Analysing ecological threats, resilience & peace

Ecological Threat Report 2025

- Results and Trends
- Rainfall Continuity and Conflict
- Freshwater Accessibility
- Shared Water Systems

IEP Institute for Economics & Peace

Quantifying Peace and its Benefits

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Contents

EXECUTIVE SUMMARY

The 2025 Ecological Threat Report (ETR) is a comprehensive, data-driven global assessment of ecological risks. It covers 3,125 sub-national areas in 172 countries and territories, representing more than 99 per cent of the world's population. It measures four interlocking threats: water risk, food insecurity, the impact of natural events, and demographic pressure.

The main finding of this year's report is the unexpected and sometimes divergent relationships between water and conflict. On the one hand, it finds that conflict death rates are 50 per cent higher in places where water stress is rising owing to heightened rainfall seasonality. On the other, it highlights how there have been no interstate wars fought over water in the modern era. In this regard, the hundreds of active freshwater treaties around the world demonstrate that strategic cooperation is effective when the downside risks are well-known, similar to nuclear non-proliferation treaties.

Precipitation patterns are shifting, and the seasonality of rainfall is increasing. Seasonality refers to the concentration of rainfall into fewer months within the year, resulting in wet seasons becoming wetter and dry seasons becoming drier, even though total annual rainfall may not change. This is occurring in over 60 per cent of the areas covered in the report, with the remainder recording a more even spread of rain throughout the year. In areas experiencing severe increases in rainfall seasonality, there are on average four times as many conflict deaths as in places where it is relatively stable or has notably decreased.

Analysis finds that rainfall seasonality tends to act as a risk multiplier rather than a core driver of conflict. These heightened risks are particularly acute where ecological fragility overlaps with rapid population growth and already-low rates of freshwater access. Sub-Saharan Africa is the most critically affected area, with per capita water usage having fallen from 113 cubic metres per person in 2000 to 89 as of 2022, less than one-fifth the global consumption rate.

When populations expand quickly, governance is weak, and there is a history of conflict and group grievances, rainfall shocks are more likely to generate competition over land, water, and food – and therefore violence. Modelling finds that when population growth exceeds roughly two to three per cent annually, heightened seasonality can add as many as six additional conflict deaths per year for every 100,000 people.

There are 263 international river basins globally with billions of people dependent on them for their freshwater. Their stability is paramount for both food security and international peace. Popular narratives have warned of looming "water wars", especially in transboundary river and lake basins. The ETR's review finds a more positive reality: outright interstate wars fought exclusively over water have not occurred in the modern era. The importance of these systems is underscored by the 157 international freshwater treaties signed between countries in the second half of the 20th century, highlighting that countries understand the cataclysmic consequences of mass disruption to freshwater and food supplies.

This cooperative approach to water management in some ways mirrors the restraint that has characterised the use of nuclear weapons over the past 80 years. As with weapons of mass destruction, threats to water supplies have the potential to lead to societal collapse. As a result, mutual vulnerability and the threat of catastrophic destruction has encouraged pragmatic collaboration.

The ETR methodology uses comparable metrics across space and time to assess how human communities interact with the natural environment – specifically in relation to resource scarcity, climatic changes, and the ways population growth amplifies existing strains. This edition of the ETR is the first to include a multi-year time series, enabling a clearer view of year-on-year volatility alongside persistent trends. The report finds that between 2019 and 2024, the level of ecological risk increased, with 96 countries deteriorating and 74 improving. The average global ETR score rose by 0.8 per cent, a significant shift given the slow-moving nature of environmental systems.

The ETR identifies 295 sub-national areas with very high water risk and another 780 with high risk, affecting nearly 1.9 billion people. Since 2019, the global average water risk score has deteriorated by 0.5 per cent, with the most severe risks in sub-Saharan Africa, South Asia, and South America. This period also captures the shock and partial recovery associated with COVID-19, especially visible in food systems. However, recovery has been uneven, with the poorest countries generally the most affected. Food security is not on track to return to its pre-pandemic levels until 2029. This period saw a 300 million increase in food-insecure people, bringing the total to almost 2.3 billion. Nevertheless, some of the lower-income countries most affected by pandemic-era downturns, such as Rwanda and Malawi, have experienced some of the most notable bounce-backs.

Annual flows of renewable freshwater remain broadly stable, yet population growth has driven a steep decline in per capita availability, from nearly 18,000 cubic metres per person in 1950 to just over 5,000 in 2025. Each year, roughly 44,000 cubic kilometres of renewable water are generated by rainfall and snowmelt that feed rivers and replenish aquifers. While this supply is relatively constant, the balance between availability and demand is deteriorating as populations expand, consumption rises, and rainfall patterns shift.

Of particular concern is the widening global inequality in freshwater access. The world's renewable supply is both finite and unevenly distributed, with worsening scarcity in many of the poorest regions while stress eases in wealthier ones. In high-income countries, per capita withdrawals have fallen by about one-third since 2000, driven by efficiency gains, industrial transitions, and slower demographic growth. These improvements have contributed to the total global volume of withdrawals appearing to have peaked around 2019 and declined slightly since. However, many poor countries have seen a differing trend with total water withdrawals continuing to rise, however in contrast withdrawals per capita have fallen because of the pace of population growth. As a result, water-scarce regions face rising extraction pressures and growing competition among farms, industries, and households, increasing the risk of conflict.

