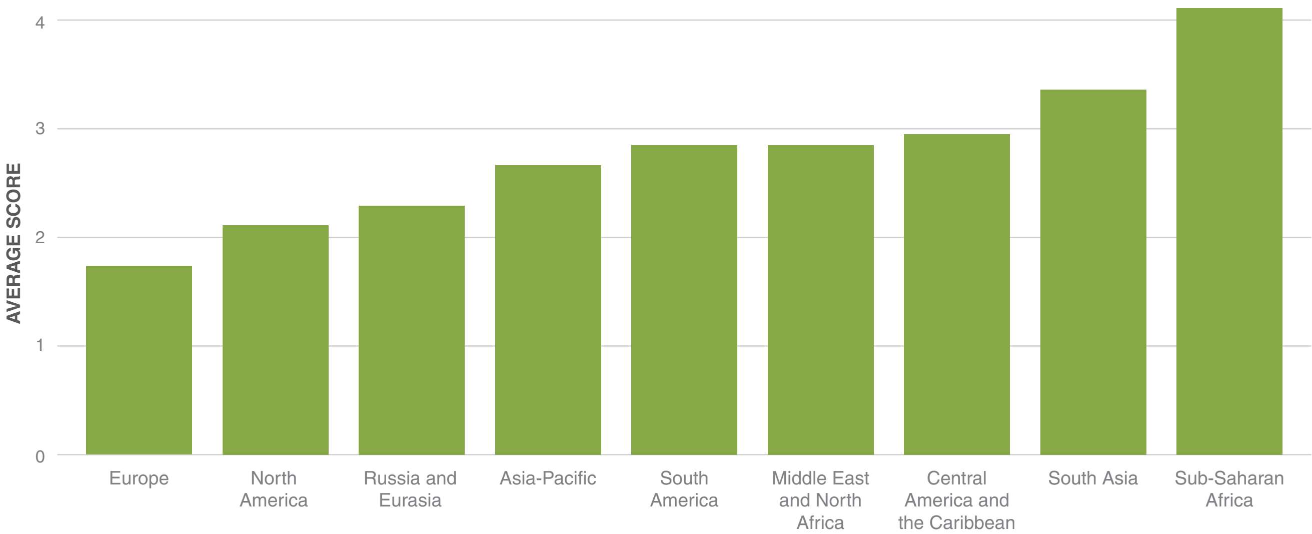
Source: IEP

Levels of ecological threat are not uniform across countries. There is considerable variation within regions. Europe and North America are the only two regions where no subnational areas face a high or very high level of ecological threat. Even in sub-Saharan Africa, the region with the highest overall average threat level, there are some subnational areas facing only a medium level of threat. Figure 1.3 shows the overall average score for each region in the ETR. North America and Europe are the regions with the lowest average scores, while South Asia and sub-Saharan Africa are the regions with the highest average scores.

FIGURE 1.3

Average ETR score by region, 2024

Countries in sub-Saharan Africa and South Asia face the highest level of ecological threat on average.



Source: IEP Calculations

Sub-Saharan Africa has the worst average ETR score of any region, with 17 of its 44 countries facing very high levels of ecological threat. By 2050, sub-Saharan Africa's population is predicted to rise to 2.1 billion, an increase of over 70 per cent, which will increase pressure on existing food and water supplies. Sub-Saharan Africa also has the highest proportion of its population suffering from food insecurity. Most countries across sub-Saharan Africa are dependent on rainfed agriculture, making the region particularly vulnerable to changes in climatic conditions, such as prolonged droughts and seasonal floods.[10] Agriculture is the mainstay of most economies in the region, accounting for just over 17 per cent of value-added GDP, higher than in any other region.[11]

On average, South Asia recorded the second highest overall ETR score, driven by its impact of natural events scores, which are the highest of any region. Natural events such as floods, hurricanes, and other sudden shocks exacerbate 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 events, resulting in more frequent, intense, and increasingly costly disasters.

There is a strong correlation between ecological threats and peacefulness. Figure 1.4 shows the correlation (r = 0.58) between the GPI, which measures peacefulness at the national level, and the overall ETR score. Less peaceful countries tend to have a higher prevalence of ecological threats, particularly food insecurity and water stress.

The GPI comprises three domains: *Safety and Security, Ongoing Conflict,* and *Militarisation*. The prevalence of all four ecological threats increases where countries are less peaceful in the *Safety and Security* and *Ongoing Conflict* domains. *Militarisation* is the only domain not strongly correlated to ecological threat.

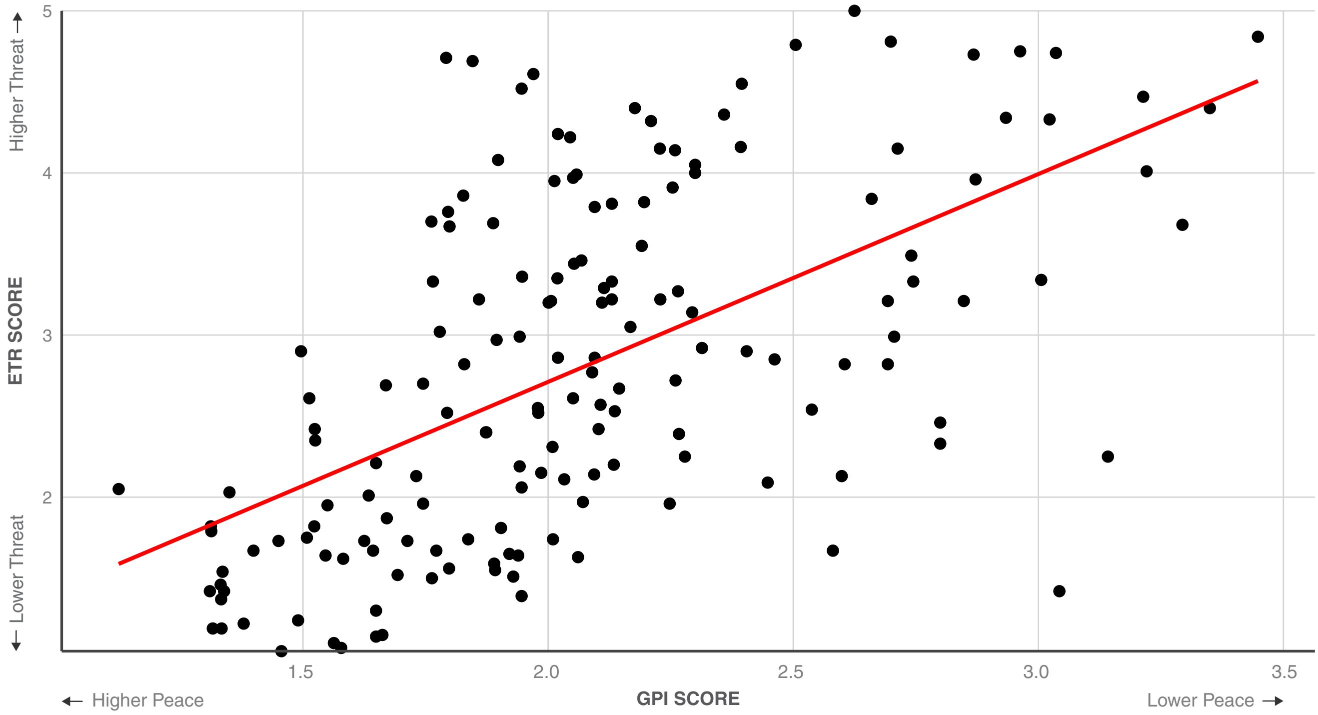
Increased ecological threats from a changing climate will have security implications at the micro and macro levels. When local communities experience ecological shocks, it can lead to political instability if the country's levels of resilience are low. For example, when a record-breaking drought in Kenya's Rift Valley limited access to land and water in the region, pre-existing conflict and grievances among herders and farmers were amplified, with conflict in the region resulting in 200 deaths in 2021.[12] Similarly, in South Sudan, ongoing conflict and a multi-year drought drove unprecedented levels of food insecurity.[13] Security can also be affected when mitigating actions taken by one community negatively affects another. This has been seen in hydroelectric dams and irrigation systems in Türkiye, China and Ethiopia, as they restricted access to water in downstream countries.[14]

One prominent consequence of natural disasters, water scarcity, food insecurity, and above-average temperature is that they cause migration and displacement. Individuals fleeing harm can add more pressure to areas that are not directly affected by the disaster. Migration can intensify competition over jobs, housing, and other resources.[15]

FIGURE 1.4

Ecological threat vs peacefulness

There is a strong correlation (r = 0.58) between the ETR and the Global Peace Index.



Source: IEP Calculations

Country Hotspots

FIGURE 1.5

Hotspots: Low Positive Peace combined with high ecological threat

There are 27 countries with very high ecological threat and low levels of resilience.

Source: IEP Calculations

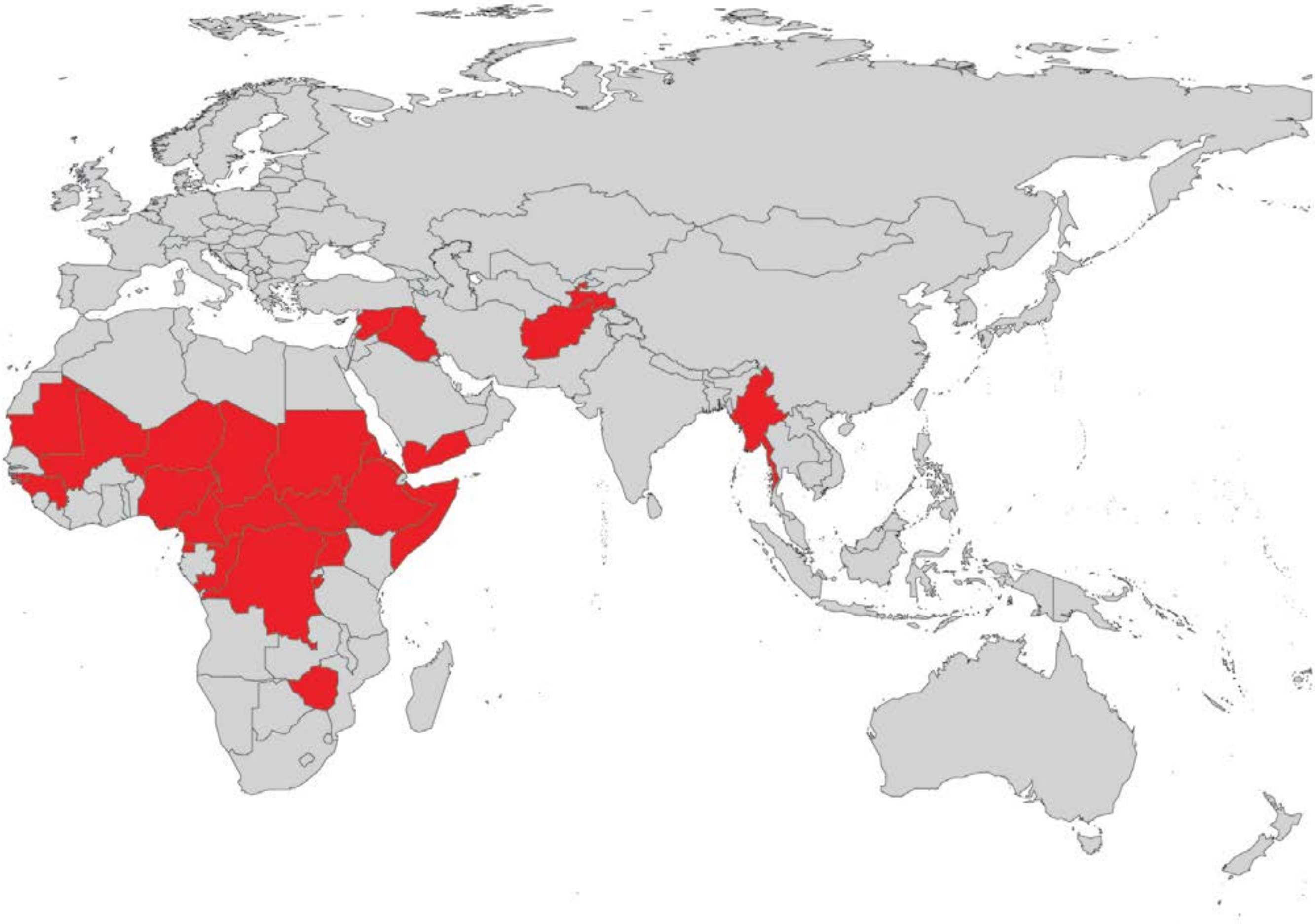
NATIONAL HOTSPOTS

COMBINING CATASTROPHIC THREATS AND LOW LEVELS OF RESILIENCE

Countries have different levels of capacity to respond to ecological threats due to the varying strength of their societal systems. This capacity to respond is captured in the Positive Peace Index (PPI) which measures resilience through the *attitudes, institutions and structures* of societies. These are the same factors that create capacity and adaptability.

Countries that rank higher in PPI have stronger institutions and coping mechanisms, which means they are better prepared to deal with ecological threats. Conversely, countries with low levels of Positive Peace lack resilience, meaning that even moderate shocks may lead to conflict or disorderly re-arrangements in the structure of the economy and political system.

Positive Peace is strongly correlated 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 are more socially cohesive. They also have more effective disaster response mechanisms, and their governance systems are more transparent, responsive, and adaptable.



KEY FINDINGS

19/27

Nineteen of the 27 hotspot countries are in sub-Saharan Africa.

4/27

Four of the 27 hotspot countries are in the Middle East and North Africa.

The relationship between peacefulness, food insecurity, water risk and demographic pressure is complex. If multiple ecological threats occur simultaneously, they can converge and amplify each other, causing a multiplier effect.

BOX 1.2

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 first conceptualised in the 1960s and empirically derived by IEP in 2012 with the development of the Positive Peace Index (PPI).

Positive Peace represents the social, economic and governance factors that create highly functional societies characterised by peace and resilience. Positive Peace is also statically connected to many other measures of wellbeing and development, including higher GDP growth, better performance in environmental protection, and better social outcomes. Countries that perform well in Positive Peace tend to operate with higher levels of peace as measured by the Global Peace Index (GPI). They also tend to improve more rapidly than their peers in GPI rankings. 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, including droughts, floods and earthquakes, and recovers more quickly in their aftermath. Thus, Positive Peace is a strong gauge of socio-economic resilience.

Nations operate according to the principles of societal systems. This means social, economic and political developments mutually affect one another, and it is difficult, if not impossible, to identify unique causes of events and trends. Another feature of social systems is that their internal structure can change from shocks, depending on the shock's severity. If a system is hit by a weak shock, it can respond without changing its internal configuration. For example, if a country is impacted by a mild economic recession, authorities will just need to respond with palliative measures that will 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 instances of nations that descended into a state of social disarray in 2020 and 2021 because of the COVID-19 pandemic and the associated global recession. The 2022 GPI 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, leading to a reconfiguration of the political system. In Sri Lanka, violent demonstrations erupted in early 2022 in response to daily power shut offs and shortages of basics such as fuel, food, and medicine, resulting in the eventual resignation of both the president and the 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 the 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.

TABLE 1.1

Hotspot countries, 2024

The following countries are classified as "hotspot" countries. This means they have a very high level of ecological threat and are ranked among the 30 countries with the lowest levels of Positive Peace.

Afghanistan	Ethiopia	Nigeria
Burundi	Guinea	Somalia
Cameroon	Guinea-Bissau	South Sudan
Central African Republic	Haiti	Sudan
Chad	Iraq	Syria
Republic of the Congo	Mali	Tajikistan
Democratic Republic of the Congo	Mauritania	Uganda
Equatorial Guinea	Myanmar (Burma)	Yemen
Eritrea	Niger	Zimbabwe

IEP's hotspot analysis compares the countries and areas facing at least one severe threat with the PPI. A hotspot country is defined as one that is ranked in the bottom 30 countries on the PPI, and also has a very high overall ETR score. The hotspot countries are shown in the map in Figure 1.5, and listed in Table 1.1.

Ecological hotspots tend to be clustered in certain geographical areas. Figure 1.6 shows the number of countries identified as hotspots by region. Nineteen of the 27 hotspot countries are in sub-Saharan Africa and four are in the Middle East and North Africa. This clustering is significant because ecological and humanitarian crises often spill over across international borders. This spillover effect occurs through population flows, cross-border conflict, and disruptions to transportation networks and supply chains between countries.

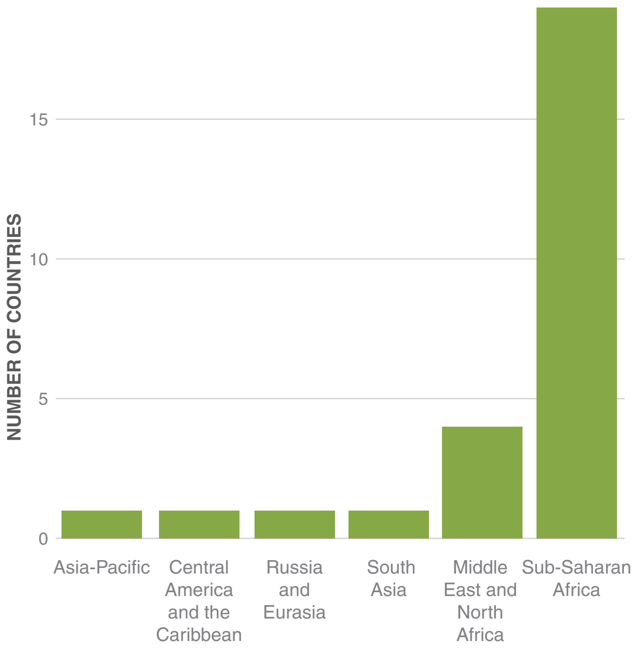
The relationship between peacefulness, food insecurity, water risk and demographic pressure is complex. If multiple ecological threats occur simultaneously, they can converge and amplify each other, causing a multiplier effect. For example, the combination of water stress and a rapidly growing population may exacerbate food insecurity, causing other effects, such as higher inflation, unplanned migration or increases in crime.

Multiple stressors are also 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. Figure 1.7 highlights the vicious cycle for changes in resource scarcity and peacefulness.

FIGURE 1.6

Number of hotspot countries by region

Only four of the 27 hotspot countries are outside of the sub-Saharan Africa and the Middle East and North Africa regions.

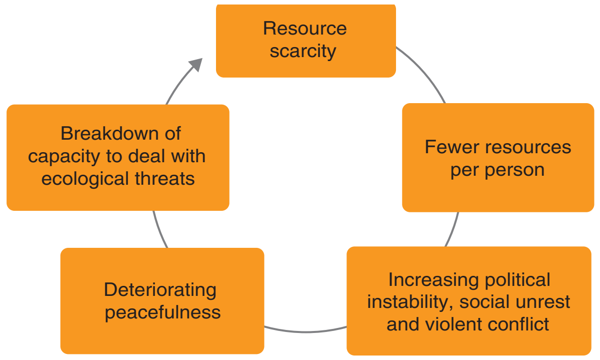


Source: IEP Calculations

FIGURE 1.7

The vicious cycle of increasing resource scarcity

Increased stress on resources can lead to a deterioration in peacefulness.



Source: IEP

Shocks can be classified as sudden substantial inputs into a system. If large enough, they will overwhelm the internal structures of the system, causing them to change or even collapse. The shock can serve to strengthen or weaken the system, depending on the resilience of the system and the severity of the shock. The COVID-19 pandemic, for instance, was a shock to society because a new input – a contagion – reshaped how individuals, groups, governments, and businesses operated.

Some shocks can be internally generated and are the result of a societal system's own dynamics. These are known as *endogenous* shocks. Examples of endogenous shocks are political revolutions, civil unrest or economic crises. *Exogenous* shocks have causes and triggers that 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 the direct impact on their sub-systems. This is known as *coping capacity* and has been defined by the United Nations as "the ability of people, organizations and systems, using available skills and resources, to manage adverse conditions, risk or disasters."[16]

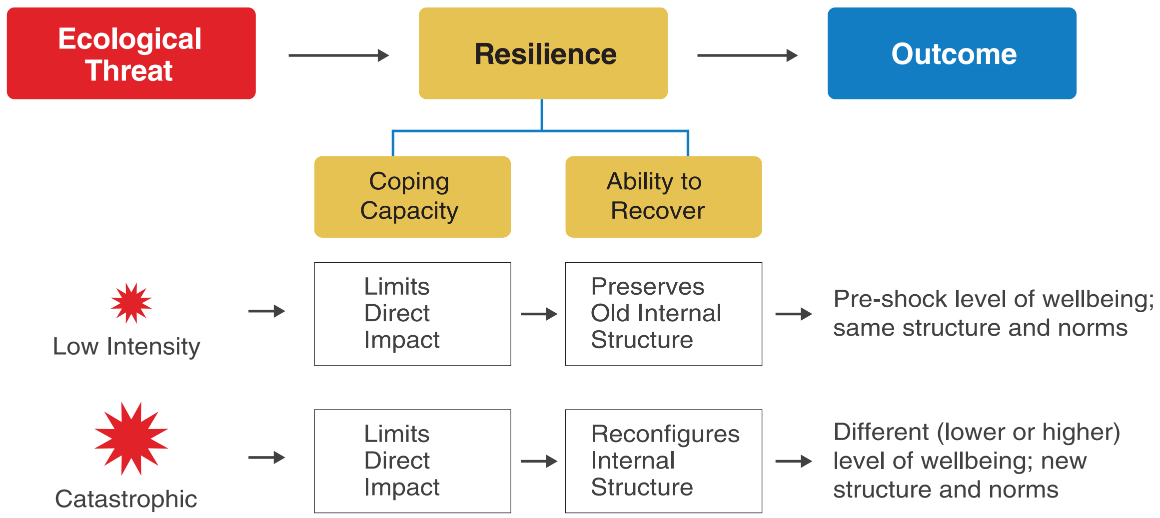
High levels of resilience mean national systems have superior coping capacity in terms of physical infrastructure, regulatory frameworks, economic strength and diversification, emergency preparedness and response systems. In addition, they also have heightened capacity to rebuild their socio-economic 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, a system may reconfigure its internal structure. This may mean that the resulting structure is less stable and contains less capacity. This can also mean that the next shock will have a more destabilising impact on the system, thereby causing a vicious cycle where a weakened societal system creates a higher likelihood of future shocks. The concept of resilience is illustrated in Figure 1.8.

FIGURE 1.8

Shocks and resilience

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.



Source: IEP

In contrast, a highly resilient system struck by a shock can reconfigure to become a more resilient system and more capable of dealing with future shocks. The 2011 Great East Japan Earthquake (GEJE) and resulting tsunami set off a chain of direct and indirect impacts felt at the societal and economic levels in Japan but also at the international level, affecting global supply chains. While the GEJE was undoubtedly ruinous, losses were reduced due to Japan's disaster risk management strategies, such as earthquake warning systems.[17] Since 2011, Japan has reconfigured its internal structure to strengthen its resilience to low-probability, high-impact threats by creating resilience policies that emphasise the holistic and continuous approach to resilience that should be maintained even during times of stability.[18]

Positive Peace is an effective predictor of socio-economic resilience for countries and regions, as discussed in previous IEP research.[19] This is because societies that operate with high levels of Positive Peace tend to:

- 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.

Shocks occur with comparable 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. For example, the *Sound Business Environment* Pillar ensures sufficient resources and infrastructure assets to treat people affected by disasters and repair physical damage. The *Equitable Distribution of Resources* Pillar means that all individuals, groups and demographics have access to protective infrastructure, equipment and services. The *Well-Functioning Government* Pillar allocates resources efficiently and transparently to groups or areas where they are most needed. The other Pillars of Positive Peace foster resilience in other complementary ways.

A socio-economic system comprises multiple sub-systems. These can be geographically situated, such as households, cities or areas, or they can be socially created constructs, 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 re-transmits the ramifications of the shock throughout the nation. This pattern is illustrated in Figure 1.9.

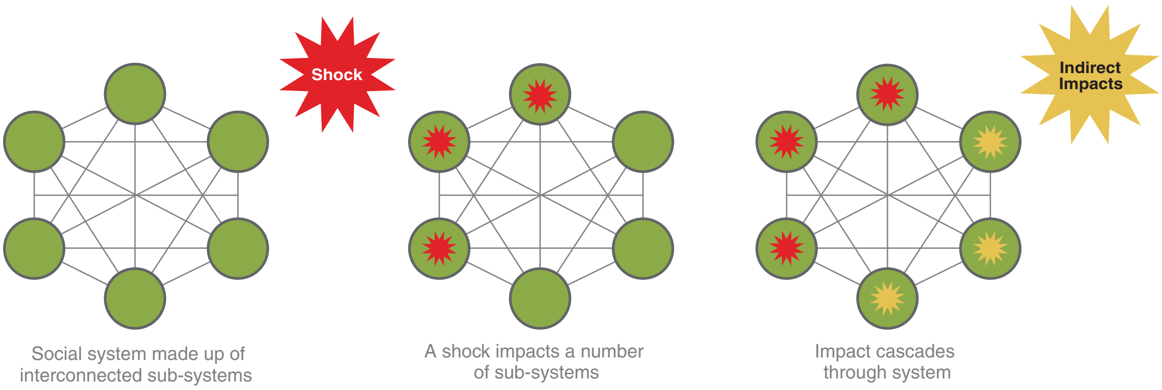
The Japanese tsunami of 2011 offers one example of shock transmission through sub-systems. In its direct impact, the disaster caused death and destruction in the north-eastern coast of the country. Subsequently, damaged nuclear power plants in the region contaminated crops and water supplies with radiation, affecting health and food production sub-systems in surrounding areas.[20]

Another example is the 2010 earthquake in Haiti, which caused severe loss of life and widespread destruction. Lacking the strong institutions of Japan, after the immediate impact, the country experienced a breakdown of law and order, contributing to civil unrest and looting.[21] Thus, the more severe threats a country faces, coupled with weak resilience, the more fragile a country will likely be.

FIGURE 1.9

The direct and indirect impact of system shocks

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



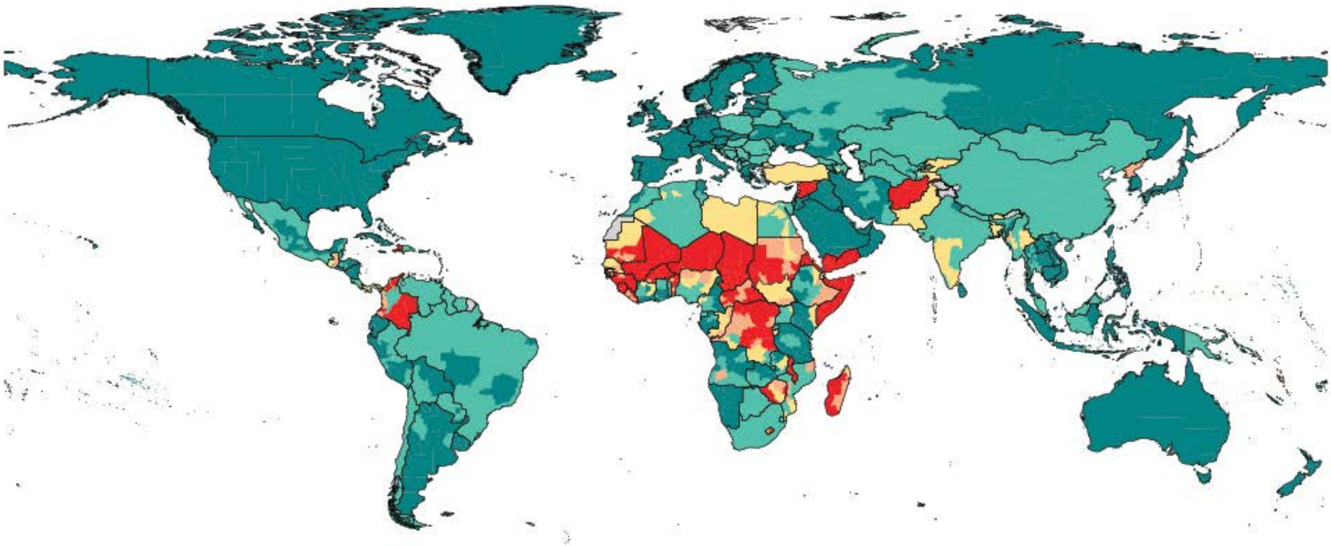
Source: IEP

Food Insecurity

FIGURE 1.10

Subnational food insecurity scores, 2024

The highest levels of food insecurity are in the Sahel region of sub-Saharan Africa.