Agriculture is by far the dominant user of freshwater. About 80 per cent of global cropland is rainfed, though the other 20 per cent that is irrigated produces 40 per cent of the world's food, highlighting the benefits of improving water capture and infrastructure. Increasingly erratic rainfall poses a direct threat to food production and household water security.

The discrepancies in global irrigation rates represent both a vulnerability and an opportunity. With appropriate investment in micro-capture, small-scale irrigation, conveyance, and on-farm water management, rain-reliant production systems can be buffered against intra-seasonal shocks. In sub-Saharan Africa, for example, the ETR finds that less than two per cent of farmland is irrigated – the lowest rate worldwide – yet the region holds an estimated 34 million hectares of land with untapped irrigation potential. These lands could be developed using less than six per cent of the region's renewable water resources.

In the past five years, the subregion of Northwest Africa experienced the biggest deterioration in the ETR because of unusually favourable conditions in 2019 followed by drought and high temperatures, which heightened water stress in the last few years. As a result, Tunisia recorded the largest country-level deteriorations in both overall ETR score and water risk score. Morocco and Algeria were also among the ten largest deteriorations for both scores. At the same time, parts of southern and eastern Africa recorded improvements, illustrating that progress can occur even in more exposed regions.

> "Analysis finds that rainfall seasonality tends to act as a risk multiplier rather than a core driver of conflict.

In parallel, the humanitarian footprint of natural hazards has expanded. Since 2015, hazardous events have displaced more than 260 million people, including 45 million internal displacements across 163 countries in 2024 alone – overwhelmingly due to storms and floods. Documented climate-related annual counts of such disasters have been relatively steady since 2005. Encouragingly, the number of deaths per event has fallen sharply in recent decades, with global disaster mortality now roughly 50 times lower than it was a century ago.

These impacts are worst where infrastructure and capacities to respond and recover are weakest. The ETR's impact of natural events indicator captures both exposure and coping capacity. Over the past five years, deteriorations outpaced improvements, with the steepest deteriorations in parts of West Africa and South Asia, while Western and Central Europe recorded notable improvements.

Sub-Saharan Africa continues to face the most acute ecological burdens, reflected in high average scores across all ETR indicators and in the clustering of the most threatened countries. While Northwest and West Africa recorded the sharpest recent deteriorations, the wider region shows the most consistently acute levels of ecological threat over multiple years. Looking ahead, demographic pressure will intensify these risks: sub-Saharan Africa's population is projected to grow by nearly 70 per cent in the next 25 years, placing even greater strain on already fragile food and water systems.

The Karamoja Cluster of East Africa reflects these dynamics, particularly in relation to water and rain-dependent food production. Despite relatively stable annual totals of rainfall, its distribution and timing have become more erratic, intensifying both drought and flood risks. Only about two per cent of the cultivated land across the four Karamoja Cluster countries is irrigated, leaving communities heavily exposed to rainfall disruptions. In recent multi-year droughts, the region saw large-scale livestock mortality and displacement. Such developments have operated in parallel to a deteriorating security situation across the subregion. Since 2019, climatic volatility has coincided with a renewed upswing in pastoralist violence after a period of relative calm, as herders travel farther for pasture and water and raiding becomes increasingly commercialised.

The dynamics observed in Karamoja are mirrored, in different forms, across many regions. As demand for water intensifies, effective management becomes not only a foundation for livelihoods but also a cornerstone of regional stability. Localised water insecurity often scales upward, shaping national development trajectories and, in some cases, cross-border relations.

This makes contemporary lessons of successful cooperation even more salient. Illustrative cases include the Senegal River basin's principles of joint ownership, equal decision-making, and shared benefits, which have transformed a potential flashpoint into a durable peacebuilding mechanism; the Sava River basin agreement in the Balkans provides a platform for cooperation among former belligerents; and in Central Asia, recent joint dam projects on the Syr Darya and Amu Darya mark a shift from conflict to collaboration. Even in tense basins such as the Indus River – shared by India and Pakistan – water-sharing has continued despite repeated episodes of war, political and military tension. In September 2025, the Grand Ethiopian Renaissance Dam opened without fully resolved water sharing arrangements with neighbouring states. Nevertheless, open warfare remains unlikely, not least because destruction would impose catastrophic ecological and human costs on all parties.

The broader takeaway from this report is twofold. First, water stress between countries has historically been more likely to foster diplomacy than war, particularly when institutional frameworks are in place. Second, as rainfall variability intensifies, so does conflict; therefore, the advantages of adaptive cooperation become more important. Improving micro water capture, flexible allocation rules, and mechanisms that spread costs and benefits can prevent disputes from escalating while sustaining the economies that depend on rainfall.

KEY FINDINGS

Section 1: Results and Trends

- Between 2019 and 2024, global ecological threat levels rose by 0.8 per cent, a significant shift given the slow-moving nature of societal and environmental systems. Ninety-six countries experienced deteriorations, while 74 improved.
- Africa is at the epicentre of risk. Niger is the most threatened country worldwide, followed by Burundi, Afghanistan, Uganda, and the Democratic Republic of the Congo. All these countries have very high population growth.
- While global ecological threat levels have risen over the past five years, Central and Western Europe recorded substantial overall improvements. In part, this represents a return to normalcy following Europe's unusually dry climatic conditions in 2019, the baseline year of analysis.
- In contrast, in the past five years, northwestern and western Africa experienced the sharpest increases in ecological threat levels.
- Northwestern Africa's deteriorations were driven by water issues. Tunisia, Algeria, and Morocco recorded the steepest rises in water risk – the result of a combination of droughts, heatwaves, erratic rainfall, and inadequate water infrastructure, undermining communities' capacities to retain and access freshwater.
- Progress is also visible in some other parts of the world, including in low-income countries. Parts of southern and eastern Africa recorded reductions in ecological threat, demonstrating that improvements are possible even in more exposed regions. The biggest improvements were recorded in Lesotho, Rwanda, Eritrea, and Eswatini.
- Food insecurity substantially increased with the onset of the COVID-19 pandemic due to supply chain and other disruptions. The situation has improved marginally since 2021 but is still worse than pre-pandemic levels.
- The number of food-insecure people rose by more than 300 million between 2019 and 2021, reaching almost 2.3 billion, and has remained at roughly that level since. Global reductions in foreign aid are likely to aggravate the situation.
- Countries that were hardest hit by increases in food insecurity at the height of the pandemic were among those to record the largest improvements since 2021. These include low-income countries such as Rwanda and Malawi.
- Many communities worldwide face growing risks from inconsistent access to freshwater, with the global water risk score increasing by 0.5 per cent since 2019. There are rising extremes of too little water (droughts and heatwaves) and too much water (floods and storms), as well as less extreme but increasingly commonplace disruptions arising from unpredictable rainfall.
- Documented floods, storms, and droughts have become twice as frequent as they were in the 1980s, but since 2005 the annual number of events has been relatively steady. The number of deaths caused per event has decreased by a factor of 50 over the last century.
- In 2024, natural hazards triggered 45 million internal displacements across 163 countries – the highest figure since at least 2008. Storms and floods accounted for nearly all the displacements, with low-income countries taking much longer to recover.
- The world has also made substantial long-term gains in water safety. Since 2000, more than two billion have gained access to safely managed drinking water and sanitation – progress that continued despite population growth, especially in urban areas.
- While many fragile countries face sizable challenges related to accelerating population growth, these demographic pressures are easing in other places. Population growth projections have repeatedly been revised down in recent years.
- Changes in population growth are unevenly distributed, with many Western and Asian countries set to see declines, while many African and South Asian countries face substantial increases, which will place added pressures on food and water. Many of these countries are among the poorest.
- Densely populated countries with fast-growing middle classes and rapid industrialisation, particularly in East Asia, are expected to undergo some of the sharpest population declines, which may in turn bring improvements in air quality, forest cover, energy efficiency, and waste reduction.

Section 2: Rainfall Continuity and Conflict

- More than 80 per cent of the world's cultivated land does not use irrigation. Increasingly unpredictable rainfall puts food production at higher risk in these areas. Sub-Saharan Africa has the lowest irrigation rates in the world, with less than two per cent of its cultivated land currently irrigated.
- Irrigated land is twice as productive as unirrigated land. 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.
- Disruptions in rainfall patterns and water availability can raise the threat of conflict, but the relationships are multifaceted and nonlinear, with water issues tending to aggravate existing conflict risks, rather than cause them.
- Conflict risks from changing precipitation are higher with rainfall-dependent food production.
- The greatest obstacle is not water scarcity, but the lack of infrastructure to capture and distribute it effectively. The situation is further exacerbated by poor governance, insecure land tenure, and the predominance of farms smaller than half a hectare, making the development of water infrastructure difficult.

- In many places around the world, net annual rainfall has changed comparatively little in recent years, but wet seasons are becoming wetter and dry seasons are becoming drier.
- Research has found that this heightened seasonality and variability in rainfall raises the risk of conflict.
- These effects can be most dramatic in the case of precipitation shocks such as droughts and floods, which can negatively affect agricultural production and economic activity.
- Increases in wet-season rainfall can be harmful to crops and produce more conflict.
- Globally, the rate of conflict deaths is more than 50 per cent higher in areas where rainfall is becoming increasingly concentrated in fewer months of the year, as compared to places where rainfall seasonality is decreasing.
- In sub-Saharan Africa, IEP analysis finds that changes in rainfall seasonality alone are not statistically linked to conflict. However, when combined with rapid population growth, the risk of fatalities can rise sharply – adding as many as six additional deaths per year for every 100,000 people.
- Across non-desert areas in sub-Saharan Africa, the Karamoja Cluster in northwest Kenya and northeast Uganda has been the site of the greatest increase in rainfall seasonality since the late 2000s.
- In East Africa, healthier vegetation and more stable rainfall have both been linked with reduced conflict risk, along with reduced likelihood of household food insecurity.
- Rising food prices contribute to instability in Africa. An evaluation of more than one hundred subnational areas on the continent found that a doubling of food prices was linked with a 13 per cent rise in the number of conflict occurrences one year later.
- Since 2017, the cost of a healthy diet in East Africa has risen by 44 per cent, leaving an additional 58 million people unable to afford it.
- Climate impacts could displace up to 38.5 million people from arid and semi-arid zones in East Africa, with a substantial share of this movement directed toward the Lake Victoria Basin.