Source: IEP

The ETR identifies 280 subnational areas that are facing very high levels of food insecurity, meaning that more than 42 per cent of the population in these areas have insufficient food consumption. A further 116 areas face high levels of food insecurity, and 309 face medium food insecurity. When large segments of a country's population lack food security, it adversely affects economic development and societal cohesion.[22]

Sudden shocks not only disrupt the accessibility of food; they can also create knock-on effects that result in increased political instability, violence, civil unrest, and levels of forced migration, as well as a higher likelihood of civil conflict. Food shortages and water scarcity are interrelated, with a lack of water often leading to reduced food production.

To be food secure, people must have access to sufficient nutritional food that meets their basic dietary needs and preferences for 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 that is 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 lacking, food security is compromised.

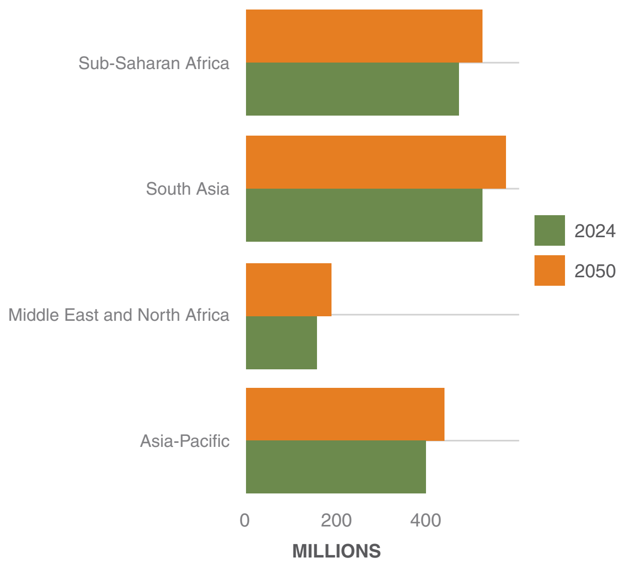
There is significant variation in food insecurity by region, as shown in Figure 1.11. In South Asia, there are an estimated 476 million people with insufficient daily food consumption. That number is expected to reach almost 600 million by 2050. The increase is expected to be even larger in sub-Saharan Africa, with IEP estimating that the number of people facing food insecurity will rise from 342 million to 530 million over the next quarter of a century, a 55 per cent increase.

Sudden shocks not only disrupt the accessibility of food; they can also create knock-on effects that result in increased political instability, violence, civil unrest, and levels of forced migration, as well as a higher likelihood of civil conflict.

FIGURE 1.11

Projected number of people facing very high food insecurity, 2024 to 2050

The number of people experiencing insufficient food consumption may reach over 1.7 billion people in the next 26 years.



Source: WFP

Many countries rely on food imports for food security, which means they depend heavily on international trade routes and supply chains. As such, major international events can impact the food security of many nations. Figure 1.12 shows the trend of the FAO Food Price Index for the period between 1990 and 2023, along with major global events over this period.

After the onset of the Global Financial Crisis in 2007, food prices rose by up to 40 per cent in the following 12 months. Similarly, in the two years following the start of the COVID-19 pandemic, 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, and as of July 2023 it remains 25 per cent higher than pre-pandemic levels.[23] Rising food prices threaten food security by making it more difficult for low-income populations to afford sufficient and nutritious food, leading to increased hunger and malnutrition. Additionally, higher food prices can strain household budgets, forcing people to cut back on other essential expenses, such as healthcare and education, further exacerbating poverty and social instability.

FIGURE 1.12

Global Food Price Index, 1990–2023

Average food prices are still almost 25 per cent higher than at the start of the COVID-19 pandemic.

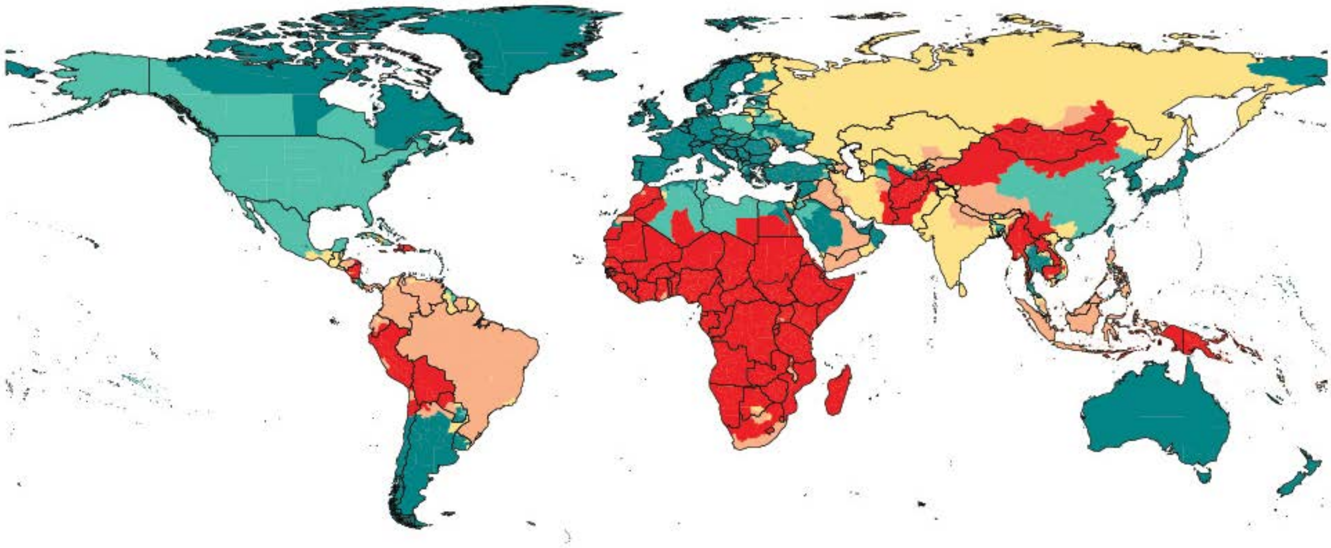
Source: FAO

Water Risk

FIGURE 1.13

Subnational water risk scores, 2024

Sub-Saharan Africa, Central Asia, and parts of South America face the highest levels of water risk.



Source: IEP

Water risk is one of the most significant ecological threats the world is currently facing. Two billion people globally do not have safe drinking water, while 3.6 billion lack access to safe sanitation.[24] Water stress impedes economic development and food production, which further compromises the health and wellbeing of the population. It can also lead to social tension, conflict and displacement. In the ETR, water risk is measured by looking at the percentage of the population of the subnational areas that has access to clean drinking water.

Figure 1.13 shows the distribution of water risk globally at the subnational level. There are 891 subnational areas where the level of water risk is very high, and a further 391 areas where it is high. Water risk is highest in sub-Saharan Africa, South Asia, and Latin America. The average level of ecological threat is higher for the water risk indicator than for any other indicator in the ETR.

The threat posed by water risk is expected to rise over the next quarter of a century. According to estimates by the World Resources Institute, 25 countries currently utilise over 80 per cent of their renewable water supply to cover irrigation, livestock, industry and domestic needs, compared to 17 countries just three years earlier.[25]

Most of the countries facing acute water risk are in sub-Saharan Africa and the Middle East and North Africa, with water risk projected to accelerate in these regions over the next 16 years. Figure 1.14 shows that these two regions will have both the greatest increase and the highest number of subnational areas where water risk increases between now and 2040.

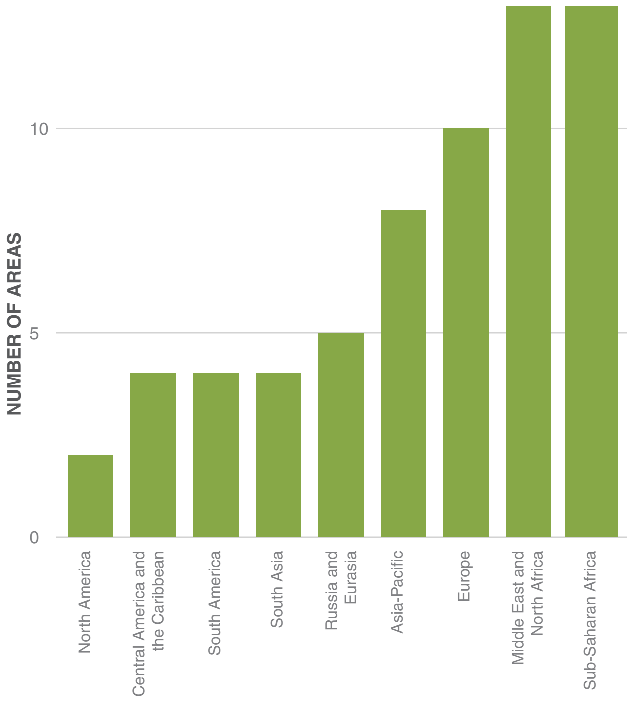
In Europe, approximately 75 per cent of total water extraction originates from rivers and reservoirs, while the remaining 25 per cent is derived from groundwater sources.[26] The region is experiencing a growing prevalence of droughts and water scarcity, affecting roughly 20 per cent of its land area and impacting 30 per cent of its population annually.[27] Southern and south-western European countries, such as Spain, Portugal and Italy, face particularly concerning trends. Here, water stress is driven by the demands of agriculture, public water supply and tourism, with pronounced peaks during the summer season. These challenges are exacerbated by excessive groundwater extraction, as intensified droughts force deeper water sourcing to counter reduced rainfall and rising temperatures.

Investments in water-use efficiency are anticipated to stabilise water usage in wealthier countries in Europe and North America. However, water resources embedded in global trade, particularly those utilised in exports from lower-middle-income countries to high-income countries, significantly contribute to the growing water stress in low- and lower-middle-income nations.[28]

FIGURE 1.14

Subnational regions where water risk will accelerate, 2024–2040

The Middle East and North Africa will face greatly accelerated water risk in the next 16 years.



Source: WRI; IEP Calculations

The effect of international trade on water scarcity varies from country to country, either increasing or decreasing water security. Countries like Germany and the Bahamas, for example, have faced decreased water scarcity due to indirect water imports as a product of globalised trade. Conversely, countries like Egypt, whose large exports flow mainly into higher-income countries, tend to face aggravated water security due to increased trade.[29] Due to these effects of trade, water efficiency in manufacturing and transportation should be further examined as a means of alleviating the effects of trade on water scarcity.

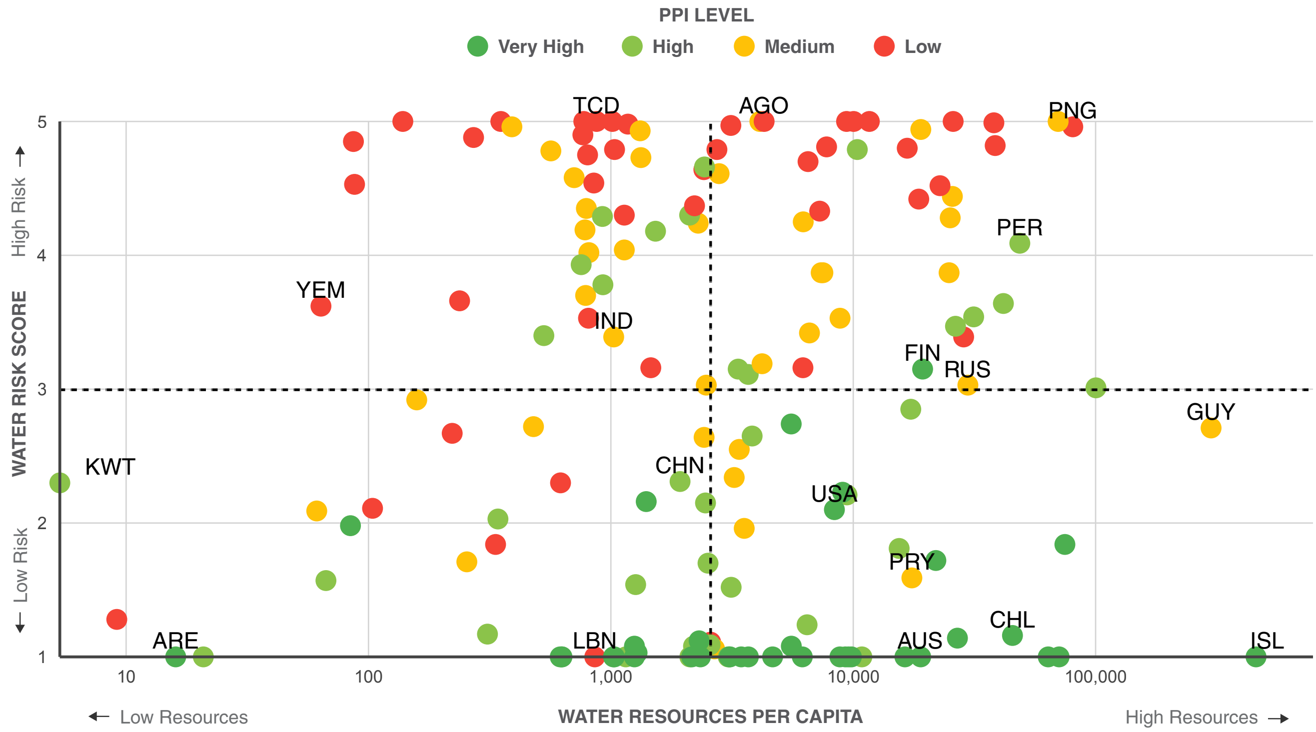
Water stress is caused by both physical and economic factors. Physical factors are associated with ecological conditions that limit water availability, posing challenges in meeting demands for agriculture, household use and industry. This shortage often stems from insufficient rainfall, seasonal variability in rainfall, or occurrences of floods and droughts. In contrast, economic factors give rise to scarcity as a result of insufficient water management and infrastructure, despite water being potentially available. Inadequate water management and infrastructure can be seen, for example, in excessive groundwater extraction and outdated distribution systems.[30]

Figure 1.15 shows the relationship between water risk, per capita water resources, and resilience, as measured by the Positive Peace Index. It highlights that water risk is not necessarily associated simply with water availability. Without strong institutions and sufficient levels of socio-economic development, water can remain inaccessible and risk can remain high even when countries have sufficient water resources.

FIGURE 1.15

Water risk vs per capita water resources

Many countries have substantial water resources but are unable to effectively access them due lower levels of institutional capacity and infrastructure development.



Source: FAO Aquastat; IEP

Countries with low water risk often exhibit high PPI scores, indicating strong governance and effective infrastructure. For example, Iceland and the United Arab Emirates (UAE) both score a one on the water risk scale, despite vast differences in their water resources. Iceland has 459,000 cubic metres of renewable water per person, while the UAE has only 16 cubic metres per person. The UAE's ability to manage its limited water resources is due to its very high PPI score, reflecting robust governance and infrastructure, such as extensive desalination plants, which provide 42 per cent of the country's drinking water.

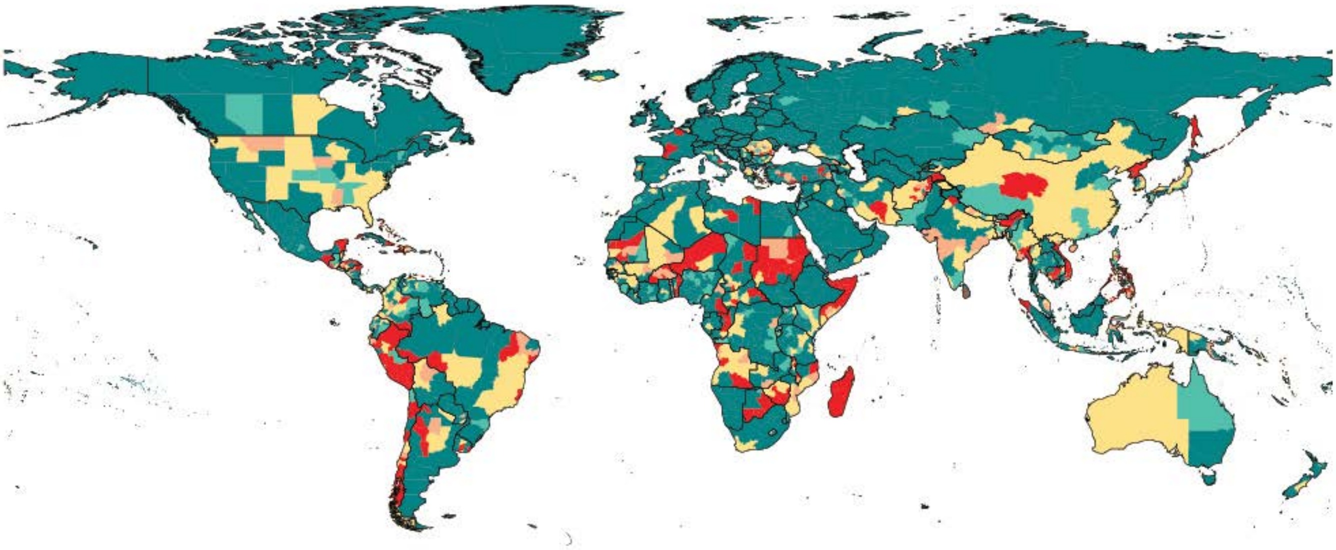
In contrast, neighbouring Yemen faces significant water risks despite having more water resources per capita than the UAE. Yemen scores 4.97 out of five on the water risk scale, primarily due to weak governance and poor infrastructure, evidenced by its low PPI score. Only 30 per cent of Yemen's population has access to a reliable water network, and 17.8 million people lack safe water access, leading to severe public health issues. The ongoing conflict in Yemen exacerbates these challenges, underscoring the importance of strong governance and infrastructure in managing water resources effectively.

Papua New Guinea (PNG) also illustrates that abundant natural water resources do not guarantee low water risk. Despite having over 80,000 cubic metres of internal water per capita, PNG faces a high water risk score of 4.97 due to inadequate infrastructure and weak governance. Many people in PNG, particularly in rural areas, lack access to clean water and sanitation facilities. The country's water infrastructure suffers from poor maintenance and limited coverage, compounded by socio-economic barriers and ecological threats such as flooding. These governance challenges hinder effective water management, highlighting that strong institutions are crucial in mitigating water risks.

Some countries are outliers on this graph in part as the result of their unique water systems. For example, Egypt’s access to water from the Nile Delta has helped the country maintain water security despite its poor PPI score and otherwise restricted water resources. Conversely, in Peru, despite a strong PPI score and abundant water resources, it has historically drawn on water from the now-retreating glaciers and thus requires future adaptation to provide water to its citizens.

Impact of Natural Events

FIGURE 1.16
Subnational impact of natural events scores, 2024
Almost every region faces some level of risk from natural events.



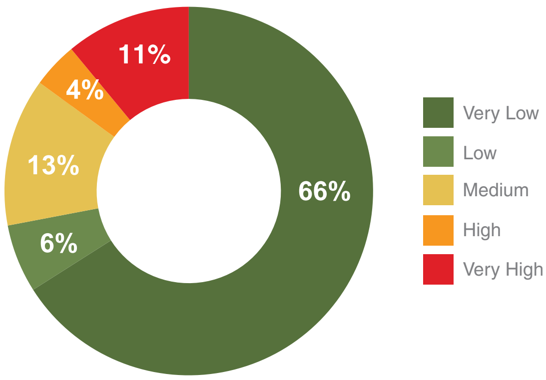
Source: IEP

Figure 1.17 shows the distribution of scores on the impact of natural events indicator. Eleven per cent of all subnational areas face a very high level risk from natural events, meaning that on average there were at least 100 people killed or displaced by natural events every year for the past 20 years. However, it should be noted that the distribution of scores within the very high category is very uneven. A small handful of subnational areas have had extremely high levels of impact from natural events over the past 20 years. For example, many areas in Puerto Rico have averaged more than 10,000 people killed or displaced per year over the past two decades.

The majority of regions in the world do not currently face a high level of risk from natural events, with 66 per cent of subnational areas scoring in the very low risk category for this indicator. The geographic distribution of risk from this indicator is also quite different than other levels of ecological threat, as shown on the map in Figure 1.16. This is the only indicator on which subnational areas in both North America and Europe face high or very high levels of risk.

However, while the risks posed by natural events are currently lower than other forms of ecological threat, their impact is continuing to rise, and will likely be exacerbated by climate change. In July 2023, UN Secretary-General António Guterres cautioned that the era of "global boiling" had commenced. He highlighted that rising temperatures have already caused significant damage and urged leaders to take action to prevent further increases in the number of catastrophic disasters.[31]

FIGURE 1.17
Subnational distribution of the impact of natural events, 2024
Nearly three-quarters of subnational areas face a low or very low threat from natural events.



Source: IEP

A disaster is a serious disruption of a society or system due to hazardous events interacting with exposure, vulnerability, societal resilience and capacity. Disasters result in environmental, societal, and economic losses and impacts which may surpass the community's coping capacity and require external assistance.[32]

Most often, disasters materialise following a significant natural event such as a storm, drought, flood, or earthquake. However, disasters occur only when a lack of resilience allows systems to be overwhelmed following the event. Figure 1.18 illustrates a disaster impact downward spiral that a country can enter following a natural event.

An example of this downward spiral occurred in the aftermath of the 2010 earthquake in Haiti, which led to widespread devastation. The event triggered substantial social unrest and the breakdown of law and order. In contrast, Japan managed the aftermath of the 2011 tsunami and nuclear plant meltdown adeptly, containing the damage, addressing the destruction and orchestrating an effective economic recovery. This divergence in immediate impact and subsequent consequences can be attributed to the substantial difference in resilience levels between the two nations. Haiti, ranked 146th on the Positive Peace Index, exhibited markedly low resilience, while Japan was among the top 20 Positive Peace countries globally. This exemplifies the role of Positive Peace as a measure of resilience, shielding populations from disaster's worst effects and facilitating post-disaster socio-economic restoration.

FIGURE 1.18

Disaster impact spiral set off by a natural event

BOX 1.3

Climate change and small-island state adaptation

Among the countries experiencing adverse effects of climate change, many of the most vulnerable countries are small island nations in the South Pacific. Most island nations in Polynesia are made up of low-lying reef islands and atolls, making them especially susceptible to sea level rise. Tuvalu and Kiribati are two of the most endangered countries in this region, with an average elevation of just two metres,[33] and Tuvalu's highest point reaching only five metres above sea level.[34] Future projections vary on the amount of sea level rise to be seen in the next century, but regardless of overall rises, massive storm surges pose a substantial threat. In 2015, as a result of Tropical Cyclone Pam, large waves heavily damaged the island nation, with some being four to five metres higher than the islands themselves.[35] With Tuvalu and Kiribati consisting of such low-lying land, any increase in sea-levels or storm frequency and magnitude poses an existential threat to the entire countries.

In an effort to ensure the security of its people, the prime minister of Tuvalu negotiated a novel bilateral agreement called the Falepili Union with Australia. The agreement outlines a commitment by Australia to aid in protecting Tuvalu from rising climate threats, and it led to a US$1.2 million donation from Australia to Tuvalu's Coastal Adaptation Project.[36] The project was implemented by the United Nation's Development Program and aims to create new land above the reaches of high tides and storm surges by expanding the capitol of Funafuti into the harbour by 3.6 square kilometres, elevating it to a level that should be safe from sea-water for over 80 years.[37] The agreement also offers a migration pathway from Tuvalu to Australia in anticipation of rising sea levels and other climatic events, allowing up to 280 migrants from the country to be granted permanent residency in Australia each year. With Tuvalu's population counting just over 11,000, it would only take 40 years at this rate for the entire country to relocate to Australia.[38]

Kiribati has adopted a similarly unique approach in combating the threat of climate change to its islands. With over 116,000 inhabitants across its three archipelagos, Kiribati has a much larger population than Tuvalu and thus requires a different approach to securing a space for its citizens. In 2012, the country purchased twenty-two square kilometres of land in the nearby country of Fiji, which is less susceptible to rising sea-levels due its much more elevated terrain. The purchased land is intended to first house skilled workers, freeing up land in Kiribati for agriculture and relocation, but is eventually planned to be the home of the nation's entire population.[39] In 2014, the prime minister of Fiji stated that Fiji would welcome the citizens of Kiribati to relocate should their country become submerged.[40]

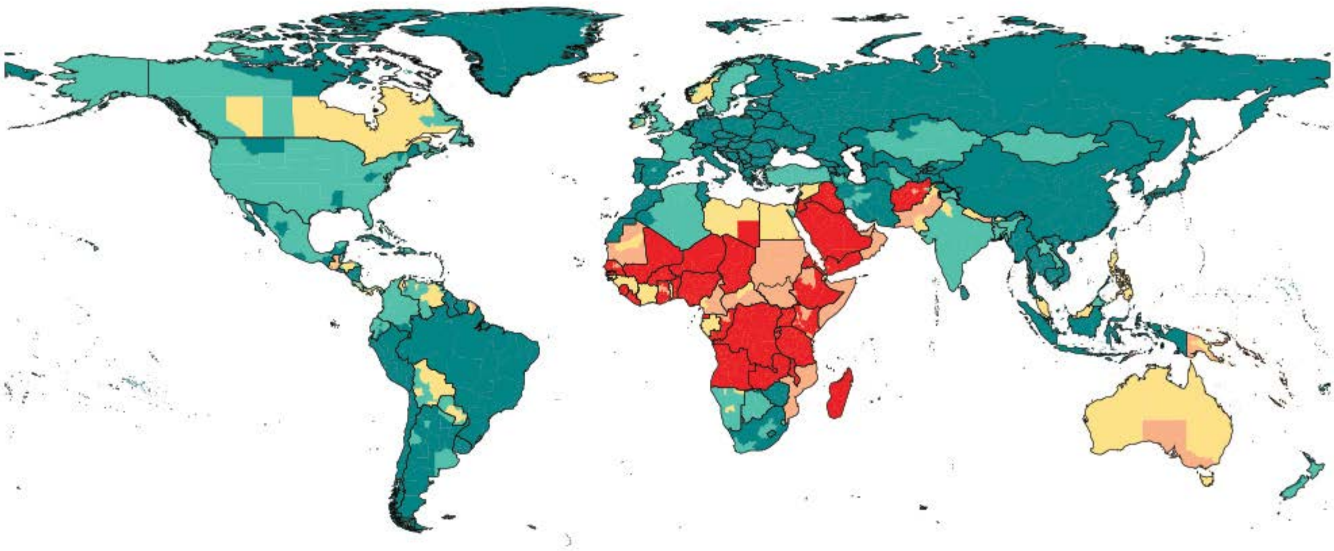
These plans introduce new challenges for international relations and security, particularly concerning state sovereignty and the continuity of nations when a country's land becomes uninhabitable due to climate change. Tuvalu's and Kiribati's survival strategies highlight the severity of the threats to their homelands and their role at the forefront of a new era of international agreements focused on mitigating environmental impact and, in extreme cases, preserving nations and their cultures through mass or even total migration.

Demographic Pressure

FIGURE 1.19

Subnational demographic pressure, 2024

Almost all of the areas projected to have high population growth are in sub-Saharan Africa.



Source: IEP

Population growth will be a significant ecological threat for many countries in the next three decades. Of the 3,518 subnational areas in the ETR, 230 have very high levels of demographic pressure, recording the maximum score of five, meaning that population growth between now and 2050 will be higher than 40 per cent. The geographic distribution of scores on the demographic pressure indicator is shown in the map in Figure 1.19.

There is a strong connection between increasing population and environmental degradation, particularly when population growth leads to higher urbanisation and increased economic activity.[41]

Consistent population growth can increase the chances of conflict breaking out in the future. Most of the world's population growth over the next three decades is expected to occur in many of the world's least peaceful countries. The 40 least peaceful countries will have an additional 1.3 billion people by 2050, at which point they will account for just under half of the total world population. This growth will pose major challenges for development and peacefulness. Moreover, the population growth is unlikely to be uniform across countries or regions, or by levels of development and peacefulness, which also means that certain areas will experience greater hardship than others. With resources becoming scarcer, the likelihood of conflict will increase.