Section 3: Shared Water Systems: Cooperation, Co-Existence and Conflict

- Global freshwater supply per capita has fallen by 70 per cent since 1950 as global population has tripled, even as the overall volume of annual freshwater flows has remained largely the same.
- Annual per capita withdrawals of freshwater have fallen by 14.4 per cent since a high of 581 cubic metres per person in 2008, owing to improved water management.
- In high-income countries, these declines also corresponded to absolute reductions, while in low-income countries total withdrawals increased slightly but failed to keep pace with rapid population growth, resulting in per capita decreases.
- As a result, even as the global population continues to grow, total water withdrawals appear to have peaked in 2019 and have been gradually declining in the years since.
- In low-income countries, per capita water withdrawals have dropped sharply across all sectors. This reflects rising water stress and hardship rather than efficiency gains.
- The agricultural sector consumes 71.4 per cent of global freshwater withdrawals. Industrial use is around 15.3 per cent and municipal (household and local) use is around 13.2 per cent.
- This dominance of agriculture is particularly visible in low- and middle-income countries. In contrast, in high-income countries, industrial and household use make up much larger shares of water withdrawals.
- Since 2000, per capita water use across all sectors has declined in both high- and low-income countries, though the latter trend is primarily driven by population growth outpacing increased water withdrawals. Middle-income countries have shown more mixed trends.
- Industrial water demand has declined in high-income countries but grown rapidly in lower-middle-income economies, highlighting a global shift of water-intensive industries toward developing regions.
- In upper-middle-income countries, household water use has increased sharply in recent decades, reflecting both growing populations and the expansion of infrastructure that allows more people to access piped water for domestic needs.
- There are over 300 transboundary river basins, and 151 countries are part of at least one such system. Increasing dependencies on river systems like the Nile and the Mekong for energy and agriculture are potential drivers of conflict between system-sharing countries.
- Shared river systems breed greater cooperation than conflict. Cooperation, including treaties and agreements, are far more common than conflicts over water.
- Conflicts within states compared to cooperation is on the rise since 2015. The most conflicts have been recorded in the Middle East, followed by South Asia and sub-Saharan Africa.
- The Indus Waters Treaty between India and Pakistan has acted as a core conflict resolution tool and point of cooperation for 60 years. India's 2025 suspension marks a period of heightened tension between the two countries.
- Several shared river basins, including those of the Sava River in the Balkans and the Senegal River in West Africa, demonstrate successful cooperative water sharing agreements.

1 Results and Trends

44 countries deteriorated

74 countries improved

Between 2019 and 2024, global ecological threat levels rose by 0.8 per cent, a significant shift given the slow-moving nature of societal and environmental systems. Ninety-six countries experienced deteriorations, while 74 improved.

Africa is at the epicentre of risk. Niger is the most threatened country worldwide, followed by Burundi, Afghanistan, Uganda, and the Democratic Republic of the Congo. All these countries have very high population growth.

In the past five years, northwestern and western Africa experienced the sharpest increases in ecological threat levels.

Food insecurity substantially increased with the onset of the COVID-19 pandemic due to supply chain and other disruptions. The situation has improved marginally since 2021 but is still worse than pre-pandemic levels.

The number of food-insecure people rose by more than 300 million between 2019 and 2021, reaching almost 2.3 billion, and has remained at roughly that level since. Global reductions in foreign aid are likely to aggravate the situation.

Countries that were hardest hit by increases in food insecurity at the height of the pandemic were among those to record the largest improvements since 2021. These include low-income countries such as Rwanda and Malawi.

Many communities worldwide face growing risks from inconsistent access to freshwater, with the global water risk score increasing by 0.5 per cent since 2019. There are rising extremes of too little water (droughts and heatwaves) and too much water (floods and storms), as well as less extreme but increasingly commonplace disruptions arising from unpredictable rainfall.

Documented floods, storms, and droughts have become twice as frequent as they were in the 1980s, but since 2005 the annual number of events has been relatively steady. The number of deaths caused per event has decreased by a factor of 50 over the last century.

In 2024, natural hazards triggered 45 million internal displacements across 163 countries – the highest figure since at least 2008. Storms and floods accounted for nearly all the displacements, with low-income countries taking much longer to recover.

The world has also made substantial long-term gains in water safety. Since 2000, more than two billion have gained access to safely managed drinking water and sanitation – progress that continued despite population growth, especially in urban areas.

While many fragile countries face sizable challenges related to accelerating population growth, these demographic pressures are easing in other places. Population growth projections have repeatedly been revised down in recent years.

Overview

The 2025 Ecological Threat Report (ETR) is a comprehensive, data-driven analysis of 3,125 subnational areas across 172 countries and territories, covering more than 99 per cent of the world's population. It assesses threats relating to water risk, food insecurity, demographic pressures, and the impact of natural events.

The ETR aims to capture human communities' complex relationships with the natural environment – specifically as they relate to resource scarcity, climatic shocks, and the ways in which growing populations can exacerbate existing stresses. It provides a foundation for debate about the ecological threats facing countries and subnational areas, with an aim to inform the design of resilience-building policies.

The report also highlights areas that are improving which are often overlooked in ecological assessments. These places can provide useful insights into areas that are more conducive to investment and building peace.

The 2025 ETR is the first edition of the report to include time series data. Covering changes between 2019 and 2024, it gives a view into the year-on-year volatility of ecological threats. Unsurprisingly, fluctuations are most evident in the areas of water risk and the impact of natural events, as shifting climatic conditions are giving rise to less predictable rainfall patterns – in the form too little rain, too much rain, and increasingly untimely rain. As such, in a given area, changing precipitation dynamics may be relatively favourable one year and then highly damaging in another. However, assessing how much of this change is due to permanent shifts in climatic conditions and what are fluctuations in local conditions is difficult. Impacts can be exaggerated by human land degradation, population growth, and the increasing use of flood prone areas and more marginal land in arid areas.

Despite this volatility, the multi-year data in this edition of the report highlights how ecological threats are generally on the rise. Since 2019, the global average ETR score rose by 0.8 per cent, a significant shift given the slow-moving nature of environmental systems. Ninety-six countries experienced deteriorations, while 74 improved and two recorded no change.

The 2019-2024 timeframe also gives a view into certain impacts of the COVID-19 pandemic on access to vital resources, as well as the world's tentative and uneven recovery. This is most evident in food security, where the onset of the pandemic disrupted markets, agricultural production, and food supply chains, which led to substantial global deteriorations in ETR food insecurity scores, along with notable increases in global undernourishment rates for the first time in more than a decade. Since the height of the pandemic in 2020-2021, food insecurity has gradually improved, but on current projections it will be 2029 before it returns to pre-pandemic levels.

Water risk is the most immediate ecological challenge because many other stresses flow from it. In the ETR, water risk captures both the reliability of access to safe drinking water and exposure to short-term rainfall deficits. This dual lens recognises that communities are vulnerable not only to chronic gaps in service but also to sudden shocks that interrupt supply.

Despite these challenges, it is important to note that, over the past 25 years, global access to safe water has expanded dramatically. Since 2000, 2.1 billion people have gained safely managed drinking water, including nearly 700 million since 2015. Reliance on unsafe water sources has fallen sharply, with hundreds of millions fewer people depending on unimproved or surface water. These gains are striking, given that the global population grew by almost two billion over the same period. Sanitation has also advanced, albeit unevenly. About 2.5 billion people have gained access since 2000, with the largest improvements concentrated in urban areas. In fact, cities account for most of the progress: two out of three people who gained safe water and three out of five who gained sanitation live in urban settings. By contrast, rural areas have generally lagged behind, underscoring the continuing challenge of extending these services to the hardest-to-reach populations.[1]

Even as billions have gained access to safe water and sanitation, the world now faces a widening water storage gap. Natural reservoirs like glaciers, wetlands, and floodplains are shrinking, while many built systems – especially large dams – are losing capacity to sedimentation and ageing faster than they can be replaced. At the same time, demand for storage is surging, driven by rapid population growth, urbanisation, and increasingly erratic rainfall. Dam construction, which peaked in the 1970s, has slowed as the best sites have already been used, environmental activism has intensified, financial risks remain high, and cheaper, cleaner energy sources are increasingly replacing hydropower. This shift is also prompting more sustainable water solutions. Integrated approaches that combine natural, built, and hybrid storage – such as protecting aquifers and wetlands, rehabilitating existing infrastructure, and using methods like managed aquifer recharge – are increasingly seen as necessary to close the storage gap and adapt to rising water variability.[2]

Environmental and human factors both drive water stress. Ecological conditions limit availability through insufficient or unseasonal rainfall, as well as floods and droughts. Human pressures can create scarcity even where water is present, for example through over-extraction of groundwater or losses in ageing distribution systems. Together these forces constrain water for households, agriculture, and industry.

In 2025, the ETR identifies 295 subnational areas at very high water risk and another 780 at high risk, affecting nearly 1.9 billion people. While over the past several decades substantial improvements in water infrastructure have brought clean water access to billions, the shorter-term trends show a rise in risk owing to increasingly erratic climatic and rainfall patterns. Since 2019, the global average water risk score has deteriorated by 0.5 per cent, with a slight majority of countries – 85 – improving in this indicator, compared to 84 that deteriorated and three that registered no change. Risk is most severe in sub-Saharan Africa, South Asia, and South America. These three regions account for more than 70 per cent of the population facing high or very high water risk while representing less than half of the global population.

Five-year trends show both recovery and deterioration. Western and Central Europe recorded the largest improvement in water risk between 2019 and 2024, driven by a sharp rise in the share of people living in very low risk areas. This follows an unusually dry baseline period around 2018–2020. As conditions returned closer to long-term norms by 2024, water stress eased across much of the region.