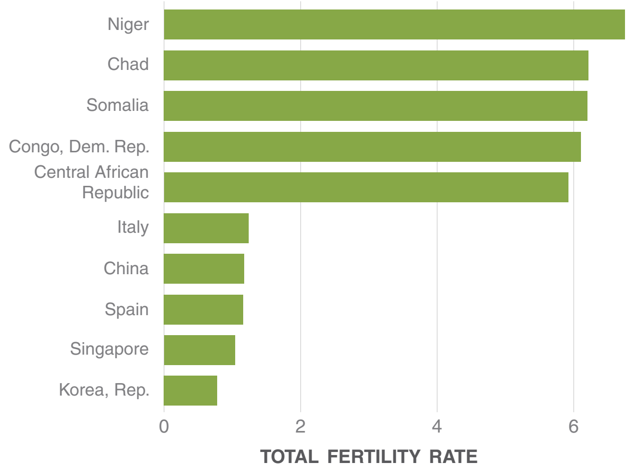
In some regions, however, population growth is expected to be close to zero. Both Europe and the Russia and Eurasia region are expected to record population growth rates of less than one per cent. Some countries, such as Bulgaria, Latvia and Moldova, are expected to see their populations fall by almost 20 per cent by 2050. Based on current trends, only 14 of the 42 European countries are expected to record positive population growth rates.

There are also many countries in the Asia-Pacific region with extremely low projected population growth. Figure 1.20 shows the total fertility rate (TFR) for the five countries with the highest and lowest levels of fertility in 2022. Of the five countries with the lowest fertility rates, three are in the Asia-Pacific region and two are in Europe. South Korea has the lowest fertility rate of any country in the world, and is the only country where the TFR is lower than one. By contrast, all five of the countries with the highest fertility rates are in sub-Saharan Africa, with four of those five countries having a TFR of over six children per woman.

FIGURE 1.20

Highest and lowest total fertility rates by country, 2022

Countries with the highest levels of fertility have rates more than six times higher than those with the lowest levels of fertility.



Source: World Bank

Increasing and declining populations will have differing effects on the demographic structure of a country. Barring large influxes of international immigrants, countries with low or even negative population growth are poised to have a much higher number of elderly people relative to their youth population, while countries with high levels of population growth are set see a rapid expansion of their population aged 25 or younger. A large increase in the youthful percentage of a population is known as a "youth bulge".

A youth bulge can have significant economic and political implications that can interact with other ecological threats in negative ways, leading to increased fragility, decreased resilience and a higher likelihood of conflict.

The likelihood of conflict increases when the size of a youth bulge increases. The size of the effect is largest among autocratic regimes, though there is a large effect among fully democratic countries as well.[42] Conversely, a decline in the youth bulge is associated with declines in terrorism and other types of internal conflict.[43] However, the risk of conflict is not the same for all different types of conflict. A youth bulge increases the risk of non-ethnic related conflict but does not lead to an increased risk of ethnic conflict.[44]

Youth bulges tend to lead to more political activism among the young.[45] Governments that are facing youth bulges are also more likely to implement harsh restrictions on protests, irrespective of the actual amount of protest activity that is taking place.[46] The main mechanism by which youth bulges lead to increased political unrest and a higher risk of conflict seems to be economic, with a surge in the number of young people putting immense pressure on the labour market.[47]

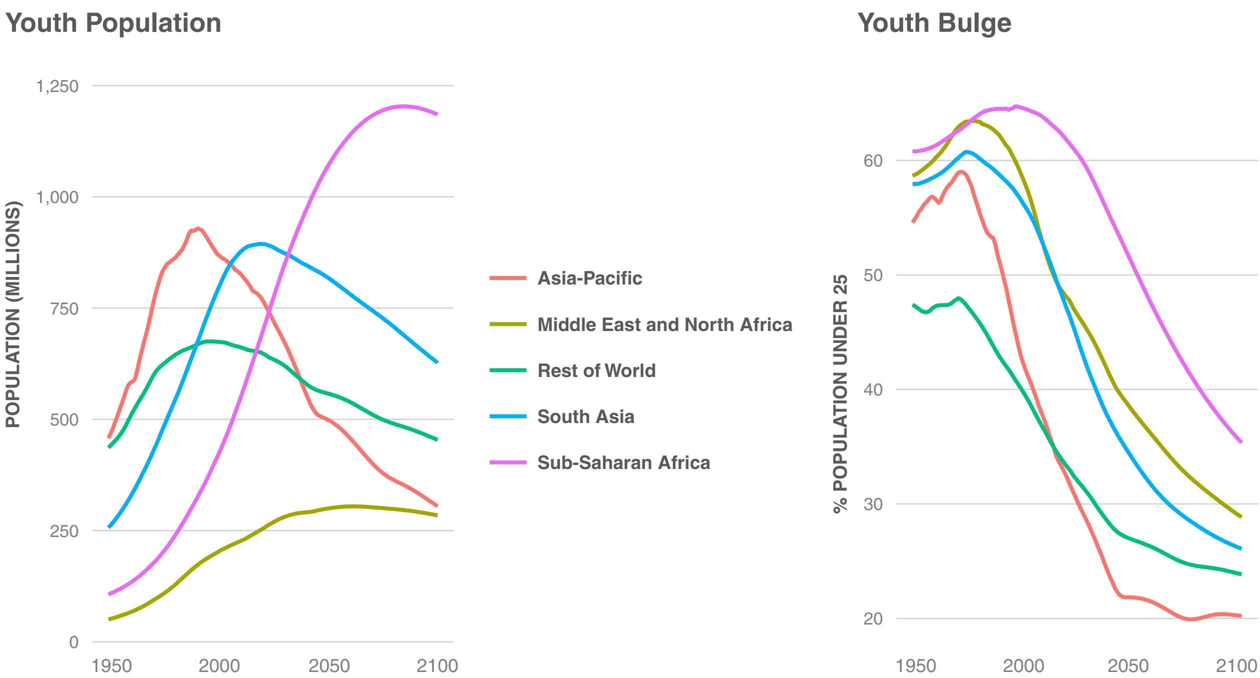
The expanding population of sub-Saharan Africa will lead to a large increase in the number of young people in that region. The number of people younger than 25 in sub-Saharan Africa is already close to 750 million and is projected to rise to over a billion by 2050, as shown in Figure 1.21. The Middle East and North Africa is the only other region in the world where the total youth population is projected to rise between now and 2050. The growth in the total number of young people in sub-Saharan Africa is so large that in the next two decades, the number of people aged 15 or under in sub-Saharan Africa will be greater than the entire population of Europe.

Although the total number of young people in sub-Saharan Africa is expected to surge over the next three decades, youth as a percentage of total population will fall. In fact, this trend began almost 25 years ago. By 2050, young people as a percentage of the total population in sub-Saharan Africa will have fallen to just over 50 per cent, down from 65 per cent in the year 2000.

FIGURE 1.21

Youth bulge and youth population trends, 1950–2100

The youth population of sub-Saharan Africa will exceed the total population of Europe by 2050.



Source: WPP; IEP Calculations

Ecological threats often exacerbate tensions in regions with significant ethnic diversity, particularly where these groups have historically contested access to natural resources such as water and arable land.

Climate change alone does not directly cause violent conflict; it acts as a threat amplifier, exacerbating existing tensions in areas with a history of conflict, weak institutions, and low resilience.

+27%

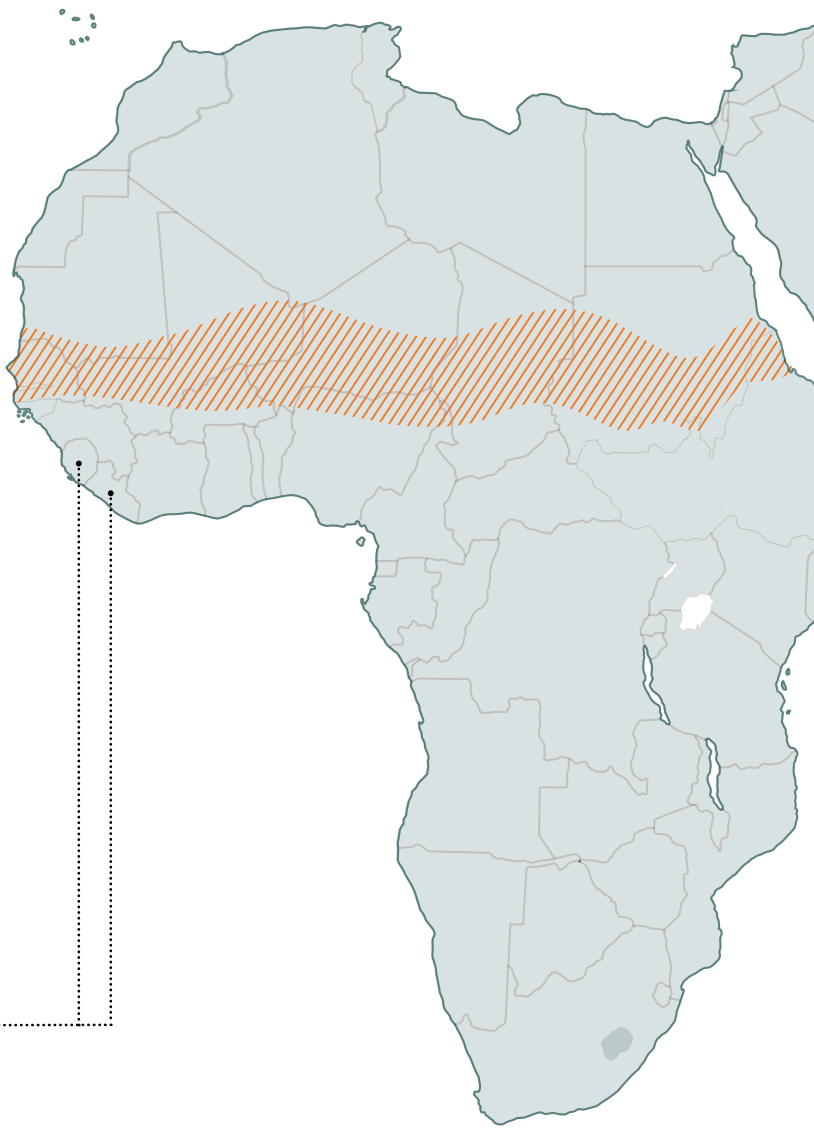
Regions with historical ethnic borders have a 27 per cent higher probability of conflict compared to non-border areas, highlighting the significance of ethnic divisions in conflict dynamics.

50 million

The Sahel region has seen a rise in agro-pastoralist conflicts, driven by climate variability, adverse government policies, rapid population growth, and disruption of traditional mobility routes, affecting over 50 million people who rely on livestock for their livelihoods.

In sub-Saharan Africa, regions with high water stress are more likely to experience communal violence, particularly in areas where local institutions are weak and public trust is low.

In countries like Sierra Leone and Liberia, where conflicts have been inactive for decades, the combination of high level of ecological threat and historical conflict could signal a need for renewed focus on ecological resilience and conflict resolution.



Despite the prevalence of agro-pastoralist conflicts, most interactions between farmers and herders remain peaceful, with cooperation over shared resources being the norm rather than the exception.

Empowering existing community systems and traditional conflict resolution methods has been identified as the most effective way to reduce conflict in agro-pastoral regions, particularly in response to climate-induced stressors.


2
Non-state Conflict and Ecological Threats

Overview

Ecological threats, such as climate change, food insecurity, and water scarcity, have increasingly been recognised as significant factors in the dynamics of armed conflict. This edition of the Ecological Threat Report (ETR) builds on previous analyses by examining how these threats specifically contribute to intercommunal and ethnic group conflicts, often transcending national borders.

By mapping ecological threats according to ethnic group homelands rather than state boundaries, with a focus on certain regions in Africa, this section highlights the nuanced and complex ways in which ecological pressures intersect with historical and contemporary ethnic tensions. The data reveals that traditional state borders are less meaningful in understanding conflict in areas where ethnic groups span multiple countries and national governance is weak, underscoring the need for a more granular approach to conflict analysis and management.

This section explores the intricate relationship between climate-induced ecological threats and armed conflict, particularly in agro-pastoralist regions like the Central Sahel and Sudan's Darfur state. It explores how resource competition, exacerbated by environmental stressors, can lead to violence, especially in areas with weak governance and a history of conflict. The section also addresses the potential for currently inactive conflicts in ecologically vulnerable regions to reignite as ecological stress increases. While climate change is often cited as a direct cause of conflict, its impact is more accurately described as a "threat amplifier", interacting with other factors such as governance, resilience, and historical grievances to increase the likelihood of conflict.

Ecological threats and armed conflict

The 2023 edition of the ETR included a review of the literature discussing the relationship between climate change and armed conflict. This year's report includes a focus on the role ecological threats can play in intercommunal conflict and conflicts between ethnic groups, which often take on national or transnational dimensions. Using data on ethnic groups' historical and contemporary homelands, ecological threats are mapped by ethnic group rather than by the political borders of modern nation-states. This approach demonstrates that while existing borders are often the focus of conflict, these boundaries are less meaningful in areas where ethnic groups span across modern state lines.

This analysis begins with a broad overview of the relationship between climate and armed conflict. It is followed by a discussion of conflict between nomadic pastoralists and sedentary farmers, with case illustrations from the Central Sahel and Sudan. In the final part of the section, currently inactive conflicts in areas facing significant ecological threats are considered. Such areas could face increased ecological stress that could threaten peacefulness in the coming years.

Despite the common perception that climate change is directly linked to violent armed conflict, the causal relationship between anthropogenic climate change and conflict is contested. Climate change is therefore sometimes referred to as a "threat amplifier", reflecting the evidence that it makes conflicts worse without necessarily causing them. However, it is likely that this relationship, and the magnitude of its effects, will increase in the coming decades as global heating intensifies.[1] For example, the combination of increasingly volatile weather and and long-term climate changes, short-term ecological threats, a history of conflict, a lack of resilience, and weak institutions will increasingly lead to a heightened conflict risk. But because these linkages are indirect and complex, one type of change or event in one country or part of the world may not have the same or even a similar impact elsewhere.

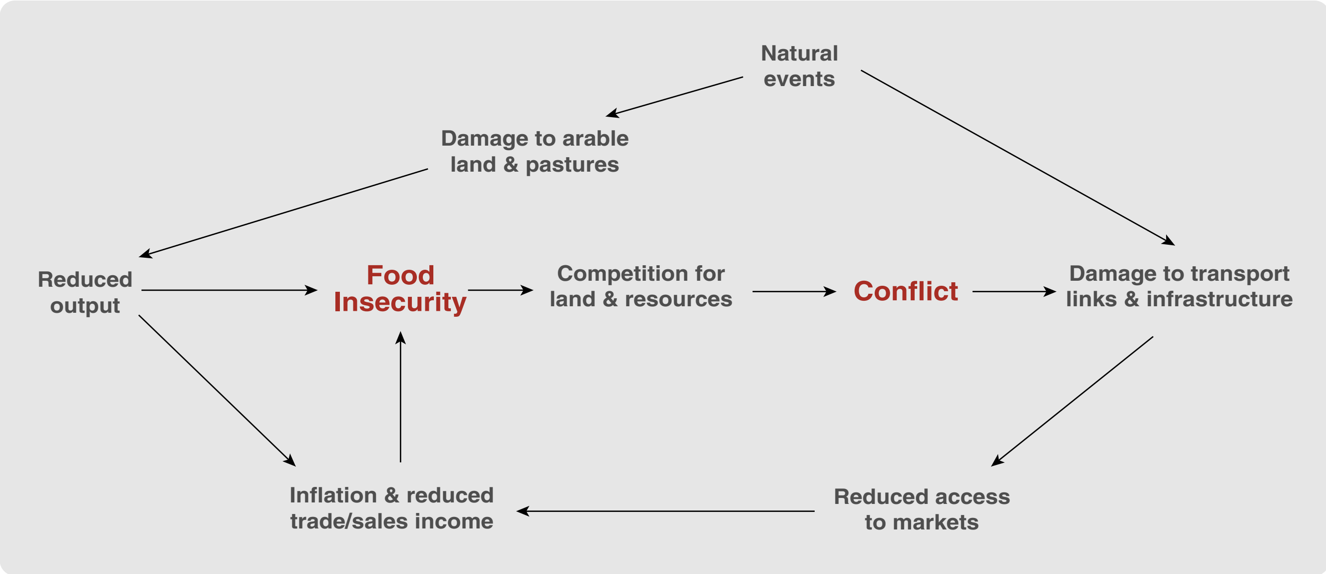
Occasionally, the impact of climate change on conflict can be overstated. One example of this is the prevalent theory that the rise of Boko Haram and other extremist groups in northeastern Nigeria is linked to the shrinking of Lake Chad. However, doubt has been cast on whether Lake Chad is permanently shrinking, and some argue that conflict in the region is more closely linked to poor water management and political factors.[2] Similarly, researchers have questioned the link between conflict over land and climate change in the Mopti region of Central Mali. They have found that weak governance is a more powerful explanation than climate variation or extreme weather events.[3]

Figure 2.1 outlines the relationship between ecological threats and the risk of conflict. The specific causal pathways vary spatially and temporally. Armed conflicts tend to escalate where natural disasters induce changes in the relative power of conflict parties—for instance, by facilitating recruitment or decreasing income. By contrast, if one conflict party is weakened by a disaster and the other lacks the capability to exploit this vulnerability, the intensity of armed conflict declines.[4]

FIGURE 2.1

Relationship between hazardous natural events, food insecurity, water risk, and conflict

Increased competition and weak institutions turn ecological threats into increased conflict.



Source: IEP

Resource competition is common, but ongoing conflict can exacerbate levels of competition for limited resources. In cases of ecological shocks, antipathy towards politically salient outgroups can increase in the immediate aftermath of a disaster.[5]

Violence against civilians across sub-Saharan Africa has been shown to be lower in situations of high food security and to increase during periods of food insecurity.[6] There are several reasons for this. During times of food scarcity, food can be a significant recruitment tool for armed groups. Rising food prices can also escalate the operational costs for insurgent groups. As a result, these groups could forcefully take food from civilians, leading to increased harm to civilian populations.[7]

Regions that are more dependent on agriculture are also more likely to be affected, in particular areas with high levels of subsistence farming. Transition zones, which are places that lie between distinct climatic or environmental areas, are particularly prone to conflict, as in the case of the Sahel. Permanently harsh climatic zones are less likely to experience conflict compared to these transitional zones which experience more variability and are more prone to precipitation shocks affecting important agricultural zones.[8]

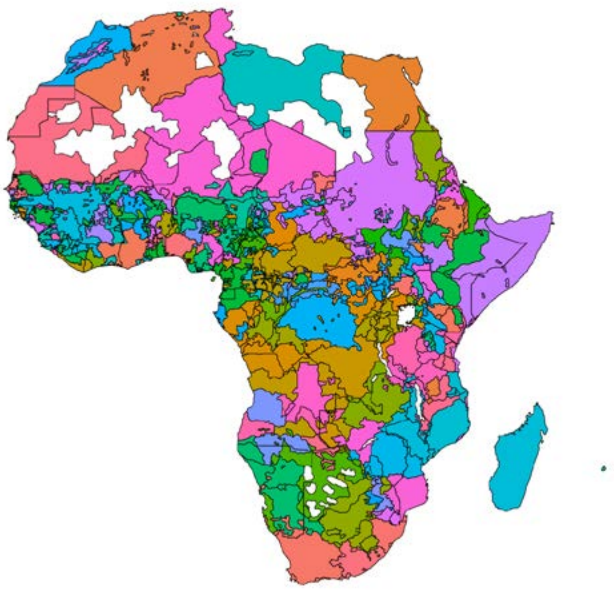
Historical Ethnic Borders and Conflict Dynamics

The relationship between climate change and conflict is highly dependent on context. Ecological threats are most likely to result in new conflicts in areas already experiencing civil strife or in areas with recent past conflict, as most other societies are able to manage disputes over resources without the use of violence. It is therefore unlikely that ecological threats alone raise conflict risks. As such, ecological threats have the potential to play a role in increasing the risk of armed conflict in areas that are historically home to conflicting ethnic groups and the borders between them. Figure 2.2 provides a map of the historical ethnic territories across Africa.

FIGURE 2.2

Map of historical ethnic territories in Africa

The historical homelands of the thousands of ethnic groups on the continent do not conform with the borders of its nation-states.



Source: Weidmann et al. (2010); IEP

Analysing the role historical ethnic borders play in conflicts is useful in understanding conflict dynamics in states and regions where colonial borders, which later became modern state borders, tended to be drawn arbitrarily. Divisions of territory were often determined by colonial actors dividing territory between themselves rather than doing so with respect for existing nations or groups.

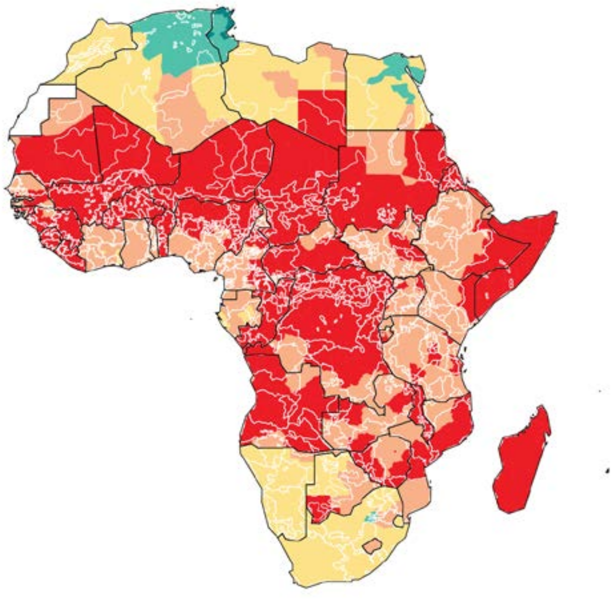
As such, distinct historical homelands were often spread across more than one state, and the clustering of diverse ethnic groups into modern states has in many instances given rise to unresolved tensions. Recent research has shown that regions with historical ethnic borders have a 27 per cent higher probability of conflict, compared to non-border areas, and 7.9 per cent higher probability of being the initial location of conflict.[9]

Such conflict risks can be exacerbated by ecological stressors, as they present new threats to lives and livelihoods. This is particularly the case when groups' traditional occupations and practices – such as pastoralism or sedentary farming – are highly dependent on the conditions of the land. Figure 2.3 provides a map of subnational ETR scores across Africa, overlaid with the historical ethnic borders in the region.

FIGURE 2.3

ETR subnational scores and historical ethnic borders in Africa

Historical ethnic territories, like ecological threats, cross established national borders.



Source: Weidmann et al. (2010); IEP

While disputes around ethnic borders may relate to many possible issues and could involve state and non-state actors, many of the conflicts related to ecological threats and ethnic group borders are linked to resource competition and tend to be smaller in scale. In areas with a larger number of ethnic groups across a geographic region, there tends to be more competition, especially in periods of relative resource scarcity. It is therefore important to focus on areas with previous conflict and high levels of ecological threat.

Water stress as a driver of agro-pastoralist conflict

One of the more prominent issues in relations between ethnic groups in areas of sub-Saharan Africa are the interactions between groups composed predominantly of sedentary farming communities and those composed predominately of nomadic pastoralist herders. In most cases, these interactions are characterised by cooperation and coexistence in the management of shared lands and natural resources. However, in some other increasingly prominent cases, disputes and even violence have arisen over the use of common resources.

The relationship between water stress and farmer-herder conflict is dynamic and context dependent. In affected regions, especially arid and semi-arid areas, water resources are limited and unevenly distributed. Farmers and herders both depend on these scarce water resources, but their needs and practices can come into conflict in periods of below average rainfall. Farmers, who are more likely to settle in specific areas, require water to cultivate crops. Herders, particularly those from nomadic communities, need water for their livestock and their travel across grazing lands. During periods of drought or reduced rainfall, these herders may encroach on farmlands in search of water and pasture, causing damage to crops, while farmers may restrict access to water sources. This is most likely to occur in cases with existing or former conflict between groups over agricultural land.

Water stress directly impacts the livelihoods of both farmers and herders. For farmers, inadequate water supply can lead to poor crop yields or crop failure, affecting food security and income. For herders, insufficient water and grazing land can result in weakened livestock, reduced milk and meat production, and ultimately, loss of livestock.

Agro-pastoralism refers to the livelihoods and lifestyles of agrarian communities, including both sedentary farmers and wandering herders. According to the United Nations' Food and Agriculture Organization (FAO), 50 million people or 72 per cent of the people in the Sahel region make their livelihoods via livestock and thus are part of agro-pastoral communities.[10] Additionally, 13 per cent of the populations of Western and Central Africa (which make up most of those Sahel region) are nomadic or semi-nomadic,[11] and thus travel seasonally and annually in search of land suitable for rearing livestock. This high concentration of agro-pastoralists in the region has led to resource and land conflicts, a trend which has been on the rise in recent years as climate variability and severe weather events continues to worsen.

The Sahel is semi-arid, and its arable land exists in a delicate balance next to the extremely arid Sahara, which is wholly unsuitable for agriculture. The Sahel is increasingly affected by desertification, with research finding that the Sahara expanded by eight per cent between 1950 and 2015. This equates to the Sahara expanding southward by 50 kilometres into the Sahel over this time. This expansion has included periods of shrinking and expansion of the Sahara. From 1950 to 1984, the desert is thought to have expanded southwards by 170 kilometres, which was followed by a period of recovery in the following decades.[12]

These shifts of the Sahara Desert have impacted the livelihoods of agro-pastoralist communities in the transitional zone. Changes in the amount and location of arable land can be a driver of conflict between nomadic pastoralists and settled farmers, with the FAO reporting increased herder-farmer conflicts in agro-pastoral areas of the Sahel. This can be due to both long- and short-term climate fluctuations, as well as adverse governmental policies, disruption of mobility routes, and land acquisition for agro-industrial projects.[13]

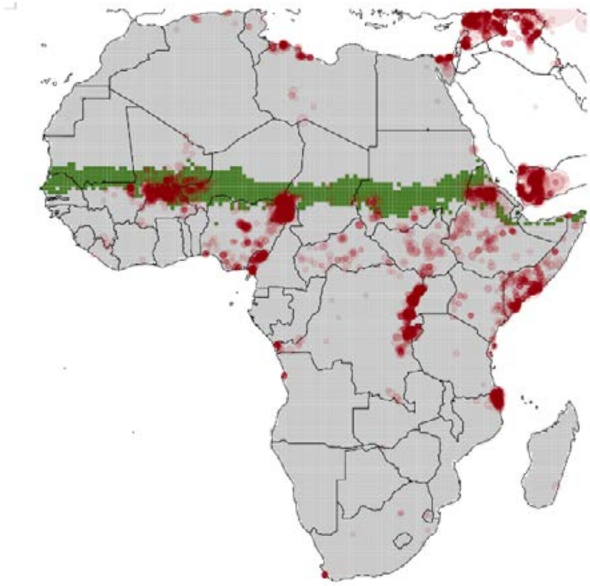
Regions that are more dependent on agriculture are also more likely to be affected, in particular areas with high levels of subsistence farming. Transition zones between desert and temperate areas, like the Sahel, are particularly prone to conflict, as they experience more variability and more precipitation shocks affecting important agricultural zones. In contrast, permanently harsh climatic zones are less likely to experience conflict, as their conditions are more predictable, they tend to have fewer people, and there is more consistency in the amounts of produce they generate.[14] Because transition zones tend to carry more people, when changes in climatic conditions occur within them, more people are affected and the effects are often more severe.

Figure 2.4 shows the Sahara transition zone and total conflict deaths in 2020. The transition zone accounts for 7.6 per cent of the total land mass, but just under 16 per cent of total deaths. Nearly 15 per cent of transition zone areas in sub-Saharan Africa recorded at least one death, compared to just 5.3 per cent for non-transition zones.

FIGURE 2.4

The Sahara transition zone and conflict deaths, 2020

Nearly 15 per cent of transition zone areas recorded conflict deaths, compared to five per cent in non-transition zones.



Source: Schon et al. (2023); IEP

Note: Brown dots denote areas of conflict, while the green denotes the Sahel transition zone.