Elsewhere, pressures intensified. South America recorded the greatest regional deterioration in water risk over the period. At the country level, the largest deteriorations were concentrated in northwestern Africa. Tunisia, Algeria, and Morocco moved from relatively favourable conditions in 2019 to widespread medium or high risk by 2024, reflecting prolonged drought and high temperatures. In Tunisia, losses from leaking pipe networks compounded supply shortfalls and triggered extended water cut-offs to residents.

Food insecurity remains a central challenge, and one of the primary ways that ecological threats affect people's daily lives. The ETR's food insecurity indicator assesses availability, access, affordability, and the risk conflict poses to supply chains.

After widespread deteriorations during the height of the COVID-19 pandemic, most countries have at least partially rebounded, with 122 improving since 2021 compared to just 50 that have deteriorated. In fact, some of the countries that were hardest hit during the pandemic are those that have since recorded the largest improvements in food insecurity. While still struggling more than other places, certain low-income countries have recorded the largest improvements in scores. For example, Rwanda and Malawi stand out, having registered the largest improvements in food insecurity scores over the past three years after suffering, respectively, the 11th and 24th steepest declines between 2019 and 2021.

As of 2024, 208 subnational areas had very high food insecurity scores and 696 had high risk, together representing more than 1.6 billion people. Another 1,084 subnational areas are at medium risk, representing an additional three billion people. Regional disparities are stark. Sub-Saharan Africa has the highest scores and the largest share of people in very high risk zones. South Asia also faces widespread challenges, while Western and Central Europe remain among the lowest risk regions.

Recent country movements underline how ecological stress interacts with economic and political shocks. Somalia and South Sudan continue to record the most severe food insecurity, shaped by erratic rainfall, recurrent drought, and conflict. Between 2019 and 2024 the steepest deteriorations in food security occurred in Lebanon, Botswana, and Colombia, driven respectively by financial crisis and inflation, prolonged agricultural drought, and conflict-related disruptions to production and markets.

The risks associated with the impacts of natural events have also risen. The ETR's impact of natural events indicator combines climate risk, population density, and poverty to reflect both exposure and coping capacity. Hazardous natural events have displaced more than 260 million people since 2015, with 45 million movements recorded in 2024 alone. Sub-Saharan Africa and South Asia face the highest risks, where floods, storms, heatwaves, and droughts are more likely to become humanitarian crises. Europe generally faces lower risk due to stronger infrastructure and higher institutional resilience.

Recent patterns point to a widening exposure gap. Deteriorations in risk outpaced improvements over the past five years, with the largest increases clustered in West Africa and parts of South Asia, where high population density and poverty increase the likelihood that hazards become disasters. As floods, storms, heatwaves, and droughts intensify, their effects cascade through food systems, health services and infrastructure, creating longer recovery times and higher cumulative losses. These shocks increasingly spill across borders through displacement, market disruptions and degraded air and water quality, underscoring that preparedness and adaptation need to scale beyond single-hazard, single-country responses.

Western and Central Europe experienced the largest regional improvement in the impact of natural events indicator, although the largest country improvement was in the small South American nation of Guyana. Although Guyana has long been exposed to flooding and has increasingly faced wildfires as well, its score change was largely driven by improvements in the resilience dimensions of the indicator, as the country has experienced substantial economic development and gains in human development measures in the past few years.

Moreover, despite rising global exposure, natural disasters are far less deadly than they used to be. Analysis finds that global disaster mortality has fallen from more than 25 deaths per 100,000 people a century ago to under 0.5 today. This is the result of better forecasting, early warning, preparedness, and sturdier infrastructure.

Demographic pressure will amplify threats from natural hazards over the next quarter century. The ETR's forward-looking measure identifies 304 subnational areas with very high projected growth to 2050 and another 337 with high growth. Much of the increase will be concentrated in sub-Saharan Africa and the Middle East and North Africa. Rapid population growth in areas already exposed to water stress, natural hazards, and fragile food systems will raise demand, strain infrastructure, and heighten the risk that ecological shocks translate into social and political instability.