Cooperation over water as a mechanism for peaceful coexistence between farmers and pastoralists

The vast majority of farmer herder interactions remain peaceful and most groups cooperate over the sharing of resources. A core challenge is seeking to manage and resolve existing conflicts that have high potential to recur.

A number of groups are working across the Sahelian transition zone to address conflict risks in these areas. The European Union's Trust Fund for Africa (EUTF) is one international organisation working with the local communities of agro-pastoralists in the Sahel to try and reduce environmental stressors and other factors that lead to conflict. The EUTF predominantly funds resilience projects that are designed to improve farmer-herder relations - but are not specifically aimed at them - such as conflict prevention and mediation, resource access, and climate change. In addition to funding and creating their own projects, the EUTF has also worked to analyse which methods of outreach and aid are most effective in reducing conflict and aiding agro-pastoral communities.

The EUTF has found that empowering existing community systems and traditional conflict method systems tends to be the best way to respond to increased conflict. Similarly, when addressing conflict stressors like resource scarcity, it has found it crucial to engage the community in decision-making processes about development projects, such as solar-powered water infrastructure or similar projects. This sometimes entails getting the perspectives of pastoral associations and other representative groups. Getting local input has been key in carefully assessing any potential negative impacts of new developments, as there are risks of the environment in previously dry areas actually being harmed by new water access infrastructure. In contrast to universal solutions imposed by foreign governments or organisations, the EUTF's review points to the need for approaches based on the specific needs and wants of local communities.[15]

In this work, the role of institutional trust is paramount. Functioning institutions and infrastructure increase resilience and reduce the risk of armed conflict following ecological shocks. In sub-Saharan Africa, flooding is linked to increased communal violence in administrative districts where there is a lack of trust in local institutions. Where local government councils and judicial courts are trusted, flood disasters result in reduced risk of intercommunal violence.[16]

Non-state Conflict and Escalation

Many of the conflicts relevant to this analysis involve non-state actors or are communal conflicts between ethnic groups or armed actors purporting to represent them. Some, however, are national or even transnational in nature. In areas like the Sahel, transnational jihadist groups like JNIM and Islamic State have co-opted existing grievances and conflicts at the intercommunal level as mechanisms for mobilising local populations or recruiting fighters. In the aftermath of the 2011 Libyan revolution, Tuareg fighters who had previously been part of Gaddafi's army deserted and returned to northern Mali where they formed a loose coalition with transnational jihadist groups in 2012 sparking the Malian civil war. Over time, jihadist groups have cemented themselves to become the key actors in the conflict, not by importing foreign fighters but by adopting the grievances of nomadic pastoralist populations through which they have recruited and mobilised fighting forces.

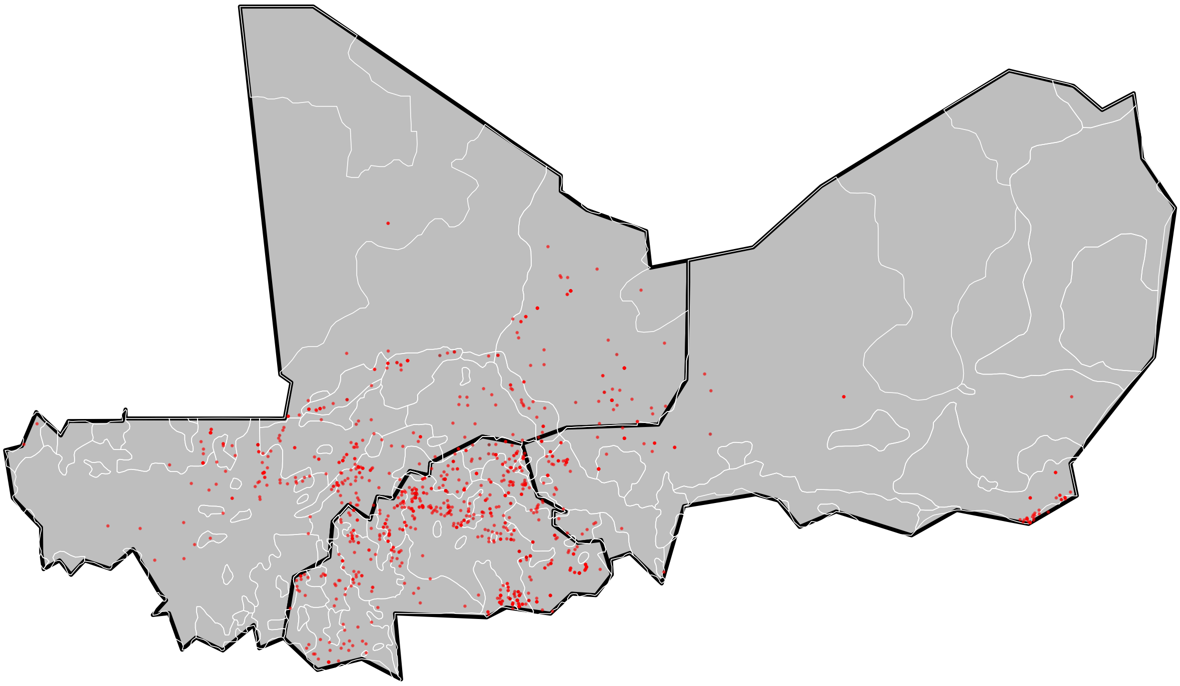
Pastoralist nomadic groups that have often come into conflict with farming communities are now a significant part of the local IS or Al Qaeda affiliates. Rather than continuing their lower-level local conflicts, they now also fight government forces and government backed paramilitaries. These pro-government militias and 'self-defence' groups are often recruited from groups in historical conflict with pastoralists. The growth of violence by these and other groups across the Central Sahel - Mali, Burkina Faso, and Niger – is significant, as it can trigger new violent conflict between herders and farmers.

The deadly events that took place in 2023 as a result of these intersecting tensions in the region are mapped in Figure 2.5. This map shows where such events have occurred with respect to the borders of the three countries, as well as historical ethnic borders. As can be seen, some areas crisscrossed by multiple historical borders show a comparatively large number of conflict events, while other ethnically diverse areas are not marked by this dynamic. This shows the complex ways in which high levels of ethnic group diversity can affect conflict. Notably, where national or transnational actors co-opt and instrumentalise smaller local conflicts, high diversity can function as a risk factor. Across the three countries, the number of such fatalities has been on the rise in recent years, with last year recording the highest number on record, as shown in Figure 2.6.

FIGURE 2.5

Conflict events resulting in deaths within country and historical ethnic borders, the Sahel tri-border area, 2023

Last year, Burkina Faso, Mali, and Niger experienced thousands of deadly conflict events driven by intersecting tensions related to ideology, territory, and resource competition.

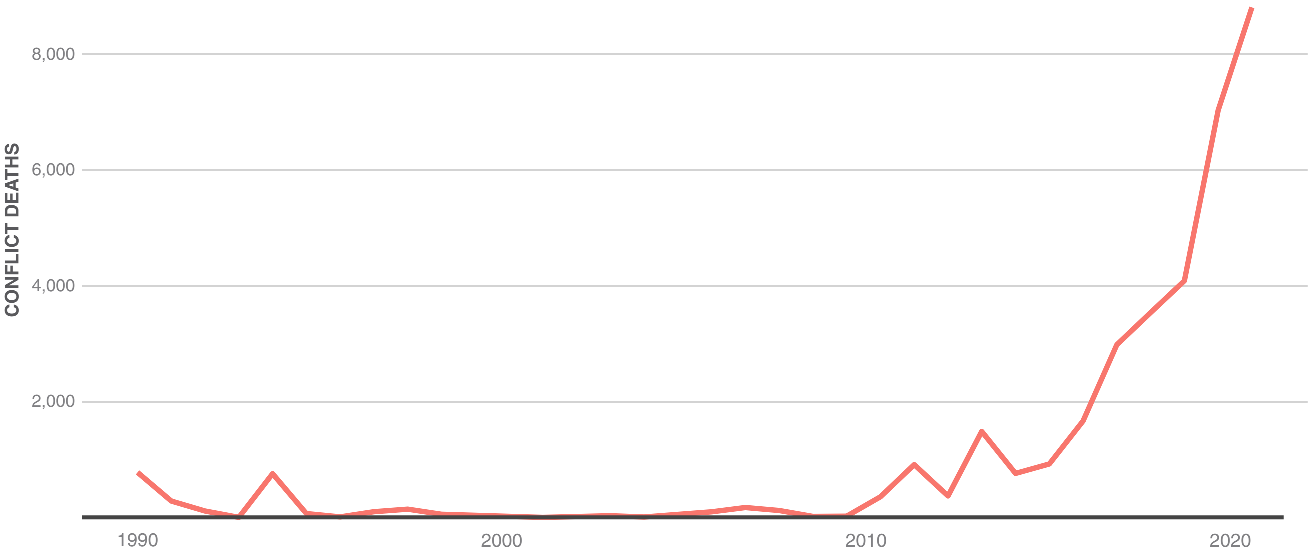


Source: UCDP

FIGURE 2.6

Conflict deaths in the Sahel tri-border area, 1990–2023

Burkina Faso, Mali and Niger, which together make up the Liptako-Gourma region, have experienced a substantial rise in conflict deaths since 2016.



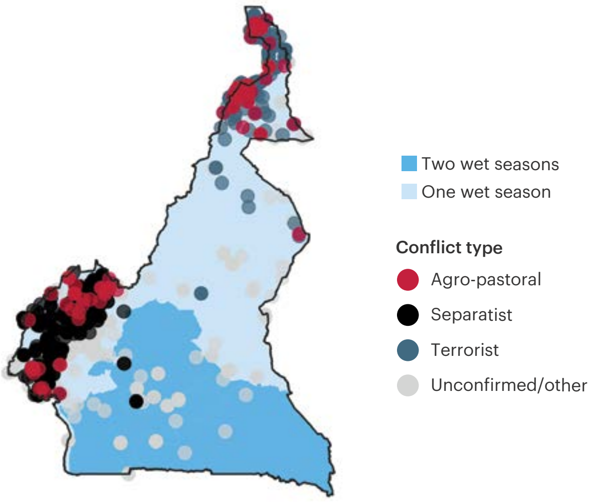
Source: UCDP

Similar dynamics can be seen in Cameroon, where almost all agro-pastoral conflict occurs in areas that are also affected by terrorist or separatist violence. As shown in Figure 2.7, the presence of other types of violence, including terrorism, can intensify conflict between farmers and herders. Violence limits access to land and water sources, forcing pastoralists to encroach on more distant farming communities.[17] Outside of the conflict-affected regions of the north and west, there is little agro-pastoral conflict, both in areas that have one wet season per year and in those that experience two.

FIGURE 2.7

Rainfall zones and conflict events by type, Cameroon, 2018–2022

Outside of the conflict-affected regions of the north and west, there are similar levels of conflict in areas which experience either one or two wet seasons.



Source: FEWS NET; ACLED; IEP

Historical conflicts and grievances often intersect with these types of conflicts, where ecological threats like water stress can exacerbate competition for resources among groups with existing tensions. While water stress may not directly cause conflict, it can intensify disputes between groups with a history of grievances.

Untangling the underlying motivations of group conflicts in these contexts can be particularly challenging, as the divide between farming and herding communities often coincides with ethnic and religious differences. These overlapping identities make it difficult to separate resource disputes from cultural, ideological, and religious tensions.

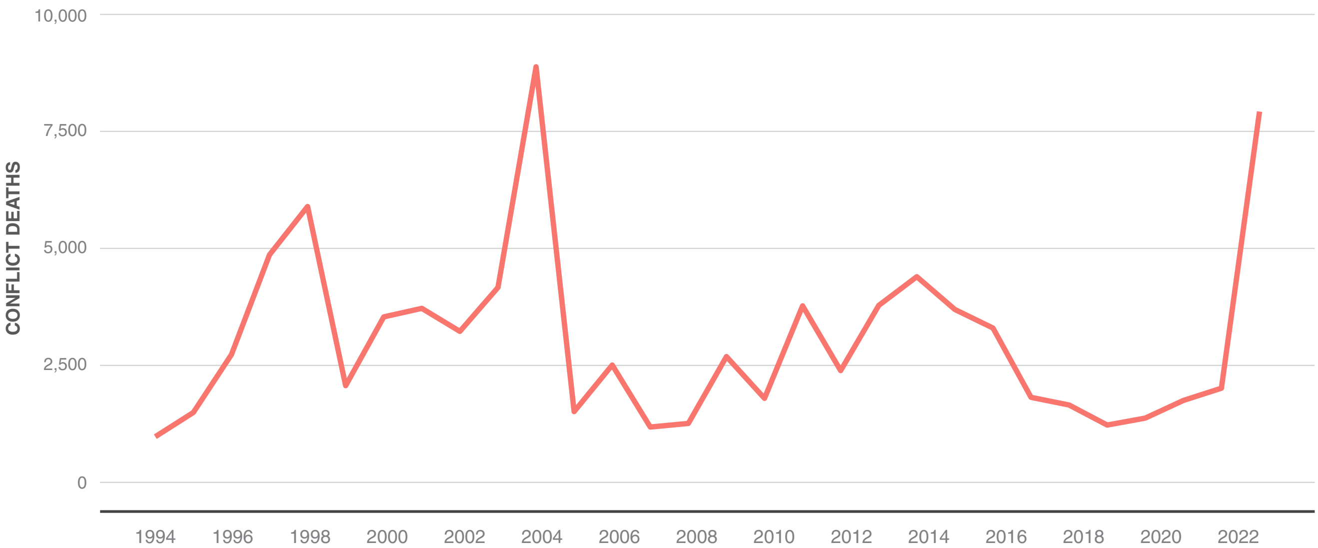
In Sudan's Darfur region, for instance, many of the Janjaweed militia responsible for the 2003-05 genocide of black African civilians belonged to Arab herder ethnic groups and specifically targeted farming communities from various Darfuri ethnic groups. While the war and genocide in Darfur involved national and rebel forces and was driven by many factors, conflicts over resources at the local level represented a significant factor behind the violence.

The violence during the genocide in some ways helped formalise the use of the Janjaweed militias and deepen the longstanding conflicts in which they were involved. What might have initially been more sporadic conflicts associated with ecological pressures and resource scarcity thus evolved into more politically and ideologically entrenched violence. Before the genocide, these conflicts were lower in intensity and resulted in fewer deaths. Following the genocide, however, conflict deaths remained relatively high, as shown in Figure 2.8. This suggests that localised ethnic and ecologically based grievances have the potential to escalate into sustained national-level civil conflict.

FIGURE 2.8

Conflict deaths in Darfur, 1994–2023

Following the genocide in Darfur in 2003–2005, conflict deaths remained higher than their pre-2003 levels.



Source: UCDP

Note: These figures do not include all civilian deaths associated with the genocide in Darfur, which are estimated to total 200,000.[18]

This evolution has carried into the present, with this same dynamic at play in the current civil war in Sudan, in which the Rapid Support Forces (RSF) represent a newer and more formalised iteration of the Janjaweed militias. Since the war began in April 2023, the RSF has primarily been seeking to take full control of Sudan from the national government in Khartoum, but it has also been involved in significant violence in the Darfur region, including attacks and massacres, as part of its broader efforts to consolidate power. The group's actions in Darfur reflect their historical roots in the Janjaweed militias and their ongoing efforts to assert dominance in regions where they have longstanding influence. While the recent violence in Darfur is driven by power struggles between the RSF and the Sudanese Armed Forces, the underlying ecological and resource challenges in the region continue to play a role in fuelling and sustaining the conflict.

Low-level conflicts and why they are important

Low-level, localised conflicts, which are often fought over resources, can be instrumentalised or co-opted by national or transnational actors to serve broader interests. While relatively few conflicts do escalate in this way, it is still worth identifying just how many conflicts meet similar criteria and could, under particular circumstances, be subject to ideological narrative manipulation and escalation. As shown in Table 2.1, there were at least 49 conflicts active in 2023 in sub-Saharan Africa that included a non-state actor fighting either civilians or another non-state actor. This list excludes gang and cartel violence as well as one-sided violence involving terror groups. The threshold for inclusion was at least five conflict deaths in 2023.

While there are outliers on this list, such as ideologically motivated groups, it primarily shows lower-level conflicts that do not currently involve major national or transnational actors but may be at risk of future co-option or escalation by such forces in the future. Greater focus on these smaller conflicts could be an effective method of preventing conflict escalation, and lower-casualty conflicts may also be more amenable to resolution. A focused analysis of root causes and conflict dynamics for each of the conflicts would be an important first step towards resolution efforts.

As shown in the table, the Democratic Republic of the Congo was the country most affected by this type of violence last year, with at least 14 such conflicts resulting in at least 1,550 deaths. Almost half of these recorded deaths came from a single conflict associated with the Cooperative for Development of the Congo/ Union of Revolutionary Forces of Congo (CODECO/URDPC). This conflict is part of the broader context of ongoing violence in the eastern regions of the country, particularly in the Ituri province. The CODECO-URDPC has been active in the Ituri region and, like many others in the area, is involved in conflicts that are deeply rooted in ethnic tensions, competition over natural resources, and grievances against the government. The violence associated with the CODECO-URDPC has often targeted civilians, including systematic and large-scale attacks on villages.[19] The conflict reflects the broader issues of governance, resource control, and ethnic strife in the country, where multiple armed groups operate with impunity due to weak state presence and ongoing instability.

TABLE 2.1

Active non-state actor conflicts in sub-Saharan Africa, 2023

There were at least 49 conflicts in the region that included a non-state actor fighting either civilians or another non-state actor.

Country	Conflicts	Deaths
Democratic Republic of the Congo	14	1,550
Nigeria	11	772
Sudan	5	500
Ethiopia	5	363
South Sudan	3	166
Central African Republic	2	129
Mali	4	129
Cameroon, Nigeria	1	105
South Sudan, Sudan	1	72
Chad	1	42
Ghana	1	15
Niger	1	14
Total	**49**	**3,857**

Source: UCDP

Historical conflicts and ecological threat

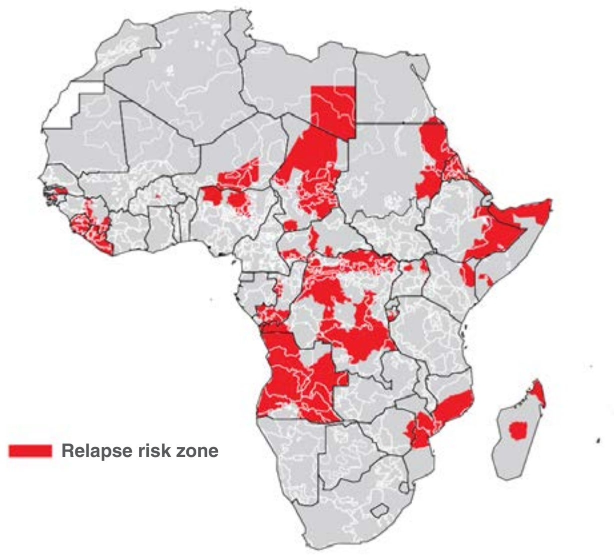
Past conflict is usually the best indicator of future conflict. As such, focusing on areas with a history of conflict, even if they are currently peaceful, is crucial for preventing relapses into violence and addressing unresolved issues that could reignite tensions. This is also true when considering the link between climate change, environmental threats and war. Areas already prone to conflict are most at risk, and ongoing conflicts may escalate due to mounting pressures associated with climate change.

Like ecological pressures, tensions along historical ethnic borders can also function as a conflict stressor. As such, examining areas that combine a history of conflict, very high ecological threats, and the presence of historical borderlands is therefore useful in identifying places that may present the greatest risks of conflict relapse. Figure 2.9 therefore provides a map of subnational units with these three characteristics. Across sub–Saharan Africa, there are dozens of such subnational units, with particularly prominent clusters in Central Africa, around the Horn of Africa, and in far western Africa.

FIGURE 2.9

Conflict relapse risk zones in Africa at the subnational level

Across the continent, there are dozens of subnational areas that face very high levels of ecological threat, cross the historical territories of multiple ethnic groups, and have a history of conflict but currently no major hostilities.



Source: Weidmann et al. (2010); IEP

Moving from the subnational to the national level, Table 2.2 lists conflicts that are currently inactive but have been active in the past 30 years in countries whose national ecological threat scores are high or very high. This list is not predictive of future conflict, but it can act as an indication of areas that may be at greater risk of conflict recurrence. It outlines areas where efforts at mitigating the impacts of ecological threats might be most effective in simultaneously functioning as strategies for conflict prevention.

Most of the places shown in Table 2.2 and Figure 2.9 have experienced significant improvements in peacefulness in recent years. As such, highlighting such cases should not be interpreted as a prediction of future conflict or instability. However, countries and subnational areas with a history of conflict are at a higher risk of seeing a recurrence of conflict, and ecological threats – along with unresolved tensions along historical ethnic territories – can serve to exacerbate such risks. These places, despite their recent progress, should remain conscious of these compounding stressors and should take proactive measures to prevent potential issues from arising. The persistent ecological challenges in these regions could reignite tensions if left unaddressed, making them important areas of focus for future stability efforts, both by the countries themselves and by international actors.

Conclusion

There is a complex and multifaceted relationship between ecological threats and armed conflict. While climate change and environmental pressures are not direct causes of violence, they significantly amplify existing tensions and vulnerabilities, particularly in regions with a history of conflict and weak institutions. Examining historical ethnic group homelands, rather than traditional state boundaries, provides a more precise understanding of how these threats intersect with socio-political dynamics, revealing patterns that might otherwise be overlooked.

The findings make clear that addressing ecological threats as part of broader conflict prevention and resolution strategies is crucial. This is particularly the case for agro-pastoralist conflicts that have been exacerbated by resource scarcity. As climate change continues to intensify, the potential for these threats to trigger or reignite conflicts is likely to grow. Therefore, it is imperative to strengthen governance, enhance resilience, and foster cooperation among communities to mitigate the risks associated with ecological threats and reduce the likelihood of conflict escalation.

TABLE 2.2

Sub-Saharan African countries with inactive conflicts and high to very high ETR scores

Seven countries in the region have a history of conflict in the past 30 years as well as severe levels of ecological threat.

Country	Conflict	Active Years	Deaths	ETR Score
Sierra Leone	Government of Sierra Leone - Revolutionary United Front (RUF)	1991-2001	11,473	4.71
Liberia	Government of Liberia - LURD	2001-2003	2,677	4.55
Angola	Government of Angola - UNITA; Government of Angola - FLEC	1975-2002; 1991 - 2022	30,222; 511	4.24
Uganda	Government of Uganda - Lord's Resistance Army (LRA); Government of Uganda - Allied Democratic Forces (ADF)	1989-2007	11,277	4
Côte d'Ivoire	Government of Côte d'Ivoire - FRCI; Government of Côte d'Ivoire - MPIGO	2002-2004; 2011	946	3.44
Senegal	Government of Senegal - MFDC	1990-2011	1,373	3.86
Republic of the Congo	Government of Republic of the Congo - MFDC	1990-2011	1,373	3.86

Source: UCDP

58%

By 2050, 58 per cent of sub-Saharan Africa's population will live in urban areas, up from 44 per cent today.

6%

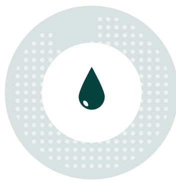
Sub-Saharan Africa has large and relatively untapped water resources. The region could irrigate all its lands with irrigation potential using less than six per cent of its renewable water resources.

2/3

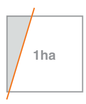
Two out of every three people in sub-Saharan Africa are food insecure, and the population of the region is expected to nearly double by 2050, significantly increasing the pressure on food systems.

1.8%

The region's yield gaps are in part a result of lack of irrigation. Sub-Saharan Africa has the lowest irrigation rates in the world, with only 1.8 per cent of cultivated land being irrigated.



Sub-Saharan Africa faces agricultural productivity challenges and large yield gaps. The region's average cereal yield is 1.7 tonnes per hectare, less than half the global average of 3.8 tonnes per hectare.



Sub-Saharan Africa has the lowest chemical fertiliser usage globally, applying less than one-sixth of the global median of nitrogen fertiliser per hectare.

To meet its basic food needs by 2050, sub-Saharan Africa will need to more than double its production of cereals, which represent the foundation of the region's diet.

14%

In low- and middle-income countries, the amount of irrigated land is expected to increase by 34 per cent by 2030, but total agricultural water usage is expected to increase by only 14 per cent.

IEP estimates that annual investments totalling about US$15 billion by 2050 in irrigation systems, new water capture projects, increased use of fertilisers, and expanded grain storage infrastructure could help the region increase its cereal production by more than 50 per cent.

34.2 million hectares

According to FAO data, sub-Saharan Africa has about 34.2 million hectares of land with untapped irrigation potential, meaning it has substantially underutilised productive capacity.

80%

IEP estimates that providing adequate water to fully utilise these lands would cost about US$9.2 billion per annum and result in average yield increases of about 80 per cent, which would have a total annual value of at least US$12.3 billion.

3 Towards Food Security in Sub-Saharan Africa

Overview

Sub-Saharan Africa is the most food insecure region in the world. According to estimates from the United Nations Food and Agriculture Organisation (FAO), 26.6 per cent of the people in the region suffer from undernourishment or severe food insecurity, and a further 40.6 per cent are moderately food insecure.[1]

Food insecurity, and particularly undernourishment, poses significant challenges to both individual and societal wellbeing and development, and its effects are particularly acute for children. For example, poor nutrition combined with inadequate stimulation in childhood has been found to result in a loss of up to 15 IQ points. This can substantially impact a person's long-term earning potential, with one study finding that children who have experienced stunting earn 25 per cent less income as adults. The critical "golden window" for preventing these effects is the first 1,000 days after conception, during which any damage is likely to be irreversible.[2]

For the region to minimally fulfill its current food needs, and also achieve a relative degree of food independence, IEP estimates that it would need to increase its production of staple cereals by at least 25 per cent. In addition, the region's population is projected to grow by more than 70 per cent in the next 26 years, with most of the growth occurring in urban areas. In view of these pressures, the region would have to more than double its cereal production by 2050 to meet its basic food needs.

These demands come in the context of rising ecological threats. In particular, stresses on access to renewable water sources are projected to become more acute in the coming years. Despite this, the region has an untapped capacity to increase its agricultural output through the expansion of agricultural water use. Combined with investments in enhanced application of other inputs and the implementation of other agricultural innovations, sub-Saharan Africa has the potential to meet and even exceed its food needs in the coming decades.

This section looks at the current food production challenges facing sub-Saharan Africa, gives an overview of the best possible strategies for improving production, and provides a model which estimates the costs of making these improvements.

Food Security Challenges

Population growth

In the next 26 years, the population of sub-Saharan Africa is projected to nearly double, from 1.2 billion in 2024 to 2.1 billion in 2050. In contrast, the population of the rest of the world is projected to grow by only about 10 per cent.

Sub-Saharan Africa's growth will shift its current rural-urban balance. At present, 44 per cent of the population live in urban settings, making it one of just two regions in the world that continues to be predominantly rural. However, by 2050 it will be majority urban, with 58 per cent of the population projected to live in towns and cities.

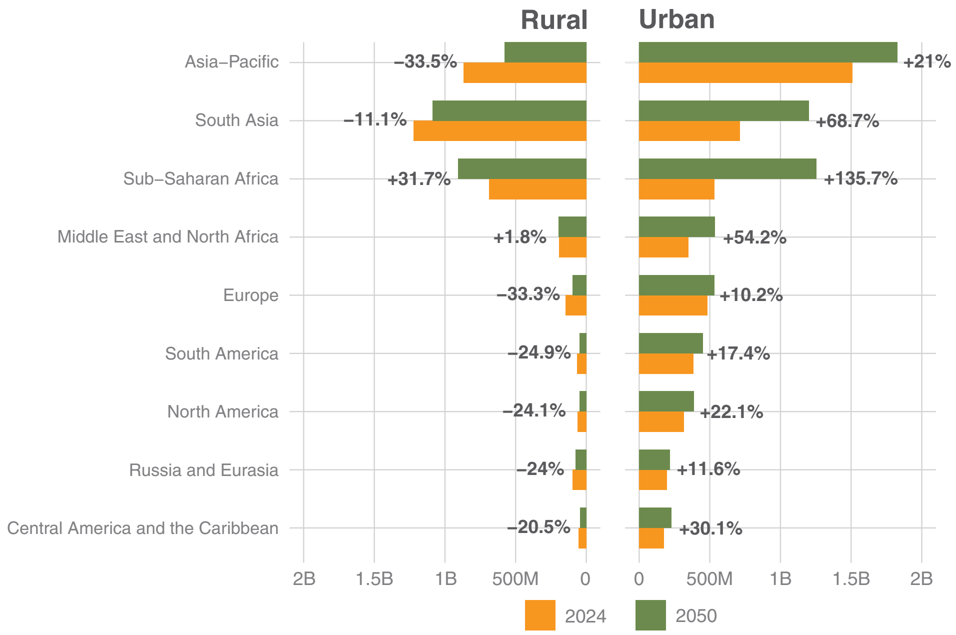
Despite this sizeable shift, the overall demographic expansion in sub-Saharan Africa will be so large that its rural population will also grow markedly. As shown in Figure 3.1, while rural populations in all other regions of the world will either shrink or remain virtually unchanged, sub-Saharan Africa's rural population will grow by 32 per cent in the next two and a half decades. Over the same period its urban population is projected to grow by 136 per cent.

This population growth will necessitate substantial increases in food productivity, especially as the proportion of the labour force dedicated to agriculture will decline as growing numbers migrate to towns and cities.

FIGURE 3.1

Rural and urban population projections by region, 2024 to 2050

Sub-Saharan Africa is the only region projected to experience sizeable growth in both urban and rural settings.



Source: UN; IEP calculations

Current production and consumption dynamics

Africa has often been labelled as food reliant, as it is a net importer of food,[3] despite most of its labour force being engaged in agriculture. However, while the continent has the highest levels of food insecurity in the world and does import more food than it exports, the reality is more complex.

The agricultural trade deficit in sub-Saharan Africa is driven by a small minority of countries. The deficits of just two countries, Nigeria and Angola, are greater than the deficit of sub-Saharan Africa as a whole, meaning that without these countries the region would have a slight surplus. In contrast, the continent's middle-income countries have agricultural trade surpluses which together total more than US$13 billion.[4]

Based on trade balance averages from 2018 to 2022, the region's annual agricultural imports have a value of US$46.4 billion, while its agricultural exports have a value of US$52.2 billion. The region's top exports are mostly tropical cash crops like cocoa, coffee, tea, and cotton, while its imports tend to be food staples like wheat, rice, and soybeans. This contrast between the types of foods that are imported and those that are exported helps explain why only about 20 per cent of the food trade in the region is intra-African.[5]

Sub-Saharan African countries are less externally food reliant than is sometimes suggested, as most of the calories they consume are grown domestically. Figure 3.2 shows estimates of consumption of locally grown cereals across 20 sub-Saharan African countries. The figures were calculated from the total average volumes (in tonnes) of all cereals – including staples like maize, sorghum, millet, rice, and wheat – that were produced across the countries, compared to the total average volumes of cereal exports and imports.[6]

This analysis focuses on cereals, as they represent the basis of the diets of most of the world's people. Cereals contribute about 50 per cent to global caloric intake and around 70 per cent of the caloric intake in sub-Saharan Africa.[7] Therefore, while vegetables, fruits, and protein-rich foods such as meat are important to a complete diet, addressing sub-Saharan Africa's current and future food needs will depend heavily on boosting cereal production. Non-cereal foods, particularly animal products, also tend to incur higher costs related to land, water, and other resources. In view of the mounting ecological challenges the region is facing, prioritising cereal production will therefore also present less intensive environmental trade-offs in many instances.

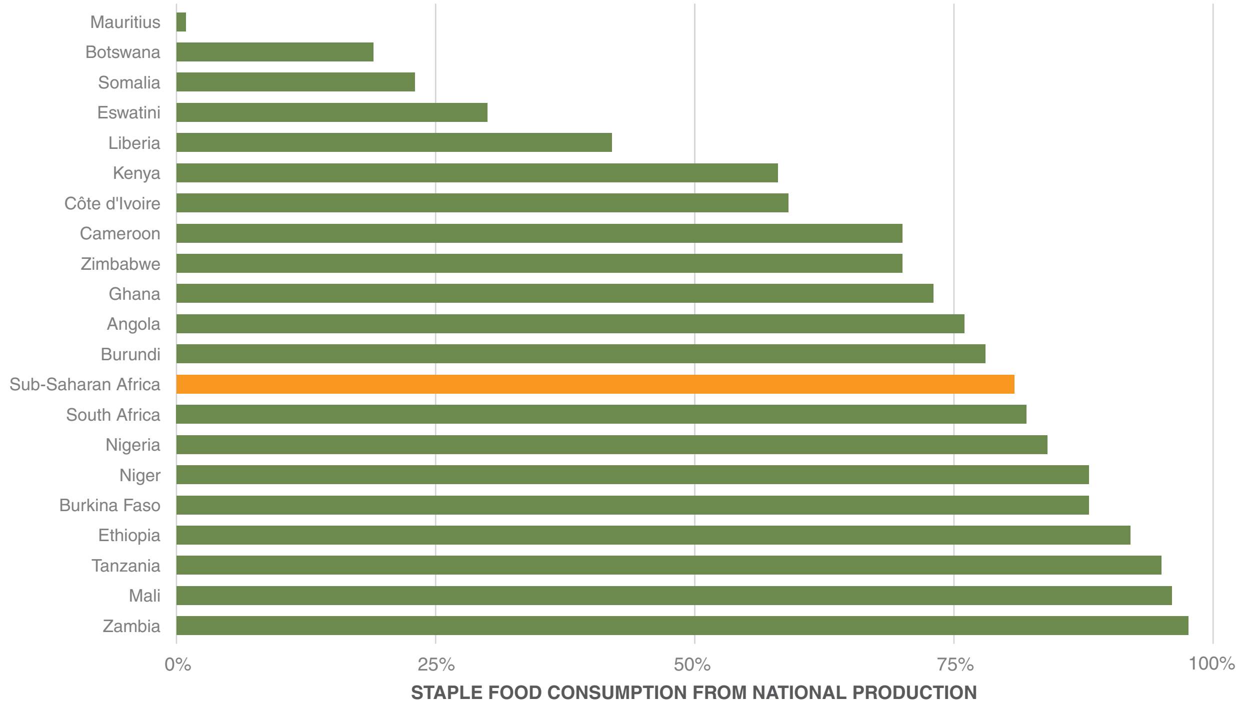
In sub-Saharan Africa, 80.8 per cent of the cereals consumed are domestically produced, slightly lower than the global rate of 85.8 per cent. However, it is significantly lower than the highest regional rate of 97.5 per cent in North America and significantly higher than the lowest regional rate of 43 per cent in the Middle East and North Africa. Within sub-Saharan Africa, the rates range from 97.6 per cent in Zambia to 0.2 per cent in the small island nation of Mauritius.

The region's heavy reliance on domestically grown food indicates that meeting growing food demand in the next quarter of a century will depend on boosting its internal agricultural production.

FIGURE 3.2

Percentage of staple food consumption from national production, 2018–2022 averages

Four-fifths of staple cereals in sub-Saharan Africa are grown and consumed domestically.



Source: FAO; IEP calculations

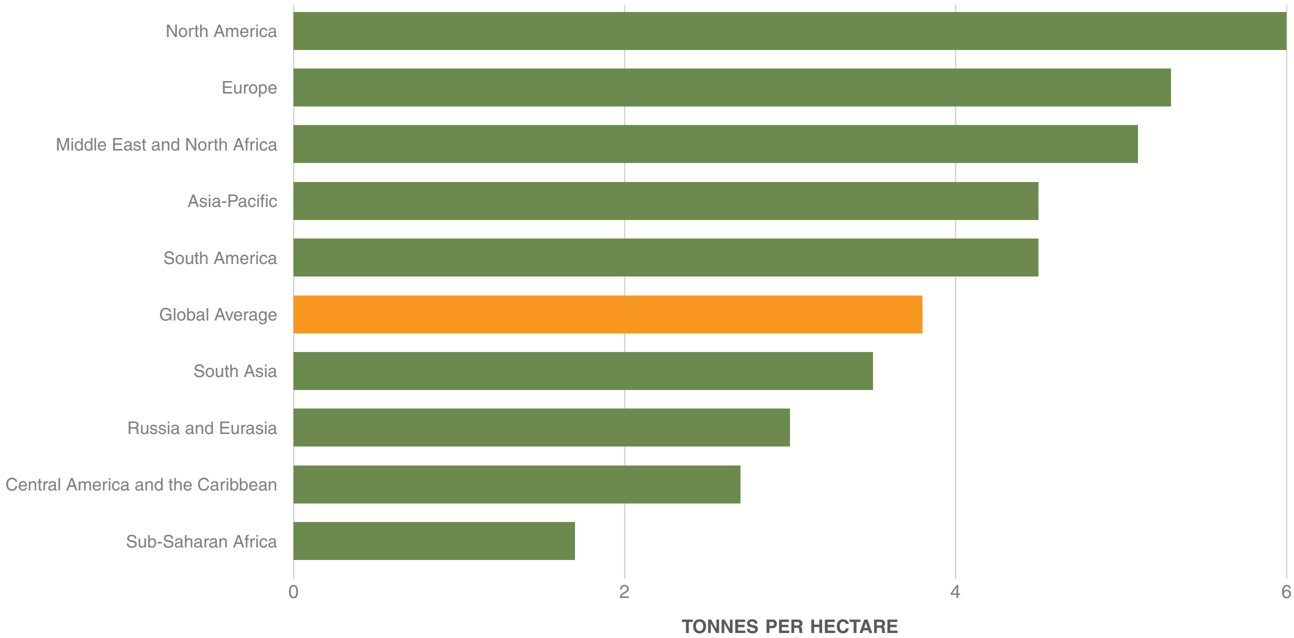
Agricultural yields

Sub-Saharan Africa has the lowest crop yields of any region in the world. As shown in Figure 3.3, farms in the region produce an average of about 1.7 tonnes of cereals per hectare each year, less than half of the global average of 3.8 tonnes per hectare. Moreover, 15 of the 20 least productive countries in the world are in sub-Saharan Africa, as shown in Table 3.1.

FIGURE 3.3

Tonnes of cereal produced by hectare, regional averages 2018–2022

Farms in sub-Saharan Africa produce less than half of the global average.



Source: FAO; IEP calculations

TABLE 3.1

Countries with the lowest output of cereals per hectare, 2018–2022 averages

Fifteen of the 20 countries with the lowest yields per hectare are in sub-Saharan Africa.

Rank	Country	Region	Annual tonnes of cereals per hectare
1	Niger	Sub-Saharan Africa	0.51
2	Somalia	Sub-Saharan Africa	0.55
3	Sudan	Middle East and North Africa	0.63
4	Namibia	Sub-Saharan Africa	0.63
5	Eritrea	Sub-Saharan Africa	0.64
6	Libya	Middle East and North Africa	0.67
7	Lesotho	Sub-Saharan Africa	0.71
8	Gambia	Sub-Saharan Africa	0.73
9	Botswana	Sub-Saharan Africa	0.79
10	Central African Republic	Sub-Saharan Africa	0.81
11	Democratic Republic of the Congo	Sub-Saharan Africa	0.84
12	Chad	Sub-Saharan Africa	0.86
13	Republic of the Congo	Sub-Saharan Africa	0.88
14	South Sudan	Sub-Saharan Africa	0.9
15	Mozambique	Sub-Saharan Africa	0.92
16	Angola	Sub-Saharan Africa	0.99
17	Haiti	Central America and the Caribbean	1.07
18	Yemen	Middle East and North Africa	1.07
19	Liberia	Sub-Saharan Africa	1.11
20	Jamaica	Central America and the Caribbean	1.13

Source: FAO; IEP calculations
Note: Only includes countries included in the GPI.

Yields in sub-Saharan Africa are generally lower than those in high-income countries. In wealthier nations, extensive use of chemical fertilisers and high levels of mechanisation, often within monoculture farming on large tracts of land, enable growers to standardise and maximise their planting, cultivating, and harvesting processes. By contrast, farmers in sub-Saharan Africa largely depend on traditional, labour-intensive methods on smaller plots of land.

Poor infrastructure further exacerbates the challenges faced by sub-Saharan African farmers. In many areas, low-quality roads and transportation infrastructure hinder access to markets, undermining farmers' ability to profit from their crops and invest in better farming practices. Additionally, inadequate storage facilities contribute to high post-harvest losses, reducing incentives to increase production. Limited access to credit and financial resources prevents investment in productivity-enhancing technologies, while insecure land tenancy discourages long-term investments in land improvement.

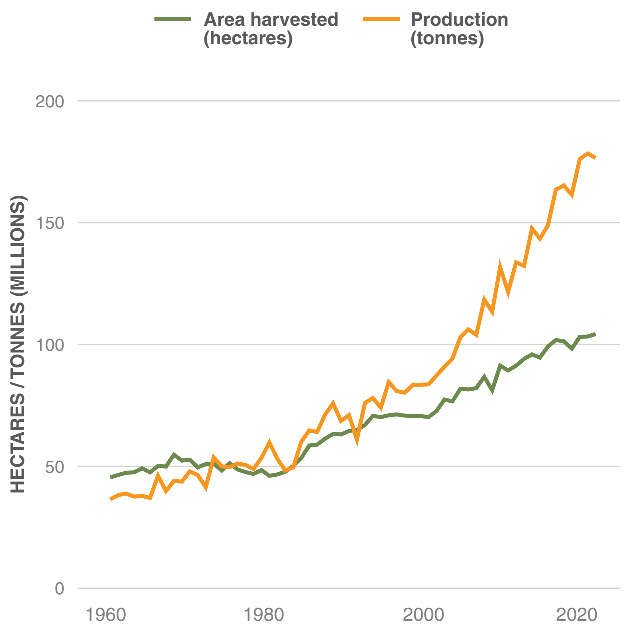
Boosting yield productivity in sub-Saharan Africa therefore presents both significant opportunities and challenges. One of the major opportunities lies in the region's vast and relatively untapped agricultural potential. Sub-Saharan Africa has approximately 200 million hectares of uncultivated arable land, representing about 60 per cent of the global total.[8]

Despite these challenges, total food production has been increasing in the region for decades. This has come from both the expansion of lands under cultivation and the increasing productivity of those lands. Figure 3.4 shows the total area under cereal cultivation and the total production in tonnes of cereals in sub-Saharan Africa from 1961 to 2022. During that time, the area has grown from 45.5 million hectares to 104.3 million hectares, equivalent to an annual growth rate of 1.5 per cent. The volume of cereals produced has grown from 36.5 million tonnes to 176.6 million tonnes, equivalent to an annual growth rate of 2.6 per cent.

FIGURE 3.4

Total area harvested and tonnage of cereal production in Sub-Saharan Africa, 1961–2022

The total volume of cereals produced in the region has increased nearly fivefold.



Source: FAO

The 4.8-fold increase in agricultural production in sub-Saharan Africa has been driven almost equally by land expansion, which grew by 129 per cent, and yield improvements, which increased by 111 per cent. Most of these gains have occurred in the past two decades, with cereal production rising by 3.6 per cent annually. If this trend continues, the region could double its production by 2056, with cultivated land increasing by half and yields per hectare by one-third.

However, these gains are not accidental; they are the result of deliberate policies and efforts by farmers, governments, and non-governmental organisations. To sustain this growth, continued promotion of best farming practices and innovations is essential. Additionally, expanding farmland comes with significant social and ecological trade-offs, making it crucial to focus more on increasing yields rather than further land expansion, though both approaches will likely be needed.

There are numerous opportunities to boost production on existing farmland in sub-Saharan Africa. One effective strategy is adopting high-yield crop varieties, which are bred to produce more per hectare than traditional varieties. These crops often have better resistance to pests, diseases, and adverse weather conditions like drought, making them more reliable for farmers.

Technology also plays a vital role in improving yields. For instance, mobile apps can provide farmers with real-time weather forecasts, helping them plan planting and harvesting more effectively and avoid losses from unexpected weather changes. These apps can also provide up-to-date information on crop prices, enabling farmers to make informed decisions about when and where to sell their produce. Additionally, digital platforms can improve access to agricultural extension services, offering advice on best practices and solutions to common problems.

The application of strategies of this kind is known as sustainable intensification, which aims to increase food production from existing farmland while minimising negative environmental impacts. This approach focuses on improving yields without expanding agricultural areas, thereby preventing deforestation and loss of biodiversity.[9]

The concept also emphasises the importance of resilience and adaptability in farming systems. This includes diversifying crops and livestock to reduce the risk of crop failure, adopting agroforestry and Farmer Managed Natural Regeneration practices and thoughtfully combining scientific innovations with local knowledge. The goal is to create agricultural systems that are not only more productive but also more resilient to climate change and other environmental stresses.

However, there are many challenges to successfully implementing these and other production-enhancing measures, particularly for smallholder and family farmers. Farms smaller than 10 hectares make up about 80 per cent of the cultivated land in the region, and most of these are smaller than two hectares. Despite their small size, these types of farms number in the tens of millions and produce up to 90 per cent of the food in some countries.[10]

Resource constraints can make it difficult or unattractive for smallholders to adopt new technologies or practices that require high initial investments. For example, they may struggle to afford high-yield seed varieties and fertilisers. Without reliable access to markets, smallholders may not see the economic benefits of investing in yield-boosting technologies. Moreover, smallholders may be more risk-averse due to their limited margins for error, making them hesitant to adopt new practices with which they are not familiar.

The 4.8-fold increase in agricultural production in sub-Saharan Africa has been driven almost equally by land expansion, which grew by 129 per cent, and yield improvements, which increased by 111 per cent.

BOX 3.1

Farmer Managed Natural Regeneration

Farmer Managed Natural Regeneration (FMNR) is a low-cost land restoration technique developed by Tony Rinaudo of World Vision. First implemented in Niger during the 1983 famine, FMNR uses micro-catchments – small areas designed to trap runoff – allowing soil and water to nourish plants directly. This method is highly effective for climate adaptation in Africa, where droughts are increasingly common, and water shortages affect millions.

Since the early 1990s, FMNR has led to the rapid re-greening of southern Niger, restoring over seven million hectares of parkland through the regrowth of 'underground' trees. Niger is now greener than northern Nigeria, despite receiving less rainfall. FMNR focuses on the regrowth of trees and shrubs from existing stumps, root systems, or seeds, making it an affordable and sustainable approach. These regrown plants restore soil structure, improve fertility, reduce erosion, and enhance biodiversity. Some tree species also enrich the soil with nutrients like nitrogen.

By regenerating trees and raising community awareness of their importance, FMNR provides a sustainable fuelwood supply and protects vital water catchment areas, which is crucial for regions facing water scarcity. FMNR programs aim to reverse environmental damage, reduce fuelwood scarcity, and increase materials and fodder essential for local ecosystems.

FMNR has spread across Africa, with successful projects like World Vision's in Humbo, Ethiopia, prompting the government to support a 15-million-hectare expansion. The Global EverGreening Alliance promotes FMNR across the Sahel, and The Charitable Foundation is implementing FMNR in northern Tanzania among pastoralists to complement land-use and pasture regeneration efforts.

FMNR helps communities move beyond subsistence farming, potentially increasing income. In Humbo, Ethiopia, an estimated US$160,000 worth of fuelwood will be harvested, creating both temporary and permanent jobs. The benefits particularly support women and girls, who spend less time gathering fuelwood and more on education and other opportunities.

Improvement Strategies

Narrowing the yield gap with irrigation

Yield gaps refer to the difference between the actual crop yields being achieved by farmers and the potential yields that could be obtained with the best available inputs, practices, and technologies. For the reasons outlined above, sub-Saharan Africa faces some of the largest yield gaps in the world. Reducing these gaps is not only important for reducing current levels of food insecurity, it will also be crucial to feeding a population that is set to double and become predominately urban over the next two and a half decades.

Maize is one of the most widely grown and consumed cereal crops globally. In Africa, it is grown on more than 40 million hectares of land and accounts for about 40 per cent of the continent's cereal production.[11] In 2020, 91 million tonnes of maize was produced in Africa, about three times the amount of sorghum, the continent's second most important cereal grain.[12]

For rainfed maize, which represents most of the maize grown globally,[13] actual annual yields from 2015 to 2020 were, on average, 5.4 tonnes per hectare around the world, while potential yields were 13.5 tonnes per hectare. This indicates that maize yields have the potential to be increased by 150 per cent globally. Across nine sub-Saharan African countries, representing more than half of the lands used for maize cultivation in the region, the average actual yield was 1.9 tonnes per hectare, while the average potential was assessed to be 14 tonnes per hectare, a more than 600 per cent difference.

Water-limited yield potential is the potential yield possible without the unrestricted application of water from irrigation. It is only calculated for crops that are currently rainfed and seeks to measure how much yield improvement could be achieved through all non-water enhancements in inputs, practices, and technologies.

By assessing the difference between an area's full yield potential and its water-limited potential, it is possible to estimate the extent to which lack of water application constrains crop yields. In this analysis, this difference is referred to as the water yield multiplier, and it captures the impact that irrigation systems alone could have on improving yields.

Figure 3.5 shows actual yields, the water-limited yield potential, and the full yield potential for maize in the nine sub-Saharan countries referenced above. Actual yields per hectare range from 0.2 tonnes in Botswana to 3.3 tonnes in Ethiopia, while potential yields range from 10.1 tonnes in Botswana to 17 tonnes in Zambia. This measure indicates that these nine countries have the potential to increase their yields by factors of between five and 50.

The role that water alone could play in closing the yield gaps also varies significantly by country. Botswana, which is a largely arid country, has by far the largest water yield multiplier in the region, with yields capable of being increased by 356 per cent. In contrast, in Ethiopia, where most of the maize is grown in the rainy areas in the west of the country, the water yield multiplier is only 1.4, equivalent to a potential improvement of 39.8 per cent. Across countries, the median maize yield could be improved by 78.3 per cent by the application of water alone.

Rainfed sorghum shows comparable dynamics across sub-Saharan Africa. However, as it is a drought-resistant crop well suited to arid and semi-arid regions, it is less water-dependent than most other cereals. As such, the median water yield multiplier for sorghum growing lands in the region is equivalent to a potential improvement of 27.6 per cent.

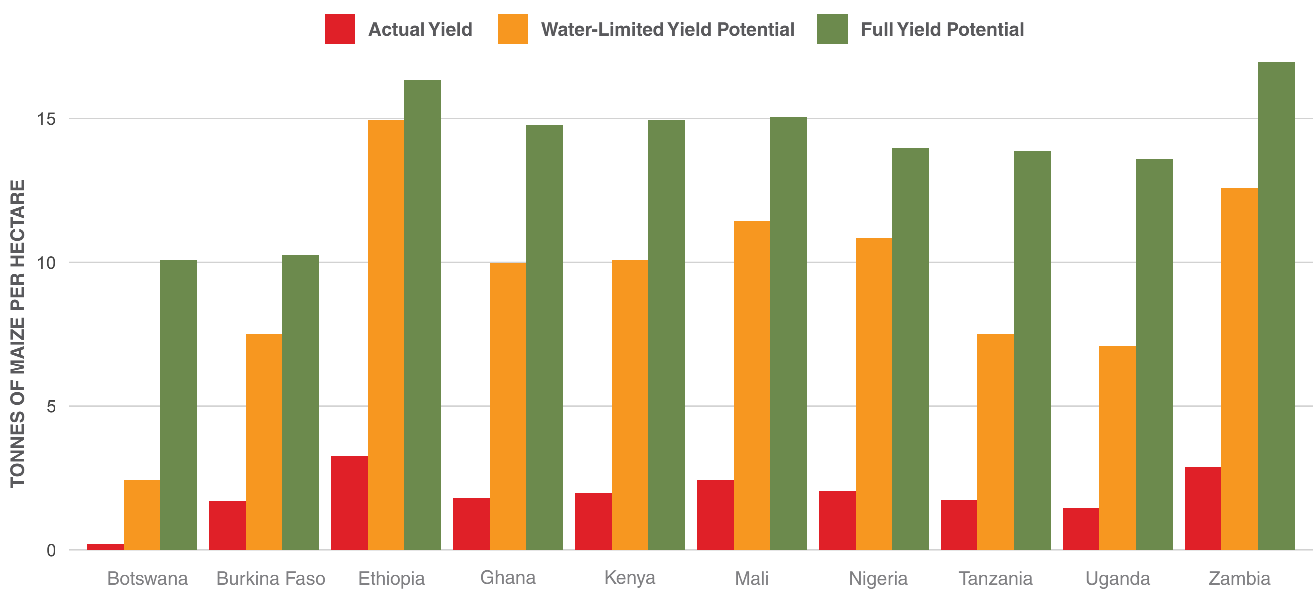
Irrigated agriculture accounts for only about 20 per cent of the total cultivated land worldwide but contributes 40 per cent of the total food produced.[14] The expansion of irrigation is thus a key strategy to boosting agricultural production in sub-Saharan Africa. This is particularly the case because irrigation practices are projected to become significantly more water efficient in the years and decades ahead. Irrigated land in low- and middle-income countries will increase by 34 per cent by 2030, but the amount of water used by agriculture will only increase by 14 per cent.[15] This is owing to improved irrigation management and practices, which include increased use of drip irrigation systems, advanced sensors and automation for precise water application, soil moisture monitoring, and scheduled irrigation based on crop needs.

At present, however, sub-Saharan Africa has the lowest irrigation rates in world. As shown in Figure 3.6, only 1.8 per cent of the cultivated land in the region is irrigated,[16] one tenth of the global rate.

FIGURE 3.5

Actual and potential maize yields, 2015–2020 averages

Water alone could increase yields in sub-Saharan Africa by nearly 80 per cent.

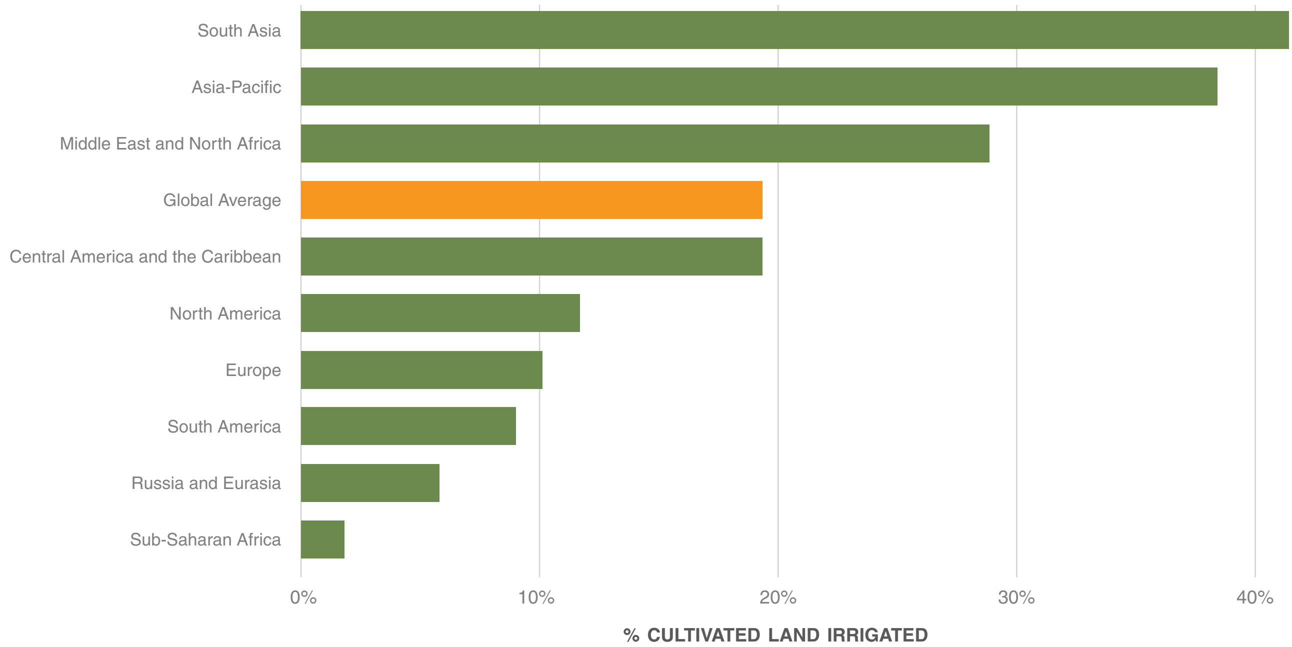


Source: Global Yield Gap Atlas; IEP calculations

FIGURE 3.6

Percentage of cultivated lands that are irrigated, by region, 2021

Only 1.8 per cent of the lands under cultivation in sub-Saharan Africa are irrigated.