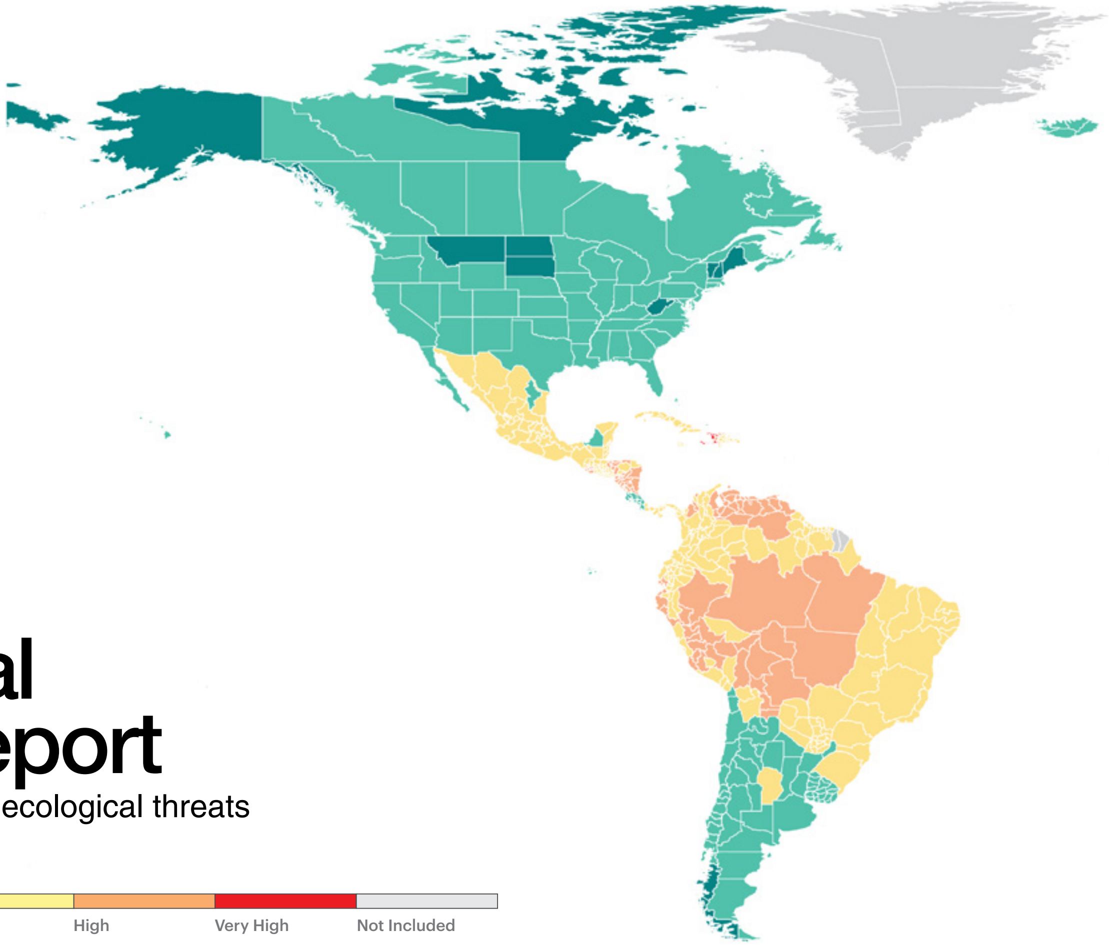
However, over the past ten years, global population projections have repeatedly been revised downward, which in many regions will imply lower long-term pressures on water, food and land. Yet slower or negative growth brings different vulnerabilities. In most parts of the world, older adults will come to outnumber children and youth in the coming decades, shrinking the working-age population and raising old-age dependency ratios. The potential impacts of such declines are unclear, but densely populated regions that have had rapid middle-class growth and rapid industrialisation – such as parts of East Asia – may see among the clearest ecological benefits. Declining populations may bolster recent improvements in air pollution, allow for greater forest restoration, enable more efficient energy generation, and lead to lower levels of waste.

Results

FIGURE 1.1

Subnational ETR scores

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



2025 Ecological Threat Report

Measuring the impact of ecological threats

ETR SCORE

Very Low | Low | Medium | High | Very High | Not Included

Source: IEP

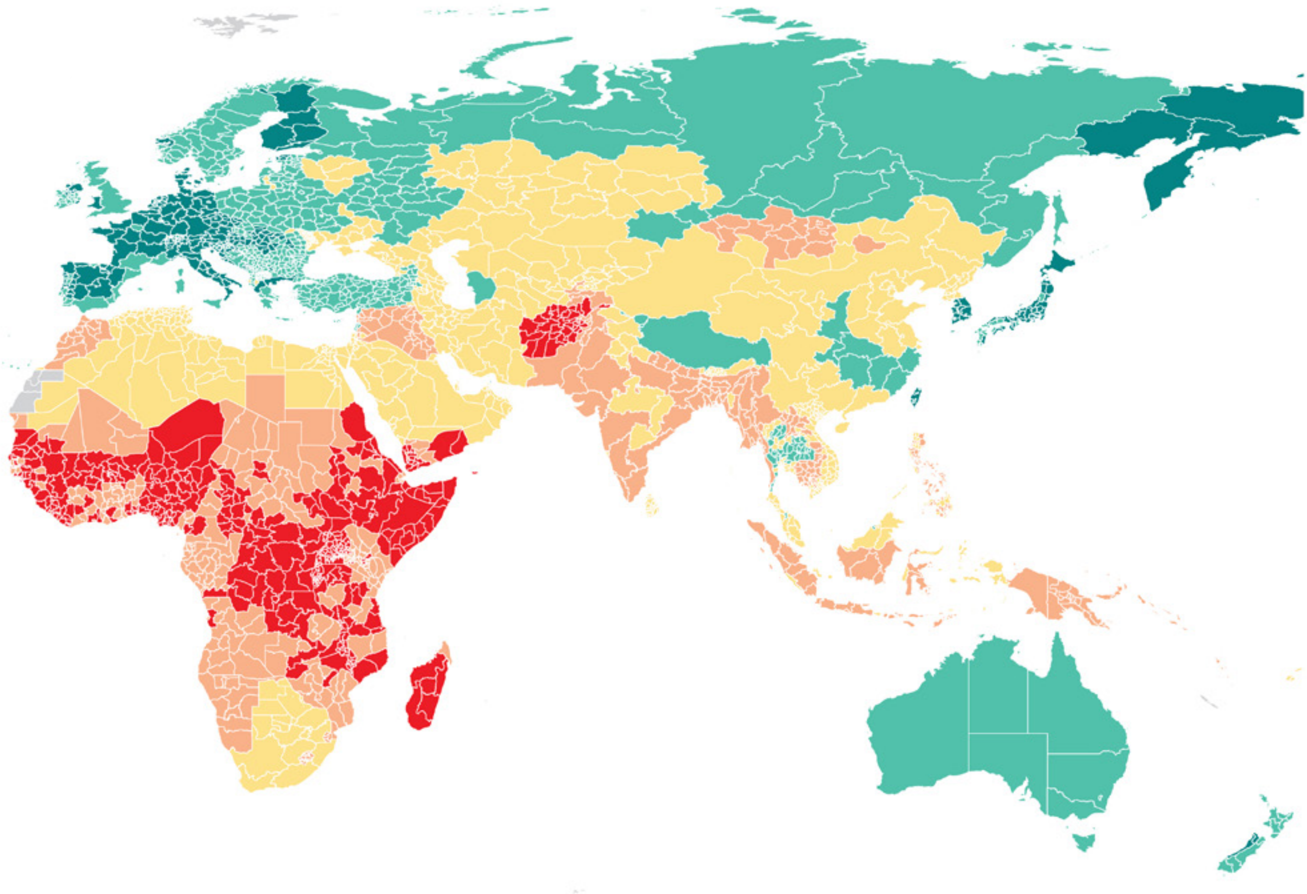
The map in Figure 1.1 highlights the severity of ecological threats faced by 3,125 subnational areas, with areas in red having an overall ETR score higher than 3.8 out of 5, indicating a very high level of threat. Of these subnational areas, 13.7 per cent face a very high overall level of ecological threat. These areas are home to an estimated 926 million people, or 13 per cent of the global population. By 2050, this figure is projected to rise to 1.4 billion people.