Source: FAO
Note: Only includes countries included in the GPI.

There are four key indicators to assess the potential for expanding irrigation in sub-Saharan Africa:

- **Cultivated area:** Arable land currently used for growing crops, including annual or seasonal crops such as maize and sorghum as well as permanent crops like fruit trees.
- **Area equipped for irrigation:** Land with infrastructure to supply water for crop production, including areas that are currently irrigated and those that have an unused capacity for irrigation.
- **Area equipped for irrigation and currently irrigated:** Cultivated land where irrigation systems are available and utilised.
- **Irrigation potential:** The maximum land area that could be irrigated given the available water resources, land suitability, and technical feasibility, independent of whether the land is currently under cultivation or not.

Table 3.2 shows regional and global land area totals for these four categories. As with Figure 3.6, the table demonstrates that sub-Saharan Africa has the lowest irrigation rates in the world, as well as the smallest percentage of cultivated land that is equipped for irrigation, at 2.9 per cent. Relative to the amount of land currently under cultivation, the region also has the least land with irrigation potential, with there being more than six times as much land currently under cultivation as land with potential for irrigation. However, relative to both the amount of land that is currently irrigated, and the amount of land equipped for irrigation, sub-Saharan Africa has by far the greatest irrigation potential.

Land with irrigation potential is nearly nine times as extensive as the land that is currently irrigated and more than five times as extensive as the land already equipped for irrigation. By comparison, at the global level, the land with irrigation potential is only about twice as extensive as the land that is currently irrigated or that is equipped for irrigation.

Sub-Saharan Africa's untapped irrigation potential is further illustrated by looking at the percentage of its renewable water resources that are currently used for agriculture. Despite the substantial current stresses on its drinking water outlined in this report, the region has much lower rates of agricultural water use than most of the rest of the world. As shown in Figure 3.7, only two per cent of its renewable water resources are used in agriculture, less than one third of the global rate of 6.7 per cent and substantially less than the 47.7 per cent used in the Middle East and North Africa. Only Europe and South America use lower percentages of their renewable water on agriculture, at 1.3 and 1.8 per cent, respectively.

Figure 3.7 also shows the total availability of renewable water resources per capita across regions. Sub-Saharan Africa has more limited water than most of the rest of the world, though the difference is comparatively small, with the region's rate standing at 4,837 cubic metres of water per person per year compared to a global rate of 6,963 cubic metres. But sub-Saharan Africa's levels of water availability compare favourably to those in the Middle East and North Africa as well as South Asia, which respectively stand at 753 and 1,995 cubic metres per person.

TABLE 3.2

Amount of land under cultivation, irrigated, equipped for irrigation, and with potential for irrigation, by region, 2021

Sub-Saharan Africa has the greatest potential for irrigation expansion of any region.

	Total area (thousands of hectares)				Percentage of cultivated area…		Ratio: irrigation potential area to…		
	Cultivated	Currently irrigat	Equipped for irrigation*	With irrigation potential*	…currently irrigated	...equipped for irrigation	…total cultivated area	…currently irrigated area	...irrigation equipped area
Sub-Saharan Africa	242,930	4,415	6,969	38,586	1.8%	2.9%	1 : 6.3	8.7 : 1	5.5 : 1
Russia and Eurasia	206,827	11991	18,806	57,031	5.8%	9.1%	1 : 3.6	4.8 : 1	3.0 : 1
South America	140,521	12,648	14,538	76,113	9.0%	10.3%	1 : 1.8	6.0 : 1	5.2 : 1
North America	198,868	23,244	27,926	N/A	11.7%	14.0%	N/A	N/A	N/A
Europe	147,144	14,879	22,649	59,509	10.1%	15.4%	1 : 2.5	4.0 : 1	2.6 : 1
Central America and the Caribbean	37,551	7,261	9,136	17,839	19.3%	24.3%	1 : 2.1	2.5 : 1	2.0 : 1
Middle East and North Africa	85,290	24,599	27,580	36,367	28.8%	32.3%	1 : 2.3	1.5 : 1	1.3 : 1
Asia-Pacific	298,154	114,512	106,723	140,210	38.4%	35.8%	1 : 2.1	1.2 : 1	1.3 : 1
South Asia	221,668	91,799	100,380	176,989	41.4%	45.3%	1 : 1.3	1.9 : 1	1.8 : 1
World	**1,578,952**	**305,348**	**334,707**	**694,062**	**19.3%**	**21.1%**	**1 : 2.3**	**2.3 : 1**	**2.1 : 1**

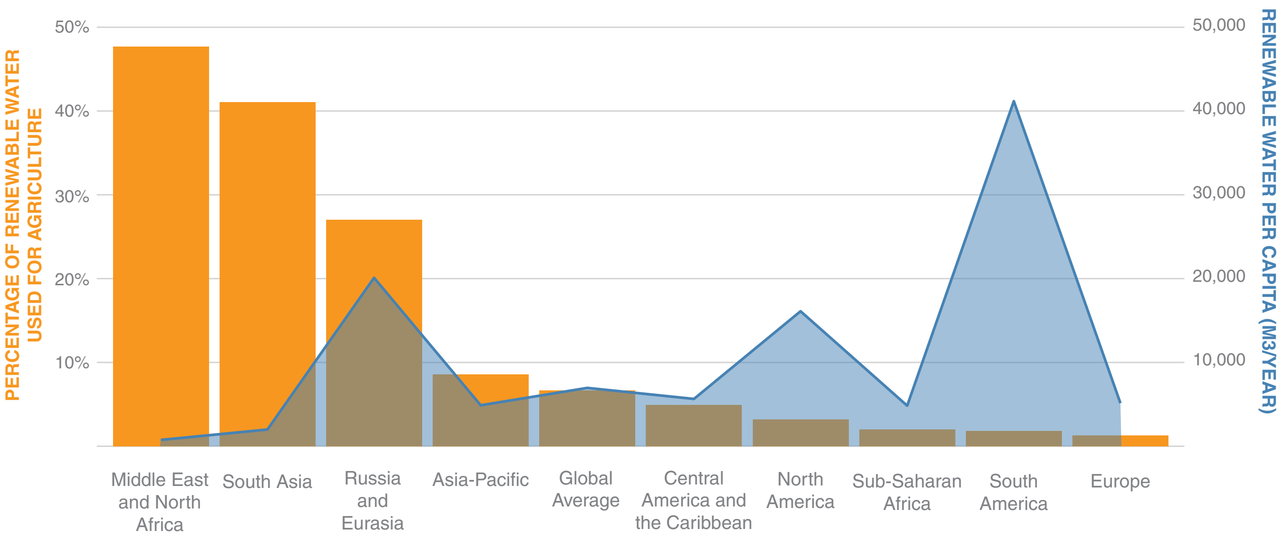
Source: FAO

Note: Country coverage is more extensive for cultivated area (n=199) than it is for irrigated area (n=155), area equipped for irrigation (n=181), or irrigation potential (n=115), so regional and world area totals for the latter three categories have been calculated based on rates across all available countries for each. Figures are based on countries in the GPI only.

FIGURE 3.7

Renewable water used in agriculture and total amount per capita, by region, 2021

Only two per cent of sub-Saharan Africa's renewable water is currently used in agriculture.



Source: FAO

Note: For the water used in agriculture rates, most of these are taken from FAO regional categories, while the rates of four (Asia-Pacific, Central America and the Caribbean, Russia and Eurasia, and South America) are based on weighted averages combining FAO regional categories with all-country averages of IEP regional categories.

Therefore, the greatest obstacle to increased water utilisation for agriculture in sub-Saharan Africa is not a lack of water, but rather the lack of infrastructure to effectively capture and distribute water. With adequate infrastructure, the region could bring its agricultural water usage in line with the global rate, and still have more than 4,500 cubic metres of water per person for other purposes.

Countries with the lowest levels of agricultural water use often have the largest reserves of renewable water, as shown in Table 3.3. For example, the Central African Republic has the lowest irrigation levels in the region but ranks fourth in renewable water per capita, with 25,838 cubic metres per person annually. In contrast, Djibouti, with the lowest renewable water per capita, has 9.9 per cent of its cultivated lands irrigated, the fifth highest in the region.

The Democratic Republic of the Congo, the largest country in the region by landmass, has the greatest potential for irrigation expansion in absolute terms. Currently, only 0.05 per cent of its 15.7 million hectares of cultivated land is irrigated, yet it has seven million hectares with irrigation potential, equivalent to 44.6 per cent of the cultivated land. With high rainfall and an extensive river network, including the Congo River, the country has 1.3 trillion cubic metres of renewable water annually. IEP estimates that irrigating all seven million hectares would use just 4.4 per cent of these resources.

Among 44 sub-Saharan African countries, there is a slight negative correlation (r=-0.14) between irrigation prevalence and renewable water per capita. Although the negative correlation between water availability and irrigation might seem counterintuitive, it likely reflects that countries with abundant water also receive more rainfall, reducing the need for irrigation. Conversely, countries with less renewable water typically receive less rain, making irrigation more crucial. Generally, higher precipitation rates (r=0.38) are associated with greater potential for irrigation expansion relative to current cultivated lands.

Many of these countries are in Central and coastal West Africa, while inland West Africa, Eastern Africa, and Southern Africa tend to have lower precipitation and less potential for irrigation expansion. Unsurprisingly, these latter regions would benefit most from irrigation due to the limitations of rainfed agriculture. However, as shown in the maize yield analysis, farmers across the region could significantly boost production with irrigation. IEP estimates that all countries in the region could fully realise their irrigation potential using less than one-third of their renewable water resources, with most needing less than one-fifth.[17] Overall, about 38.6 million hectares could be irrigated using less than six per cent of the region's renewable water.

Measured use of fertilisers

Sub-Saharan African countries have the lowest levels of chemical fertiliser use in the world. Thus, in addition to the expansion of irrigation systems, there is substantial potential for sub-Saharan Africa to boost its agricultural yields through careful increases in its use of fertilisers.

Fertilisers replenish soil nutrients depleted by continuous cropping and can significantly increase yields by enhancing plant growth and productivity. For instance, nitrogen, phosphorus, and potassium are essential for plant processes like photosynthesis and root development. By adopting best practices in fertiliser use, such as proper timing and application rates tailored to specific crops and soil types, farmers can achieve substantial gains in crop yields.

However, the increased use of fertilisers also brings significant trade-offs that need to be carefully managed. Over-reliance on chemical fertilisers can over time lead to soil degradation, fertility loss, and environmental pollution through runoff that contaminates water bodies and can ultimately lead to eutrophication.

Farmers in Kenya have attributed drastic reductions in crop yields to the acidification of soils from long-term overuse of chemical fertilisers. The government initially promoted these fertilisers through subsidies, making them accessible to smaller-scale farmers. However, this contributed to nearly two-thirds of the arable land becoming acidic, which has impacted the production of staple crops like maize. This issue has also severely affected lands in nearby Zimbabwe, where the loss of traditional knowledge and practices related to soil management has worsened the problem. As a result, increased use of chemical fertilisers should be measured and complemented by other practices, such as crop rotation and the use of organic compost to restore soil health.[19]

Despite the challenges related to chemical fertilisers, their potential for boosting crop yields is substantial, at least in the short-term. Figure 3.8 shows the prevalence of nitrogen fertiliser against countries' average cereal crop yields in tonnes.[20] There is a strong correlation (r=0.57) between average yield volumes and the average amount of nitrogen applied per hectare.

TABLE 3.3

Cultivated land, renewable water, irrigation, and irrigation potential in sub-Saharan Africa, 2021

Countries with the most available water in the region tend to have among the lowest rates of irrigation and the greatest potential for irrigation expansion.

Country	Total cultivated area (hectares)	% of cropland currently irrigated	Total renewable water resources (m3/year)	Renewable water per capita (m3/year)	Total land with irrigation potential (hectares)	Land with irrigation potential relative to all cultivated land (%)	% of renewable water it would take to irrigate all lands with irrigation potential	Potential irrigated land expansion (hectares)
Central African Republic	1,920,000	0%	141,000,000,000	25,838	1,900,000	99.0%	10.8%	1,899,931
Lesotho	433,000	0.02%	3,022,000,000	1,325	12,500	2.9%	3.3%	12,433
Democratic Republic of the Congo	15,698,000	0.05%	1,283,000,000,000	13,379	7,000,000	44.6%	4.4%	6,992,700
Uganda	9,100,000	0.10%	60,100,000,000	1,311	90,000	1.0%	1.2%	79,420
Republic of the Congo	678,000	0.2%*	832,000,000,000	142,568	340,000	50.1%	0.3%	338,755*
Liberia	700,000	0.2%*	232,000,000,000	44,672	600,000	85.7%	2.1%	598,693*
Angola	5,690,000	0.20%	148,400,000,000	4,301	3,700,000	65.0%	19.9%	3,688,480
Cameroon	7,750,000	0.2%*	283,150,000,000	10,410	290,000	3.7%	0.8%	274,028*
Togo	2,820,000	0.20%	14,700,000,000	1,700	180,000	6.4%	9.8%	173,753
Gambia	447,000	0.20%	8,000,000,000	3,030	80,000	17.9%	8.0%	78,920
Ghana	7,417,500	0.40%	56,200,000,000	1,712	1,900,000	25.6%	27.0%	1,869,730.00
South Sudan	2,479,700	0.5%*	49,500,000,000	4,605	1,500,000	60.5%	24.2%	1,488,171*
Rwanda	1,618,400	0.50%	13,300,000,000	988	165,000	10.2%	9.9%	157,060
Chad	5,338,000	0.50%	45,700,000,000	2,660	335,000	6.3%	5.9%	308,800
Niger	17,813,000	0.50%	34,050,000,000	1,348	270,000	1.5%	6.3%	182,130
Nigeria	43,472,000	0.50%	286,200,000,000	1,341	2,331,000	5.4%	6.5%	2,112,200
Benin	3,400,000	0.50%	26,390,000,000	2,030	322,000	9.5%	9.8%	304,800
Guinea	3,938,000	0.50%	226,000,000,000	16,701	520,000	13.2%	1.8%	499,610
Gabon	495,000	0.6%*	166,000,000,000	70,904	440,000	88.9%	2.1%	437,229*
Malawi	4,200,000	0.60%	17,280,000,000	869	161,900	3.9%	7.5%	135,000
Côte d'Ivoire	10,300,000	0.60%	84,140,000,000	3,062	475,000	4.6%	4.5%	408,070
Burkina Faso	6,740,000	0.70%	13,500,000,000	611	165,000	2.4%	9.8%	118,870
Namibia	812,000	0.80%	39,910,000,000	15,774	47,300	5.8%	0.9%	41,160
Burundi	1,620,000	0.8%*	12,536,000,000	999	215,000	13.3%	13.7%	201,658*
Mozambique	5,950,000	1%	217,100,000,000	6,768	3,072,000	51.6%	11.3%	3,010,000
SierraLeone	1,749,000	1.0%*	160,000,000,000	19,001	807,000	46.1%	4.0%	788,721*
Botswana	262,000	1.40%	12,240,000,000	4,729	13,000	5.0%	0.8%	9,250
Tanzania	15,521,200	1.5%*	96,270,000,000	1,514	2,132,000	13.7%	17.7%	1,905,689*
Kenya	6,410,000	1.50%	30,700,000,000	579	353,000	5.5%	9.2%	255,800
Senegal	3,911,000	1.80%	38,970,000,000	2,309	409,000	10.5%	8.4%	340,000
Equatorial Guinea	100,000	1.8%***	26,000,000,000	15,907	30,000	30.0%	0.9%	28,200***
Eritrea	692,000	1.90%	7,315,000,000	2,021	187,500	27.1%	20.5%	174,010
Mali	8,491,000	2.10%	120,000,000,000	5,478	566,000	6.7%	3.8%	390,200
Ethiopia	18,595,000	2.9%*	122,000,000,000	1,014	2,700,000.00	14.5%	17.7%	2,165,722*
Zimbabwe	4,100,000	3%	20,000,000,000	1,251	365,600	8.9%	14.6%	241,700
Zambia	3,839,000	4.10%	104,800,000,000	5,382	523,000	13.6%	4.0%	367,100
Guinea-Bissau	550,000	4.10%	31,400,000,000	15,237	281,300	51.1%	7.2%	258,740
Mauritania	460,000	5%	11,400,000,000	2,470	250,000	54.3%	17.5%	227,160
Somalia	1,129,000	5.80%	14,700,000,000	861	240,000	21.3%	13.1%	175,000.00
Djibouti	3,900	9.90%	300,000,000	271	2,400	61.5%	6.4%	2,012.00
South Africa	12,413,000	12.10%	51,350,000,000	865	1,971,651**	15.9%**	30.7%**	473,651**
Madagascar	3,600,000	15.30%	337,000,000,000	11,655	1,517,000	42.1%	3.6%	967,000
Mauritius	79,000	19.40%	2,751,000,000	2,118	33,000	41.8%	9.6%	17,667
Eswatini	195,000	23%	4,510,000,000	3,783	93,220	47.8%	16.5%	48,380
Sub-Saharan Africa	**242,929,700**	**1.80%**	**5,484,884,000,000**	**4,833**	**38,586,371**	**15.9%**	**5.6%**	**34,171,376**

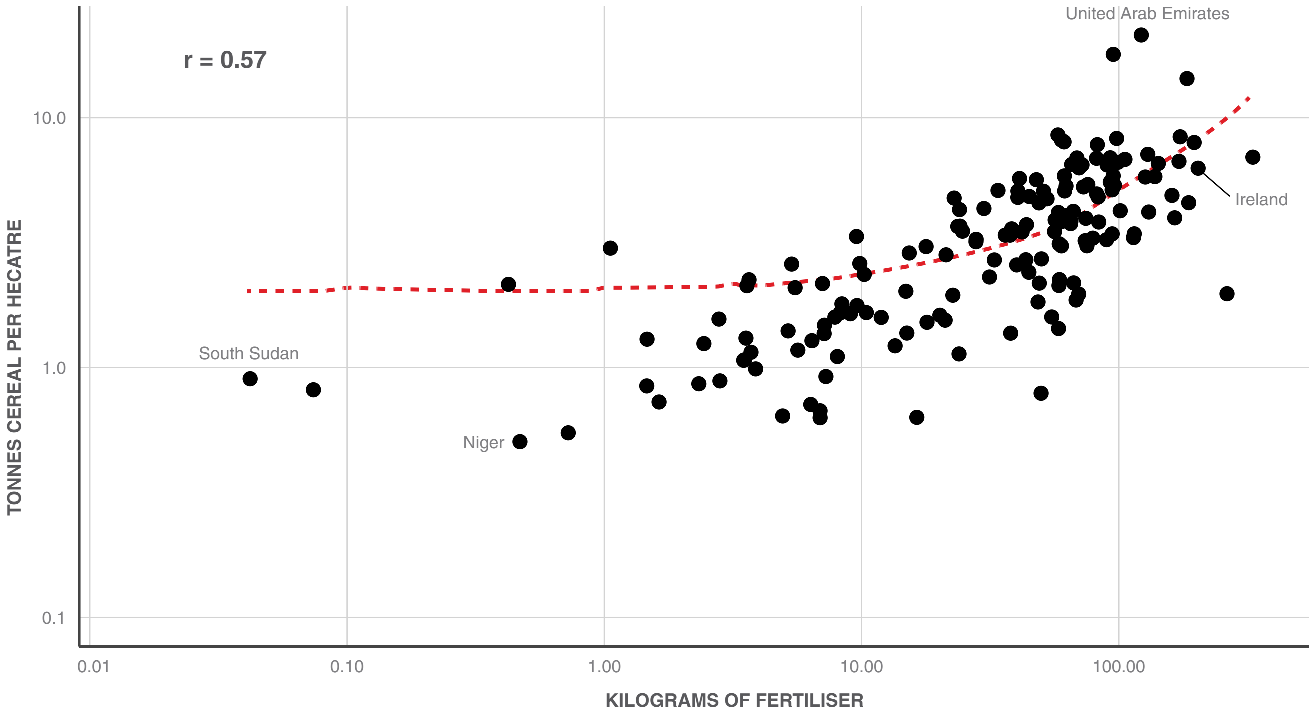
Source: FAO; IEP calculations

Notes: The estimates on the percentage of renewable water required to irrigate all lands with irrigation potential is based on each hectare receiving 8,000 cubic metres of water per year.[18] The figures* on percentage of cultivated land that is irrigated for nine countries are imputed based on their percentage of cultivated land equipped for irrigation figures and the regional average on the percentage of land equipped for irrigation that is actually irrigated. The figures** related to the total land with irrigation potential for South Africa are imputed based on the regional average of lands with irrigation potential being 15.9 per cent as extensive as the cultivated land. The figures*** related to the percentage of cropland currently irrigated in Equatorial Guinea is based on the regional average of 1.8 per cent.

FIGURE 3.8

Cereal crop yields vs nitrogen fertiliser use, 2018–2022 averages

Crop yields tend to rise with increased use of chemical fertilisers.



Source: FAO; IEP calculations
Note: Only includes countries included in the GPI.

High-income countries such as the United Arab Emirates and Ireland make heavy use of such inputs and reap high yields, while low-income countries such as South Sudan and Niger make minimal use of them and reap much lower yields. While the yield increase potential of fertilisers varies substantially by crop, local climate, and a wide array of other factors, on average for every 10 additional kilograms of fertiliser applied per hectare, annual cereal yields increase by an average of about 0.3 tonnes.

Median nitrogen fertiliser usage in sub-Saharan Africa is about 7.2 kilograms per hectare, less than one sixth the global median of 44.8 kilograms per hectare. The region could therefore triple its fertiliser use on cereal croplands and its rate would still be less than half of the global rate.

However, fertilisers are comparatively expensive in the region, owing largely to supply-chain issues. For example, Tanzanian farmers must spend around US$48 for a 50-kilogram bag of nitrogen fertiliser, against an import price of US$23.[21] Based on these estimates, raising the region's median fertiliser application to about 20 kilograms per hectare would require an added cost of about US$12.3 per hectare. Addressing these supply-chain inefficiencies would therefore greatly increase the accessibility of fertilisers, especially for smallholders.

Sand dams: An innovative approach to expanding water capture

The lands in sub-Saharan Africa with irrigation potential represent only 15.9 per cent of all cultivated land, indicating limited capacity for irrigation expansion. To address this, it is essential to develop systems for capturing water in arid areas, thereby unlocking irrigation potential for more lands. Various innovative, low-cost practices can enhance water availability and soil fertility in arid and semi-arid regions, including Farmer Managed Natural Regeneration (FMNR) and other agroforestry techniques.

Over the past two decades, The Charitable Foundation (TCF), a sister organisation of IEP, has supported a range of projects aimed at capturing and storing water from runoff in arid and semi-arid regions of Kenya and Uganda. These projects include large, excavated reservoirs in valleys known as valley tanks, earth dam tanks created by building dams across low-lying areas, rock catchments that use natural rock formations to collect water, and selangoes, which are traditional water storage pits dug in areas which naturally accumulate water. Costs for these projects have ranged from about US$21,000 to US$69,000, with water storage capacities from around 700 cubic metres for rock catchments to 30,000 cubic metres for selangoes.[22]

Another promising technique is sand dams, which capture and store water from heavy seasonal rainfalls in regions with low precipitation during most of the year. Abstraction of water from sandy seasonal riverbeds is an ancient practice, where natural dikes capture water stored in the sand. Subsurface dams and sand dams are artificial enhancements to these natural dikes, and when constructed properly, can last 50 to 100 years.

As shown in Figure 3.9, a sand dam is built in a seasonal dry riverbed, anchored onto bedrock or an impermeable layer. It blocks the subsurface flow of water through the sand, creating an upstream reservoir that can hold up to 40 per cent water when filled with coarse sand. This water can be used for domestic purposes, livestock, and irrigation. Additionally, the captured water seeps into the riverbanks, enhancing vegetation and biodiversity. The cost to build a sand dam is approximately US$35,000.

A very large sand dam can hold 71,000 cubic metres of water, which when amortised over 10 years will yield water for US$0.29 per thousand litres. This suggests that around six to nine hectares of land could be fully irrigated from a single dam.[23]

A study on sand dams in Kenya commissioned by TCF estimated that the increases in yields from lands irrigated from such a dam would have a value of around 20 million Kenyan shillings (US$180,000). The return on investment will vary depending on the crops and price of staples at the time. In many locations of TCF projects, little or no agriculture was being undertaken before the installation of the sand dam, and subsequent agricultural activity has been central to uplifting the regions. TCF has built 30 sand dams in the country and is exploring ways of scaling the benefits, including by highlighting the business case for investing in the construction of sand dams.[24]

Figure 3.10 shows the countries in the region with the most potential to benefit from sand dams. Further to the above discussion, these countries are mostly in Eastern Africa, Southern Africa, and inland West Africa. These tend to be the areas with the lowest precipitation levels and potential for irrigation expansion from current water resources.

In many parts of Africa, small-scale water capture projects like sand dams could be transformative. In some instances, they could open cultivated lands to irrigation that are now purely rainfed, while in others they could help turn areas with little or no agricultural viability into productive lands. Based on the capacity of large sand dams, IEP estimates that the implementation of one million comparable water capture projects across the continent could make irrigated agriculture possible in nearly nine million additional hectares of land. This could result in up to 12.1 million additional tonnes of cereals per year.

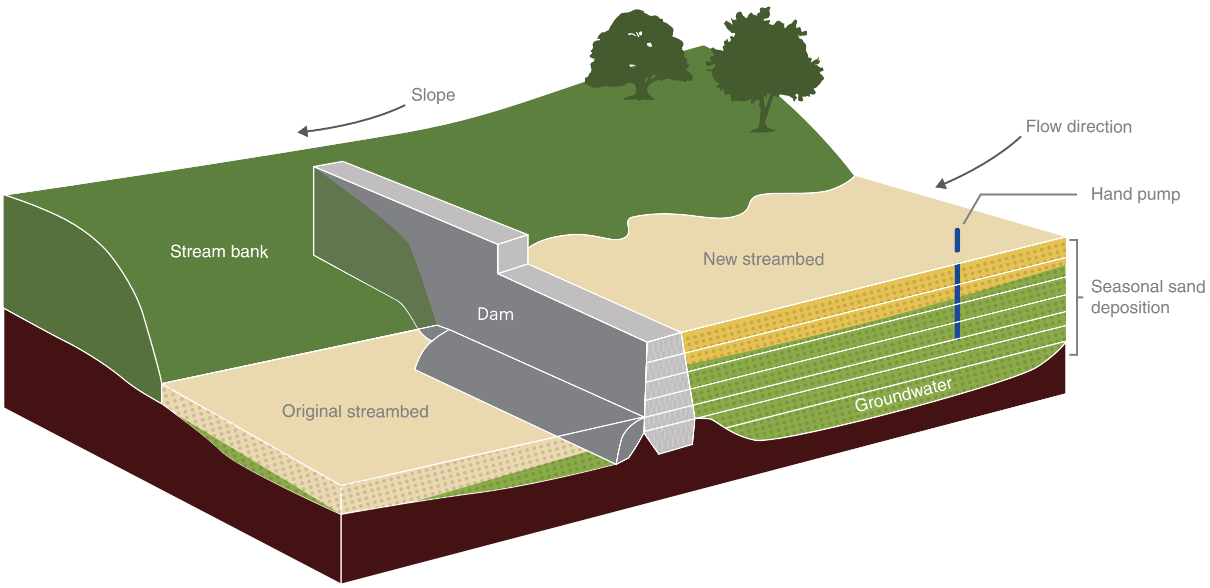
71
thousand

A very large sand dam can hold 71,000 cubic metres of water, which when amortised over 10 years will yield water for US$0.29 per thousand litres.

FIGURE 3.9

Schematic diagram of a sand dam in Kenya

For the cost of US$35,000, a sand dam can capture water with a return on investment value of US$180,000.

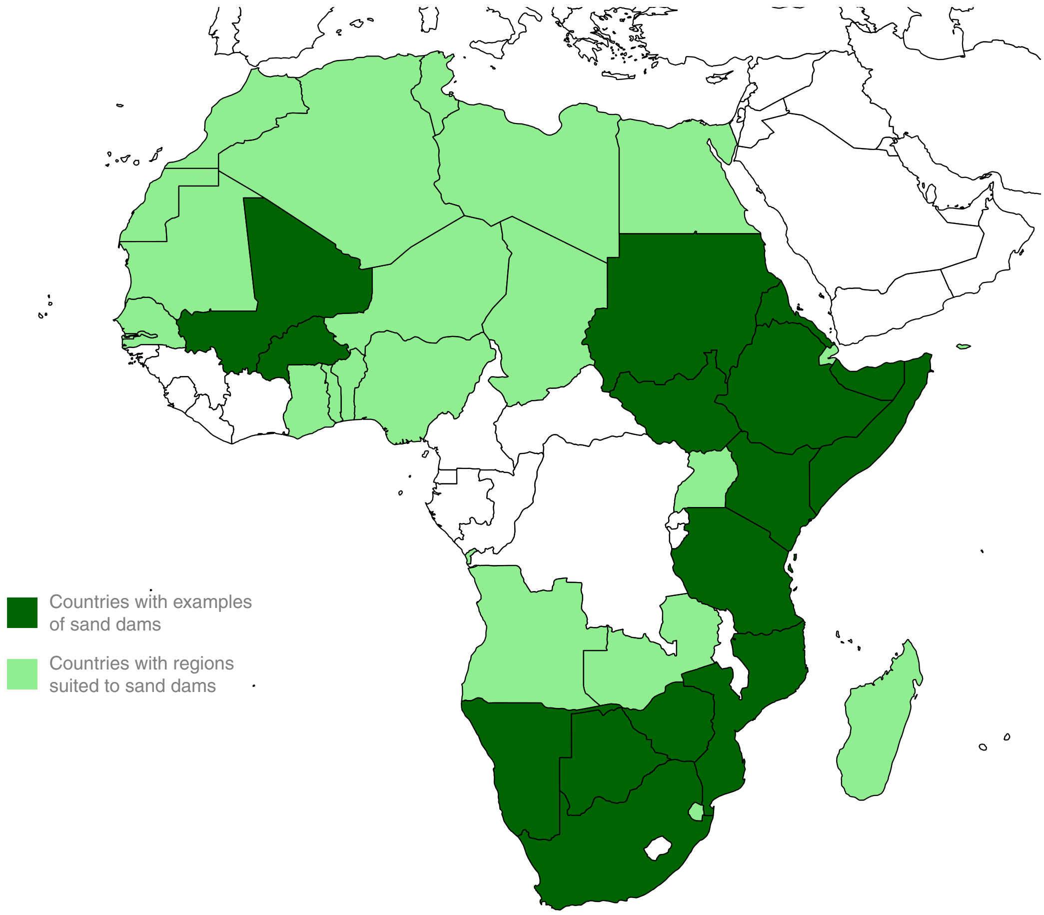


Source: IEP

FIGURE 3.10

African countries suitable for sand dam implementation

With the exception of Central Africa and some parts of coastal West Africa, most countries in sub-Saharan Africa would benefit from the implementation of sand dams.



Source: Sustainable Sanitation and Water Management

Boosting Yields: Costs and Potential Returns

Costing the expansion of yield-boosting measures

To meet sub-Saharan Africa's current and future food needs, IEP estimates that the region will need to produce 194.7 million additional tonnes of cereals per year by 2050, more than twice as much as it currently produces. This could be achieved through the following strategies:

- **Realising all current irrigation potential:** Equipping with irrigation capacity and irrigating the 34.2 million hectares of land with irrigation potential that are not currently equipped for irrigation, and irrigating the 2.5 million hectares of land equipped for irrigation that are not currently irrigated (with the assumption that cereal production would be prioritised on at least three-quarters of the lands)

- **New water capture and irrigation in arid areas:** Implementing one million small-scale water capture projects comparable to sand dams in semi-arid and arid areas to expand irrigation potential to an additional 8.9 million hectares of land, equipping these lands with irrigation systems, and activating those systems (with the assumption that cereal production would be prioritised on all the lands)

- **Limited fertiliser increases:** Raising the median nitrogen fertiliser application to 20 kilograms per hectare across all cereal-producing lands in the region

- **New grain storage infrastructure:** Improving and expanding grain storage facilities to reduce post-harvest losses by 4.7 per cent[25]

Figure 3.11 depicts the gains that these measures could generate over current production levels. It is estimated that they would result in additional 105.3 million tonnes of cereals per year, a 59.6 per cent increase.

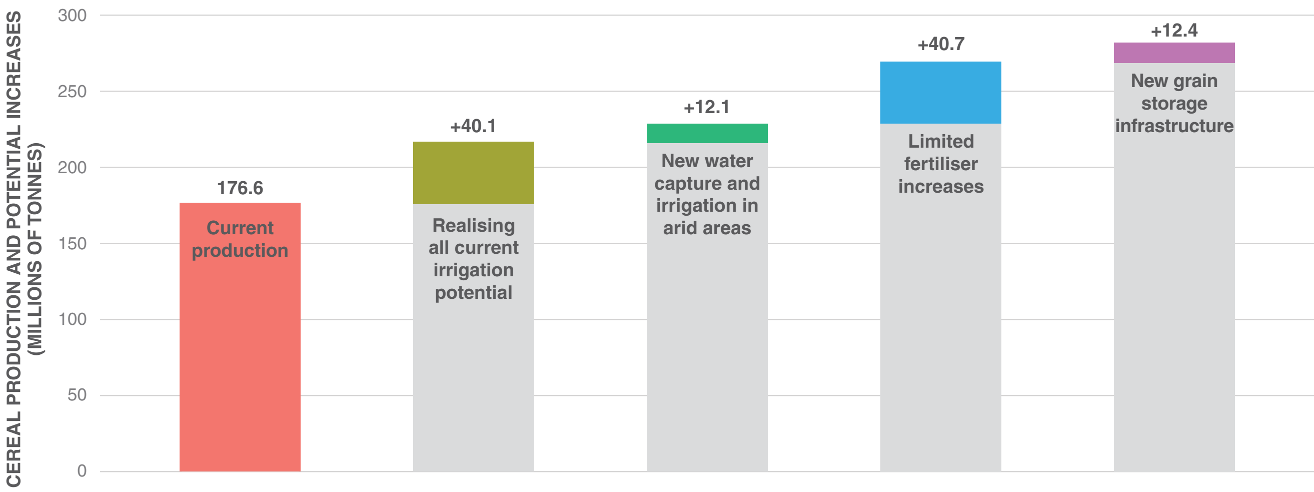
At the centre of this example is a substantial expansion of agricultural water use. The costs of installing and maintaining irrigation systems vary substantially depending on the type of irrigation employed, crop needs, topography, and a variety of other factors. A 2010 study, for example, estimated a medium investment cost across Africa of US$2,000 per hectare based on a five-year reinvestment cycle, which equates to inflation-adjusted annualised cost of about US$575 per hectare.[26] As irrigation technology has advanced, however, it has become cheaper and more water efficient; the average cost has fallen in the region and will likely continue to fall going forward.[27] Leading irrigation companies, for example, have put forward costs in Africa of around US$4,000 per hectare for state-of-the-art drip irrigation technologies that can last around 15 years, equating to an annual cost of about US$270.[28] For the purposes of this analysis, this latter figure has been used as a best estimate of the costs the region could expect for expanding high-quality irrigation systems.

When combined with projected costs for new water capture projects, modest increases in fertiliser use, and expanded grain storage facilities, this estimate forms the basis for calculating the cost of a comprehensive program to boost sub-Saharan Africa's agricultural output. At full implementation, these combined strategies would result in an average annual cost of US$14.7 billion across the region. Table 3.4 provides a detailed breakdown of these costs.

FIGURE 3.11

Potential gains in cereal production

Sub-Saharan Africa could potentially produce 281.9 million tonnes of cereals each year by 2050.



Source: IEP

TABLE 3.4

Average annual cost of implementing cereal yield-boosting strategies

Irrigation expansion and new water capture would account for nearly 90 per cent of the cost.

Strategy	Calculation	Annual cost at full implementation in 2050
Developing and maintaining new irrigation systems on lands with irrigation potential	$270 per year on 34.2 million hectares	$9,226,271,520
One million new small-scale water capture projects and the development and maintenance of new irrigation systems on surrounding lands	$34.6 billion over 26 years and $270 per year on 8.9 million hectares	$3,734,076,923
Raising median fertiliser use to 20 kgs per hectare on cereal croplands	$14.2 per year on 104.3 million hectares	$1,281,649,558
New grain storage facilities	$12 billion over 26 years	$461,538,462
Total		**$14,703,536,462**

Source: IEP

This model assumes that these systems and resources would not be made available in all areas immediately, but rather would progressively expand over the next 26 years. Based on a linear expansion of the strategies involving annual fixed costs or ongoing mid-term costs (such as fertiliser use and irrigation system installation and maintenance), this would entail a total cost of US$220.9 billion by 2050. While the annualised and total sums in the model may appear high, they are comparable with the levels of foreign aid that sub-Saharan Africa receives at present. In 2023, for example, official development assistance (ODA) to the region totalled US$36 billion.[29]

Moreover, this model only considers the investment costs associated with these yield-boosting measures; it does not account for the substantial returns that farmers and national economies would reap from the resultant yield increases. On a one-hectare farm growing cereals, for each dollar invested in these combined yield-boosting measures, a farmer could expect to see nearly three dollars in additional income. This return is outlined in Table 3.5, which shows the average annualised investment costs per hectare of each measure (over a 26-year period), along with current average output and estimated income for cereal production, and projected output and income with the yield-boosting enhancements.

TABLE 3.5

Return on investment for yield-boosting measures, per hectare

Farmers could achieve a nearly threefold return on their investments in irrigation and associated measures.

	Item	Value (per hectare per year)
Investment	Irrigation	$270.00
	New water capture	*$149.60*
	Added fertiliser	$12.30
	New grain storage	$4.40
	Total investment cost	$436.30
	Total investment cost in areas not requiring new water capture	$286.70
Yields	Current average cereal yield	1.7 tonnes
	Estimated yield increase	162%
	New cereal yield	4.5 tonnes
Prices	Median price of cereals per tonne (2022)	$451.00
	Price for current yield	$768.00
	Price for new yield	$2,008.00
Returns	New revenue	$1,240.00
	Net profit	$803.70
	Net profit in areas not requiring new water capture	*$953.30*

Source: IEP

Based on a median cereal price of about US$450 per tonne,[30] a farmer growing grains on a one-hectare farm in the region would currently generate around US$770 in revenue per year. With investments costing between about US$290 and US$440, however, the average per-hectare yield could be raised 162 per cent, from 1.7 tonnes to 4.5 tonnes,[31] a moderate estimate compared to other assessments of comparable yield-boosting strategies.[32] This would result in a new total yield value of around US$2,000, representing US$1,240 in new income and a net profit of US$800-US$950.

In a region in which 52 per cent of the labour force is dedicated to agriculture and the vast majority are smallholders operating farms smaller than two hectares, income increases of this kind would be transformational.

Non-input-based enhancements

While significant investments are essential for sub-Saharan Africa to meet its food production needs by 2050, the model presented here would only address about 54 per cent of the shortfall. This is because general inputs like water and fertilisers alone have limited effectiveness in helping the region's agricultural sector reach its full potential.

To bridge this gap, experts often stress the importance of localised, context-specific practices, innovations, and technologies that enable farmers to maximise the productivity of the lands and inputs they already have. These include adopting improved seed varieties, precision agriculture, and better pest and disease management. Conservation agriculture techniques – such as crop rotation, minimal tillage, and the use of cover crops to enhance soil health and fertility – are also vital. Additionally, strengthening agricultural extension services through training and information dissemination can empower farmers to adopt best practices and new technologies effectively.

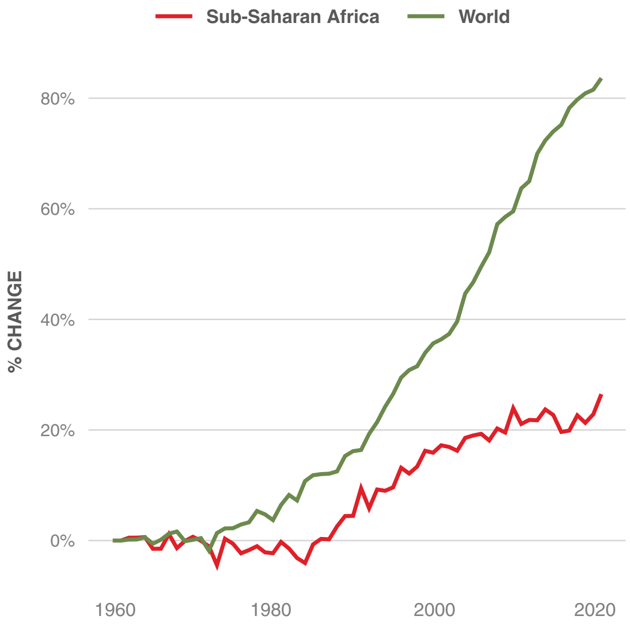
The concept of total factor productivity (TFP) captures the potential for increasing output relative to inputs. Agricultural TFP measures inputs like labour, land, capital, and materials against yields produced. Figure 3.12, based on data from the United States Department of Agriculture (USDA), shows the indexed changes in agricultural TFP globally and in sub-Saharan Africa since 1961.

Globally, agricultural TFP has risen substantially over the past six decades, with output increasing by 83.6 per cent relative to inputs. In sub-Saharan Africa, TFP has also improved, but at a much slower pace, increasing by only 26.5 per cent. While global improvements began in the 1970s and have continued steadily, sub-Saharan Africa's gains started in the mid-1980s and have slowed since the mid-2000s.

FIGURE 3.12

Indexed changes in total factor productivity in agriculture, global and sub-Saharan Africa, 1961–2021

Relative to inputs, increases in agricultural output in sub-Saharan Africa have lagged global increases.



Source: USDA; IEP calculations

This discrepancy likely stems from advantages enjoyed by farmers in other parts of the world. In many high-income countries, agriculture is more technologically advanced and highly mechanised, leading to significant gains in output relative to input costs. This difference underscores that relying solely on input-based strategies, such as expanding irrigation and increasing fertiliser use, will likely be insufficient for sub-Saharan Africa to achieve the yield improvements needed to meet its food demands by 2050. The region must close its TFP gap with the rest of the world to meet its growing food needs.

Therefore, implementing non-input-based improvement measures is essential to complement the input-based strategies discussed. By enhancing TFP through sustainable practices, technology adoption, and better resource management, the region can boost agricultural productivity while minimising environmental impact. Investing in a balanced approach that combines material inputs with non-material innovations will be crucial for sub-Saharan Africa to achieve food security, reduce poverty, and ensure agricultural growth keeps pace with population growth.

Appendices

Appendix A

Methodology

The ecological threats included in the Ecological Threat Report (ETR) are water risk, food insecurity, demographic pressure, and the impact of natural events. These indicators are calculated first at the subnational level and then at the national level.

The calculation of subnational scores involves two steps. In the first step, all indicators are normalised on a 1-5 scale, with a higher score representing a higher threat level. In the second step, the overall ETR score is calculated by taking the mean of the indicator scores and then adding the variance (as measured by the standard deviation) across the four scores. This creates a weighted average, which is represented in the following equation:

$$ETR\ Score = \frac{Threat\ score\ 1 + Threat\ score\ 2 + Threat\ score\ 3 + Threat\ score\ 4}{4} + SD$$

This means that a subnational area with scores of 5, 5, 1 and 1 across the four indicators would have a higher overall score than an area with scores of 3,3,3 and 3. This weighting is applied to capture the disproportionate impact of severe ecological threats.

At the national level, a country's four indicator scores and its overall score are the population-weighted averages of the scores across its subnational areas.

ETR INDICATOR SOURCES, DEFINITIONS, AND SCORING CRITERIA

Impact of Natural Events	
Indicator type	Quantitative
Data Sources	Geocoded Disasters (GDIS) Dataset / Centre for Research on the Epidemiology of Disasters' Emergency Events Database (EM-DAT)
Measurement period	2000–2019

Definition: The average annual number of deaths and displacements per 100,000 people from hazardous natural events over the past 20 years.

Calculation: This indicator is calculated based on the average number of deaths and displacements associated with natural events over the past 20 years, sourced from with disaster data sourced by GDIS, mortality data sourced from GBD, and displacement data sourced from EM-DAT. This number is then divided by the population of the subnational unit to calculate the levels of mortality and displacement per 100,000 people per year on average over the last 20 years. The rate is then normalised and scaled on an exponentialbanding system from 1 to 5.

Scoring Bands:

	1	2	3	4	5
	(Very Low)	(Low)	(Medium)	(High)	(Very High)
Deaths and displacements per 100,000 people	<5	5-10	10-50	50-100	>100

Demographic Pressure	
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 3 7.0. This is considered the middle of the range of baseline outcomes.

Definition: The percentage difference between the 2020 population and the projected population in 2050.

Calculation: This indicator is calculated using population data available at a one-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:

	1	2	3	4	5
	(Very Low)	(Low)	(Medium)	(High)	(Very High)
Projected population growth to 2050	<10%	10%–20%	20%–30%	30%–40%	>40%

Food Insecurity	
Indicator type	Quantitative
Data Sources	World Food Programme HungerMap
Measurement period	2024

Definition: The percentage of the population that is not consuming enough food to meet daily energy requirements for a healthy and active life.

Calculation: This indicator is based on data from the World Food Programme's World Hunger Map, which measures the prevalence of insufficient food consumption at the subnational level. WFP conducts continuous food security monitoring via computer assisted telephone interviewing (CATI) through call centers. Data is collected on a rolling basis, spread evenly over the past 28/30 calendar days or over a three-month period. For countries without data, IEP used a combination of machine learning and qualitative estimates of food insecurity.

Scoring Bands:

	1	2	3	4	5
	(Very Low)	(Low)	(Medium)	(High)	(Very High)
Prevalence of insufficient food consumption	<18%	18%-26%	26%-34%	34%-42%	>42%

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: The percentage of population without access to clean drinking water.

Calculation: This indicator is calculated as the percentage of the population collecting drinking water from an unprotected dug well or spring, or directly from a river, dam, lake, pond, stream, canal, or irrigation canal, in alignment with WHO/UNICEF Joint Monitoring Programme (JMP) categories.

Scoring Bands:

	1	2	3	4	5
	(Very Low)	(Low)	(Medium)	(High)	(Very High)
Percentage of the population without access to clean drinking water	<2.5%	2.5%–5%	5%–10%	10%–20%	>20%

APPENDIX B

ETR Domain Scores

Note on country/territory inclusion: The Ecological Threat Report aims to provide the widest possible geographic coverage of ecological threats affecting human communities around the world. The inclusion of countries and territories in the following list and assessed throughout the report is based on data availability and should not be interpreted as an endorsement of any political claims concerning sovereignty or related issues. The focus is on ensuring accurate representation of global and regional dynamics without engaging in political or territorial adjudications.

Country	Overall Score	Demographic Pressure	Food Insecurity	Impact of Natural Events	Water Risk
Afghanistan	4.84	4.49	5	2.98	4.98
Albania	1.96	1.01	2.15	1.21	2.21
Algeria	2.14	2.32	2.21	1.64	1.72
American Samoa	2.31	1.41	1.76	3.18	1
Andorra	1.38	1.75	1	1	1
Angola	4.24	4.39	1.72	2.88	5
Antigua and Barbuda	2.06	2.15	2.52	1.01	1
Argentina	1.74	1.82	1.75	1.64	1.24
Armenia	1.51	1	1.62	1	1.67
Australia	2.35	3.38	1	1.79	1
Austria	1.19	1.37	1	1.03	1
Azerbaijan	2.77	1.47	2.33	1.49	3.70
Bahamas	1.95	2.41	1	1.97	1.02
Bahrain	2.67	4.35	1	1	1
Bangladesh	2.61	2.02	2.82	2.60	2.30
Barbados	2.76	1.26	1	4.43	1
Belarus	1.96	1	2.44	1	1.96
Belgium	1.82	1.75	1	2.28	1
Belize	2.76	2.34	2.29	2.81	2.93
Benin	4.4	4.33	3.87	4.50	4.35
Bermuda	1.01	1	1	1.02	1
Bhutan	2.9	2.84	2.92	1.28	2.94
Bolivia	3.2	2.53	1.77	1.93	4.28
Bosnia and Herzegovina	1.55	1	2.09	1.02	1
Botswana	3.7	2.35	2.16	4.36	3.78
Brazil	2.85	1.56	2.03	2.67	3.47
British Virgin Islands	1.47	1.77	1	1.39	1
Brunei	2.46	3.08	1	1	2.61
Bulgaria	1.67	1	1.90	1.79	1
Burkina Faso	4.73	4.45	4.89	4.05	4.78
Burundi	4.16	4.16	3.33	2.20	4.75
Cambodia	3.36	1.72	1.20	3.32	4.33
Cameroon	3.84	3.44	1.95	2.14	5
Canada	2.03	2.62	1	1.19	1.84
Cape Verde	1.8	1.41	2.41	1.11	1
Cayman Islands	1.13	1.25	1	1.04	1
Central African Republic	4.34	3.51	4.22	2.65	5
Chad	4.81	4.39	5	2.02	5
Chile	2.4	1.59	1.95	3.17	1.16
China	2.31	1.01	2.14	2.46	2.31
Colombia	3.21	2.33	3.31	2.06	3.64
Comoros	2.76	3.56	1.83	1.73	2.24

Country	Overall Score	Demographic Pressure	Food Insecurity	Impact of Natural Events	Water Risk
Costa Rica	2.13	2.59	1.90	1.09	1.72
Côte d'Ivoire	3.44	2.95	1.84	1.61	4.63
Croatia	1.73	1	2.42	1.14	1
Cuba	2.42	1	1.74	2.77	2.55
Cyprus	1.81	2.60	1	1.06	1
Czechia	1.22	1.40	1	1.03	1.08
Democratic Republic of the Congo	4.47	4.35	3.95	1.56	5
Denmark	1.42	1.84	1	1	1
Djibouti	3.82	2.93	3.18	1.58	4.88
Dominica	2.87	1.05	1.78	4.42	1
Dominican Republic	3.35	2.11	1.88	2.91	4.30
Ecuador	2.86	2.36	1.23	1.65	3.87
Egypt	2.39	2.92	2.49	1.03	1.29
El Salvador	2.25	1.11	1	2.00	3.03
Equatorial Guinea	3.95	4.20	1.95	1	4.93
Eritrea	4.79	4.34	5	1	5
Estonia	1.1	1	1	1	1.21
Eswatini	3.05	1.96	1.87	1.26	4.37
Ethiopia	3.96	4.14	2.01	1.03	5
Faroe Islands	1.16	1.31	1	1	1
Fiji	2.42	1.24	1.54	1.51	3.40
Finland	1.67	1.62	1	1	2.05
France	1.64	1.94	1	1.67	1
French Polynesia	1.89	2.13	1	2.12	1
Gabon	3.46	2.79	1.20	1.40	4.98
Gambia	3.69	3.96	2.80	1.90	4.04
Georgia	1.97	1	2.23	1.79	1.84
Germany	1.05	1.02	1	1.08	1.03
Ghana	3.67	4.17	1.74	1.27	4.30
Greece	1.59	1.19	1	2.09	1.08
Greenland	1	1	1	1	1
Grenada	1.6	1.38	1.83	1.52	1
Guam	1.96	2.18	1	2.24	1
Guatemala	3.22	3.52	2.76	2.60	3.16
Guinea	4.36	2.89	4.88	2.06	4.80
Guinea-Bissau	4.22	3.33	4.31	1.55	4.81
Guyana	2.2	1	2.29	1.09	2.71
Haiti	4.55	1.88	5	4.28	4.30
Honduras	3.27	2.82	1.45	3.39	3.53
Hungary	1.75	1.01	2.48	1.03	1
Iceland	2.05	3.07	1	1.11	1
India	2.92	2.52	2.26	2.51	3.39
Indonesia	2.82	1.54	1.74	1.96	3.87
Iran	2.46	1.79	1.67	1.81	3.16
Iraq	3.34	4.32	1	1.16	3.54
Ireland	1.82	2.63	1	1.01	1
Isle of Man	1.3	1.61	1	1	1
Israel	2.99	4.19	1	2.11	1.97
Italy	1.15	1.06	1	1.28	1
Jamaica	2.15	1.09	1.34	2.10	2.65
Japan	1.54	1	1	2.08	1
Jordan	2.97	4.31	1.45	1.21	2.09
Kazakhstan	2.52	1.88	2.20	1.32	3.15
Kenya	3.91	4.14	1.68	1.22	4.95
Kosovo	1.39	1.01	1.73	1.03	1.11

Country	Overall Score	Demographic Pressure	Food Insecurity	Impact of Natural Events	Water Risk
Kuwait	2.69	4.28	1	1	1.27
Kyrgyzstan	3.2	1.54	3.31	1.75	3.90
Laos	3.02	2.20	1.14	1.24	4.44
Latvia	1.62	1	1	1	2.23
Lebanon	1.67	1.53	2.03	1.21	1
Lesotho	3.55	1.73	3.83	1.70	4.24
Liberia	4.52	4.55	4.24	1.21	4.75
Libya	2.82	2.85	3.23	1.71	2.12
Liechtenstein	1.32	1.64	1	1	1
Lithuania	1.87	1	1	1	2.75
Luxembourg	2.19	3.37	1	1.02	1
Madagascar	4.69	4.34	4.15	4.54	5
Malawi	4.61	4.68	5	2.53	4.02
Malaysia	2.61	2.85	1.90	1.35	2.84
Mali	4.75	4.42	5	2.64	4.79
Malta	1.05	1.10	1	1	1
Marshall Islands	2.28	2.82	2.26	1.39	1
Mauritania	4.15	3.79	3.53	2.58	4.85
Mauritius	1.64	1.42	2.04	1.21	1
Mexico	2.13	2.05	1.95	1.56	2.34
Micronesia	2.56	1	2.97	2.98	1
Moldova	2.4	1	1.81	1.16	3.42
Mongolia	3.33	2.16	1.89	1.53	4.79
Montenegro	1.67	1.01	2.23	1.19	1.12
Morocco	2.86	1.44	1.79	1.28	4.20
Mozambique	4.14	3.89	2.61	2.98	4.97
Myanmar	3.49	1.07	2.37	3.28	4.42
Namibia	3.22	2.61	1.10	1.15	4.66
Nauru	1.86	1.47	2.53	1	1
Nepal	3.21	3.36	2.27	2.66	3.42
Netherlands	1.24	1.47	1	1.01	1
New Caledonia	2.52	3.00	1	2.84	1
New Zealand	1.79	2.38	1	1.49	1
Nicaragua	3.14	1.56	1	2.36	4.53
Niger	5	4.99	5	4.45	5
Nigeria	4.15	4.53	2.66	1.44	4.79
North Korea	3.21	1	3.63	3.93	1.11
North Macedonia	1.73	1.57	2.15	1.13	1.09
Northern Mariana Islands	2.11	1	1	3.23	1
Norway	1.95	2.89	1	1.02	1.02
Oman	2.52	3.87	1	1.35	1.17
Pakistan	3.33	3.47	2.77	1.24	3.66
Palau	2	2.53	1.91	1.16	1
Palestine	2.54	2.25	2.36	1.11	2.92
Panama	2.99	2.62	2.59	1.81	3.54
Papua New Guinea	3.79	3.35	2.22	1.87	4.96
Paraguay	2.19	2.78	1.71	1.45	1.59
Peru	3.33	1.46	1.61	3.52	4.09
Philippines	3.22	3.15	1.29	3.34	3.19
Poland	2.01	1	2.39	1.04	2.16
Portugal	1.37	1.35	1	1.57	1
Puerto Rico	2.06	1	1	2.84	1.69
Qatar	2.42	3.84	1	1	1
Republic of the Congo	4.32	4.21	3.47	2.39	4.99
Romania	2.21	1	1.85	3.04	1.08

Country	Overall Score	Demographic Pressure	Food Insecurity	Impact of Natural Events	Water Risk
Russia	2.25	1.04	1.84	1.28	3.05
Rwanda	3.97	4.34	2.13	2.09	4.58
Samoa	2.25	1	3.19	1.77	1
San Marino	1.09	1.18	1	1	1
São Tomé and Príncipe	1.71	1.80	1.98	1.03	1
Saudi Arabia	2.72	4.23	1	1.01	1.58
Senegal	3.86	4.11	3.15	1.56	4.18
Serbia	1.65	1.03	2.15	1.34	1
Seychelles	1.64	1.25	2.18	1	1
Sierra Leone	4.71	4.11	5	1.60	4.94
Singapore	1.46	1.93	1	1	1
Slovakia	1.07	1.03	1	1.03	1.12
Slovenia	1.19	1.31	1	1.16	1
Solomon Islands	3.5	3.76	2.32	2.37	3.87
Somalia	4.74	3.60	5	3.87	5
South Africa	2.9	1.90	2.15	1.40	3.93
South Korea	1.5	1	1	2.01	1
South Sudan	4.01	4.02	3.24	1.04	4.61
Spain	1.3	1.54	1	1.14	1
Sri Lanka	2.53	1.44	1	3.09	2.64
St. Kitts and Nevis	1.43	1.86	1	1	1
St. Lucia	1.61	1.69	1.84	1.05	1
St. Vincent and Grenadines	2.15	1.12	1.80	2.68	1.70
Sudan	4.33	4.01	4.22	4.13	4.53
Suriname	2.64	1.89	2.13	1	3.49
Sweden	1.73	2.45	1	1.02	1
Switzerland	1.42	1.83	1	1.05	1
Syria	3.68	3.30	4.99	1.24	1.82
Taiwan	1.14	1	1	1.28	1
Tajikistan	3.29	1.41	2.52	1.45	4.70
Tanzania	3.99	4.42	1.18	1.62	4.93
Thailand	1.63	1.18	1.78	1.56	1.52
Timor-Leste	3.76	3.79	3.09	1.20	4.25
Togo	3.81	3.55	2.38	2.28	4.73
Tonga	1.62	1.09	1.74	1.82	1
Trinidad and Tobago	2.06	1	2.82	1	1.70
Tunisia	1.74	1.62	1.51	1.02	2.00
Türkiye	2.33	2.09	2.99	1.51	1.06
Turkmenistan	2.57	1.81	2.12	1.01	3.38
Turks and Caicos Islands	1.56	1.82	1	1.32	1.43
Tuvalu	2.02	2.73	1.73	1	1
Uganda	4	4.70	1.84	1.48	4.55
Ukraine	1.42	1	1.47	1.18	1.53
United Arab Emirates	2.55	4.10	1	1	1
United Kingdom	1.52	2.00	1	1.13	1
United States	2.09	2.24	1	1.91	2.10
Uruguay	1.56	1	1	2.07	1.14
Uzbekistan	2.11	1.61	1.95	1	2.56
Vanuatu	3.63	3.82	3.78	2.84	3.13
Venezuela	2.82	2.52	2.22	1.71	3.39
Vietnam	2.7	1.43	1.77	2.85	3.11
Virgin Islands, U.S.	1.21	1.10	1	1.08	1.36
Yemen	4.4	4.43	5	1.25	3.62
Zambia	4.08	4.44	1.76	1.52	5
Zimbabwe	4.05	1.22	3.65	3.39	4.89

ENDNOTES

EXECUTIVE SUMMARY

1 European Civil Protection and Humanitarian Aid Operations. (2024). “Sahel”. European Commission. https://civil-protection-humanitarian-aid.ec.europa.eu/where/africa/sahel_en.

2 Kaderi Noagah Bukari, et al. (2018). “Cooperation and Co-Existence Between Farmers and erders in the Midst of Violent Farmer-Herder Conflicts in Ghana”. African Studies Review. https://www.cambridge.org/core/journals/african-studies-review/article/cooperation-and-coexistence-between-farmers-and-herders-in-the-midst-of-violent-farmerherder-conflicts-in-ghana/16A94FD119CAECC178B12F5A3721A5A3.

SECTION 1: RESULTS

1 International Organization for Migration. (2024). “Report Overview: Migration Continues to Be Part of the Solution in a Rapidly Changing World, but Key Challenges Remain”. World Migration Report. https://worldmigrationreport.iom.int/what-we-do/world-migration-report-2024-chapter-1/migration-continues-be-part-solution-many-economies-societies-and-families-around-world.

2 IDMC, and Norwegian Refugee Council. (2023). “2023 Global Report on Internal Displacement.” IDMC. https://www.internal-displacement.org/global-report/grid2023.

3 Trevino, Jorge, and Thierry Davy. (2023). “Water Security Is the Way out of the Conflict-Climate Risk Trap in Lake Chad Basin.” World Bank Blogs. https://blogs.worldbank.org/water/water-security-way-out-conflict-climate-risk-trap-lake-chad-basin.

4 Scollon, Michael. (2023). “Iran and Afghanistan’s Taliban Clash as Water Dispute Boils Over.” Radio Free Europe/Radio Liberty. https://www.rferl.org/a/iran-taliban-water-dispute-/32435442.html.

5 IPPC. (2021). “Climate change widespread, rapid, and intensifying”. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/

6 For example, when unprecedented precipitation from Storm Daniel converged with inadequate maintenance of dams, catastrophic flooding occurred in Derna, Libya. It is estimated that the flood killed as many as 20,000 people and displaced over 30,000, sweeping at least a quarter of the city into the Mediterranean Sea. (Perry, Tom. (2023). “Libya floods: what caused them and why are they so bad?” Reuters. https://www.reuters.com/world/africa/what-caused-floods-libya-why-are-they-so-bad-2023-09-14/; The Economist. (2023) “The Lethal Negligence of Politicians in Morocco and Libya.” The Economist https://www.economist.com/middle-east-and-africa/2023/09/13/the-lethal-negligence-of-politicians-in-morocco-and-libya.)

7 Box, Jason E., et al. (2022) “Greenland Ice Sheet Climate Disequilibrium and Committed Sea-Level Rise.” Nature Climate Change. https://doi.org/10.1038/s41558-022-01441-2.

8 UNHCR. (2023). “Briefing notes: As the Horn of Africa drought enters a sixth failed rainy season, UNHCR calls for urgent assistance”. The UN Refugee Agency https://www.unhcr.org/news/horn-africa-drought-enters-sixth-failed-rainy-season-unhcr-calls-urgent-assistance; Hauser, Christine, and Claire Moses. (2023) “Smoke Pollution from Canadian Wildfires Blankets U.S. Cities, Again”. The New York Times. https://www.nytimes.com/2023/07/17/us/wildfire-smoke-canada-ny-air-quality.html; AJLabs. “Mapping the Scale of Canada’s Record Wildfires.” Al Jazeera. https://www.aljazeera.com/news/2023/8/23/mapping-the-scale-of-canadas-record-wildfires.

9 International Trade Administration. (2022). “Costa Rica’s Renewable Energy”. United States Department of Commerce. https://www.trade.gov/market-intelligence/costa-ricas-renewable-energy.

10 Shepard, Dan. (2018). “Global warming: severe consequences for Africa”. United Nations Africa Renewal. https://africarenewal.un.org/en/magazine/global-warming-severe-consequences-africa

11 World Bank. (2022). “Databank: World Development Indicators”. https://databank.worldbank.org/./.

12 International Crisis Group, (2023)“Absorbing Climate Shocks and Easing Conflict in Kenya’s Rift Valley”. International Crisis Group. https://www.crisisgroup.org/africa/east-and-southern-africa/kenya/b189-absorbing-climate-shocks-and-easing-conflict-kenyas-rift

13 1UN News. (2022). “South Sudan: Conflict and climate crisis drives rising hunger”. UN News. https://news.un.org/en/story/2022/11/1130152

14 Kullab, Samya. (2022). “Politics, climate conspire as Tigris and Euphrates dwindle.” Associated Press News. https://apnews.com/article/iran-middle-east-business-world-news-syria-3b8569a74d798b9923e2a8b812fa1fca

15 Reuveny, Rafael. (2007). “Climate Change-Induced Migration and Violent Conflict.” Political Geography 26, no. 6: 656–73. https://doi.org/10.1016/j.

16 UNDRR. (2017). “Sendai Framework Terminology on Disaster Risk Reduction: Capacity”. UNDRR. https://www.undrr.org/terminology/capacity.

17 Shoko Takemoto, et al. (2022). “Learning from Mega disasters: A Decade of Lessons from the Great East Japan Earthquake,” World Bank. https://www.worldbank.org/en/news/feature/2021/03/11/learning-from-megadisasters-a-decade-of-lessons-from-the-great-east-japan-earthquake-drmhubtokyo.

18 Ranghieri, Federica, and Mikio Ishiwatari. (2014). “Learning from Megadisasters: Lessons from the Great East Japan Earthquake” World Bank. https://www.researchgate.net/publication/273945904_Learning_from_megadisasters_Lessons_from_the_Great_East_Japan_Earthquake

19 Institute for Economics and Peace. (2019). “Positive Peace Report 2019”. http://visionofhumanity.org/app/uploads/2019/10/PPR-2019-web.pdf

20 UN Environment Programme. (2011). “Great East Japan Earthquake and tsunami” UNEP. https://www.unep.org/explore-topics/disasters-conflicts/where-we-work/japan/great-east-japan-earthquake-and-tsunami.

21 The Guardian (2010). “Haiti earthquake: the aftermath” The Guardian. https://www.theguardian.com/world/gallery/2010/jan/20/haiti-earthquake-looting-aftermath.

22 Elgar, F. J., et.al. (2021). “Relative Food Insecurity, Mental Health and Wellbeing in 160 Countries.” Social Science & Medicine. https://doi.org/10.1016/j.socscimed.2020.113556.

23 Kearns, Jeff. (2023). “Global Food Crisis May Persist, With Prices Still Elevated Year After War” IMF. https://www.imf.org/en/Blogs/Articles/2023/03/09/global-food-crisis-may-persist-with-prices-still-elevated-after-year-of-war.

24 UNESCO. (2023). “Imminent Risk of a Global Water Crisis, Warns the UN World Water Development Report 2023”. https://www.unesco.org/en/articles/imminent-risk-global-water-crisis-warns-un-world-water-development-report-2023

25 Kuzma, Samantha., et.al. (2023). “25 Countries, Housing One-Quarter of the Population, Face Extremely High Water Stress”. World Resource Institute. https://www.wri.org/insights/highest-water-stressed-countries

26 European Union. (2024). “Water Resources of Europe” WISE EU. https://water.europa.eu/freshwater/europe-freshwater/freshwater-themes/water-resources-europe

27 European Environment Agency. (2023). “Water Stress Is a Major and Growing Concern in Europe”. European Union News. https://www.eea.europa.eu/highlights/water-stress-is-a-major

28 Kuzma, Samantha, and Liz Saccoccia (2023). “25 Countries Face Extremely High Water Stress”. World Resource Institute. https://www.wri.org/insights/highest-water-stressed-countries.

29 Zhang, H., et al. (2022). “Assessing the impact of renewable energy consumption on CO2 emissions: Evidence from G20 countries” Journal of Cleaner Production, 379, 134883. https://doi.org/10.1016/j.jclepro.2022.134883

30 Liu, J., et al. (2017). “Water scarcity assessments in the past, present, and future” Earth’s Future. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016EF000518

31 UN News. (2023). “Hottest July ever signals “era of global boiling has arrived” says UN chief. United Nations. https://news.un.org/en/story/2023/07/1139162

32 UNDRR. (2017). “Sendai Framework Terminology on Disaster Risk Reduction: Disaster”. UNDRR. https://www.undrr.org/terminology/disaster.

33 Central Intelligence Agency. (2024). “Kiribati”. The World Factbook. https://www.cia.gov/the-world-factbook/countries/kiribati/.

34 Central Intelligence Agency. (2024). “Tuvalu”. The World Factbook. https://www.cia.gov/the-world-factbook/countries/tuvalu/#geography.

35 United Nations. (2024). “Press release: State of emergency issued by the Office of the Prime Minister”. Permanent Mission of Tuvalu to the United Nations. https://www.un.int/tuvalu/activities/press-release-state-emergency-issued-office-prime-minister-0

36 UNDP. (2017). “TV Coastal Adaptation”. UNDP Transparency Portal. https://open.undp.org/projects/00100068

37 TCAP. (2018). “Tuvalu Coastal Adaptation Project.” https://tcap.tv/; UNDP. (2022). “Crucial Coastal Protection Set to Begin Under Tuvalu Coastal Adaptation Project”. https://www.undp.org/pacific/stories/crucial-coastal-protection-set-begin-under-tuvalu-coastal-adaptation-project

38 Perry, Nick. (2023). "Tuvalu Climate Change: Australia, Cook Islands Respond". Associated Press. https://apnews.com/article/tuvalu-climate-change-australia-cook-islands-8c46845f69d5ffe7d29c2a47a7ad8d6e

39 Griggs, Mary Beth. (2014). "Kiribati's Climate Change Plan: Buy a New Island Home". Smithsonian Magazine. https://www.smithsonianmag.com/smart-news/kiribatis-climate-change-plan-b-buy-new-island-home-180952039/

40 Central Intelligence Agency. (2024). "Kiribati". The World Factbook. https://www.cia.gov/the-world-factbook/countries/kiribati/.

41 Solarin, Sakiru Adebola. (2020). "An Environmental Impact Assessment of Fossil Fuel Subsidies in Emerging and Developing Economies." Environmental Impact Assessment Review https://www.sciencedirect.com/science/article/abs/pii/S0195925520300469.

42 Urdal, Henrik. (2006). "A Clash of Generations? Youth Bulges and Political Violence". International Studies Quarterly. https://www.jstor.org/stable/4092795.

43 Weber, H. (2018). "Age structure and political violence: a re-assessment of the "youth bulge" hypothesis". Democratization. https://www.tandfonline.com/doi/full/10.1080/03050629.2019.1522310

44 Yair, Omer, and Dan Miodownik. (2016). "Youth bulge and civil war: Why a country's share of young adults explains only non-ethnic wars." Conflict Management and Peace Science. https://www.researchgate.net/publication/265650970_Youth_bulge_and_civil_war_Why_a_country%27s_share_of_young_adults_explains_only_non-ethnic_wars

45 Ginges, Jeremy. (2005). "Youth Bulges, Civic Knowledge, and Political Upheaval". Physiological Science. https://journals.sagepub.com/doi/10.1111/j.1467-9280.2005.01590.x

46 Nordas, Ragnhild, Christian Davenport. (2013). "Fight the Youth: Youth Bulges and State Repression". Peace Research Institute Oslo and University of Michigan. https://www.researchgate.net/publication/282333568_Nordas_Davenport_2013

47 Bricker, Noah Q. and Mark C. Foley. (2013). "The Effect of Youth Demographics on Violence: The Importance of the Labor Market". International Journal of Conflict and Violence. https://www.researchgate.net/publication/286568848_The_Effect_of_Youth_Demographics_on_Violence_The_Importance_of_the_Labor_Market

SECTION 2: NON-STATE CONFLICT AND ECOLOGICAL THREATS

1 Mach, Katharine., et al. (2019). "Climate as a Risk Factor for Armed Conflict." Nature. https://doi.org/10.1038/s41586-019-1300-6.

2 Daoust, Gabrielle, and Jan Selby. (2023). "Understanding the Politics of Climate Security Policy Discourse: The Case of the Lake Chad Basin." Geopolitics https://doi.org/10.1080/14650045.2021.201482

3 Tor A. Benjaminsen.,et al, "Does Climate Change Drive Land-Use Conflicts in the Sahel?" Journal of Peace Research https://doi.org/10.1177/0022343311427343.

4 Ide, Tobias. (2023). "Rise or Recede? How Climate Disasters Affect Armed Conflict Intensity." International Security. https://doi.org/10.1162/isec_a_00459.

5 Chung, Eunbin, and Inbok Rhee. (2022). "Disasters and Intergroup Peace in Sub-Saharan Africa." Journal of Peace Research. https://doi.org/10.1177/00223433211065249.

6 Rezaeedaryakenari, Babak., et al. (2017). "Food Price Volatilities and Civilian Victimization in Africa." Conflict Management and Peace. https://doi.org/10.1177/0738894217729527.

7 Koren, Ore. (2019). "Food Resources and Strategic Conflict." The Journal of Conflict Resolution https://doi.org/10.1177/0022002719833160

8 Schon, Justin., et al. (2023). "The Need for Willingness and Opportunity: Analyzing Where and When Environmental Variability Influences Conflict in the Sahel." Population and Environment. https://doi.org/10.1007/s11111-023-00413-8.

9 Depetris-Chauvin, Emilio and Özak, Ömer. (2020). "Borderline Disorder: (De facto) Historical Ethnic Borders and Contemporary Conflict in Africa" SSRN http://dx.doi.org/10.2139/ssrn.3541025 .

10 1Food and Agriculture Organization of the United Nations. (2023). "Pastoralism: Supporting Livelihoods, Building Peace." FAO Newsroom. www.fao.org/newsroom/detail/pastoralism-supporting-livelihoods-building-peace/en

11 Food and Agriculture Organization of the United Nations. (2024). "West and Central Africa." FAO Pastoralist Knowledge Hub, www.fao.org/pastoralist-knowledge-hub/pastoralist-networks/regional-networks/west-and-central-africa/en/.

12 Liu, Y., & Xue, Y. (2020). "Expansion of the Sahara Desert and shrinking of frozen land of the Arctic". Scientific Reports, 10, Article 4109. https://www.nature.com/articles/s41598-020-61085-0

13 Food and Agriculture Organization of the United Nations. (n.d). "West and Central Africa." Pastoralist Knowledge Hub. www.fao.org/pastoralist-knowledge-hub/pastoralist-networks/regional-networks/west-and-central-africa/en/.

14 Schon., et.al. (2023) "The Need for Willingness and Opportunity: Analyzing Where and When Environmental Variability Influences Conflict in the Sahel." Population and Environment. https://doi.org/10.1007/s11111-023-00413-8.

15 European Union Emergency Trust Fund for Africa (2022). "Case Study - Farmers and Herders." Altai Consulting, European Union. https://trust-fund-for-africa.europa.eu/system/files/2023-07/EUTF%20SLC%202022%20Case%20study%20-%20Farmers%20and%20herders%20-%20Report%20EN.pdf.

16 Petrova, Kristina. (2022). "Floods, Communal Conflict and the Role of Local State Institutions in Sub-Saharan Africa." Political Geography. https://doi.org/10.1016/j.polgeo.2021.102511

17 George, J., A. Adelaja., et.al. (2021). "Terrorist attacks, land resource competition and violent farmer-herder conflicts". Land Use Policy

18 Holocaust Encyclopaedia. (2023). "Darfur". USHMM https://encyclopedia.ushmm.org/content/en/article/darfur.

19 Mélanie De Groof., et al. (2023). "Letter dated 13 June 2023 from the Group of Experts on the Democratic Republic of the Congo addressed to the President of the Security Council". UN Security Council. https://www.ecoi.net/en/file/local/2094036/N2312380.pdf.

SECTION 3: TOWARDS FOOD SECURITY IN SUB-SAHARAN AFRICA

1 FAO, IFAD, UNICEF, WFP and WHO. (2023). "The State of Food Security and Nutrition in the World 2023: Urbanization, agrifood systems transformation and healthy diets across the rural-urban continuum". Rome, FAO. https://doi.org/10.4060/cc3017en.

2 The Economist. (2024). "How to raise the world's IQ". Leaders: The Economist. https://www.economist.com/leaders/2024/07/11/how-to-raise-the-worlds-iq.

3 Fox, Louise and Thomas S. Jayne. (2020). "Unpacking the misconceptions about Africa's food imports". Brookings Institution. https://www.brookings.edu/articles/unpacking-the-misconceptions-about-africas-food-imports/.

4 IEP calculations based on FAO trade figures.

5 Fox, Louise and Thomas S. Jayne. (2020). "Unpacking the misconceptions about Africa's food imports". Brookings Institution. https://www.brookings.edu/articles/unpacking-the-misconceptions-about-africas-food-imports/.

6 Averages based on 2018-2022 FAO production and trade figures.

7 Swaminathan, Sumathi and Mahshid Dehghan, et al. (2020). "Associations of cereal grains intake with cardiovascular disease and mortality across 21 countries in Prospective Urban and Rural Epidemiology study: prospective cohort study". BMJ. https://www.bmj.com/content/bmj/372/bmj.m4948.full.pdf.

8 The Economist. (2018). "Africa has plenty of land. Why is it so hard to make a living from it?". The Economist. https://www.economist.com/middle-east-and-africa/2018/04/28/africa-has-plenty-of-land-why-is-it-so-hard-to-make-a-living-from-it

9 Mary Donovan. (2020). "What is sustainable intensification?". CIMMYT. https://www.cimmyt.org/news/what-is-sustainable-intensification/.

10 Steve Wiggins. (2013). "Leaping & learning: Linking smallholders to markets". Agriculture for Impact. https://media.odi.org/documents/8401.pdf.

11 Global Yield Gap Atlas. (2020) "Maize production in nine Sub-Saharan African countries". Global Yield Gap Atlas. https://www.yieldgap.org/ssa-maize.

12 Global Yield Gap Atlas. "Sorghum production in nine Sub-Saharan African countries". Global Yield Gap Atlas. https://www.yieldgap.org/ssa-sorghum.

13 Aakash, et al. (2022). "Sustainability in Rainfed Maize (Zea mays L.) Production Using Choice of Corn Variety and Nitrogen Scheduling". Sustainability. https://www.mdpi.com/2071-1050/14/5/3116

14 FAO. (2024). "Water". https://www.fao.org/water/en/.

15 FAO. (2024). "Water". https://www.fao.org/water/en/.

16 Higher estimates suggest that 5-6 per cent of the cultivated land in sub-Saharan Africa is irrigated. (Thompson, Tom and Tashi Gyatso. (2020). "Technology Adoption for Improving Agricultural Productivity in Sub-Saharan Africa". Global Agricultural Productivity. https://globalagriculturalproductivity.org/wp-content/uploads/2019/01/Ag-Tech-Africa_2020_GAP.pdf.)

17 The estimates on the percentage of renewable water required to irrigate all lands with irrigation potential is based on each hectare receiving 8,000 cubic metres of water per year. For maize, the most widely grown cereal in sub-Saharan Africa, a study in Australia suggested that between 6,800 and 8,000 cubic metres of water are required to irrigate the crop each year. (Grains Research & Development Corporation. (2017). "Maize". GRDC. https://grdc.com.au/__data/assets/pdf_file/0025/238822/grdc-grownotes-maize-northern.pdf.pdf.)

18 For maize, the most widely grown cereal in sub-Saharan Africa, a study in Australia suggested that between 6,800 and 8,000 cubic metres of water are required to irrigate the crop each year. (Grains Research & Development Corporation. (2017). "Maize". GRDC. https://grdc.com.au/__data/assets/pdf_file/0025/238822/grdc-grownotes-maize-northern.pdf.pdf.)

19 Musambi, Evelyne. (2024). "Farmers in Africa say their soil is dying and chemical fertilizers are in part to blame". Associated Press. https://apnews.com/article/kenya-agriculture-farming-soil-acidic-93a2d59e54cf39f9aff972d6c8599285.

20 Adapted from: Richtie, Hannah., et al. (2022). "Crop Yields". Our World in Data. https://ourworldindata.org/crop-yields.

21 Figures have been adjusted for inflation based on 2015 dollars calculated in an International Fertilizer Development Center (IFDC) study. (Cited in Goedde, Lutz., et al. (2019). "Winning in Africa's agricultural market". McKinsey & Company. https://www.mckinsey.com/industries/agriculture/our-insights/winning-in-africas-agricultural-market.)

22 Based on records from The Charitable Foundation (TCF).

23 A study on sand dams in Kenya estimated that 5.6 hectares could be irrigated from a single large sand dam, while the estimates used in this analysis suggest that about 8.9 hectares could be irrigated from 71,000 cubic metres of water. (The Charitable Foundation. (2020). "Economic Analysis of Sand Dams in Kenya: Cost-Benefit Analysis".)

24 The Charitable Foundation. (2020). "Economic Analysis of Sand Dams in Kenya: Cost-Benefit Analysis".

25 This present analysis uses an estimated total cost of US$12 billion for the requisite expansion of grain facilities, which is 50 per cent higher than an estimate based on current grain production put forward by Goedde et al. This latter analysis is grounded in estimates for reducing post-harvest losses from 14 to 10 per cent in Ethiopia, Ghana, Mali, and Tanzania. (Goedde, Lutz., et al. (2019). "Winning in Africa's agricultural market". McKinsey & Company. https://www.mckinsey.com/industries/agriculture/our-insights/winning-in-africas-agricultural-market.)

26 Liangzhi You, et al. (2010). "What Is the Irrigation Potential for Africa?". International Food Policy Research Institute. https://ageconsearch.umn.edu/record/93736/files/ifpridp00993.pdf.

27 For example, a 2021 study based on a four-year irrigation project in Burkina Faso, Mali, Niger, and Senegal documented the implementation of multiple irrigation systems, including a "Californian system", which appealed to farmers owing to its relatively low installation and maintenance costs. Against an initial investment cost of around US$800 per hectare, this system was estimated to last around eight years in West African conditions, though the method resulted in lower water savings and yield gains than much more costly drip irrigation systems. (International Center for Bio-Saline Agriculture. (2021). "Scaling Up Small-Scale Irrigation Technologies for Improving Food Security in Sub-Saharan Africa". ICBA. https://www.biosaline.org/sites/default/files/Project-Report-Final-OFID-October-2021.pdf.)

28 The Israeli firm Netafim quotes prices between US$1,000 and US$4,000 per hectare for installation of its drip irrigation systems in Africa. Its highest quality dripper and driplines reportedly last between 15 and 25 years. (CNBC Africa. (2023). "Is drip irrigation tech cost-effective for African farmers?". CNBC Africa. https://www.cnbcafrica.com/media/6328136205112/; Netafim. (2024). "Drippers and driplines". Netafim. https://www.netafim.com.au/irrigation-products/product-offering/drip-irrigation-products/.)

29 OECD. (2024). "Development Co-operation Profiles". OECD Publications. https://www.oecd.org/en/publications/2023/06/development-co-operation-profiles_17afa013/full-report/component-2.html.

30 Based on FAO figures from 2022.

31 The 162 per cent overall increase in yield would be the result of an 80 per cent yield increase from irrigation, a 39 per cent yield increase from added fertilisers, and a 4.7 per cent yield increase from improved grain storage (averted yield losses).The 162 per cent overall increase in yield would be the result of an 80 per cent yield increase from irrigation, a 39 per cent yield increase from added fertilisers, and a 4.7 per cent yield increase from improved grain storage (averted yield losses).

32 Biazin, Birhanu., et al. (2012). "Rainwater harvesting and management in rainfed agricultural systems in sub-Saharan Africa – A review". Physics and Chemistry of the Earth. https://www.sciencedirect.com/science/article/abs/pii/S147470651100235X.

Our research analyses peace and its economic value.

We develop global and national indices, calculate the economic impact of violence, analyse country level risk and have developed an empirical framework for Positive Peace that provides a roadmap to overcome adversity and conflict, helping to build and sustain lasting peace.

Download our latest reports and research briefs for free at:
visionofhumanity.org/resources

FOR MORE INFORMATION
INFO@ECONOMICSANDPEACE.ORG
EXPLORE OUR WORK
WWW.ECONOMICSANDPEACE.ORG AND
WWW.VISIONOFHUMANITY.ORG

GlobalPeaceIndex

@GlobPeaceIndex

IEP is an independent, non-partisan, non-profit think tank dedicated to shifting the world's focus to peace as a positive, achievable, and tangible measure of human well-being and progress.

IEP is headquartered in Sydney, with offices in New York, Brussels, The Hague, Mexico City and Nairobi. It works with a wide range of partners internationally and collaborates with intergovernmental organisations on measuring and communicating the economic value of peace.

OCTOBER 2024 / IEP REPORT 99

ISBN 978-1-7637550-0-0