There is considerable variation in levels of ecological threat both within and across regions. Europe and North America are the only two continents 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.

While not all of the people in these areas will suffer from the direct impacts of adverse ecological conditions, the indirect impacts will be widely felt. This is especially true of the areas which are in countries facing conflict, civil unrest, or poor governance.

In contrast, societies characterised by higher levels of per capita income, institutional resilience, and more abundant material resources are better equipped to withstand and adapt to shocks. The relationship between ecological degradation, conflict, and population pressures is highly systemic; when multiple stressors converge, they can amplify one another and drive instability. But countries with stronger institutions and more equitable resource distribution are better able to buffer these impacts. In such contexts, ecological threats may still generate hardship, but they are less likely to escalate into conflict or systemic breakdown, as resilience mechanisms help limit primary impacts and speed recovery.

Countries with high levels of societal resilience can withstand higher systemic shocks, such as floods, droughts,

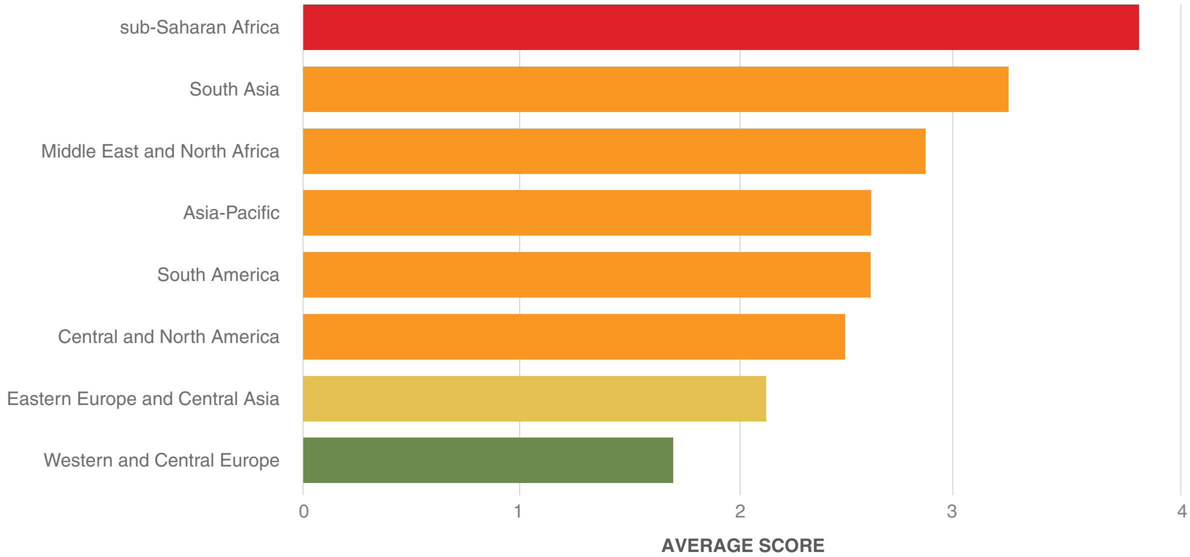


or pandemics, and in the aftermath, they can become more resilient to future shocks. However, once a shock overpowers a societal system, then it degrades the system, making it less resilient to future shocks. This is especially evident when multiple shocks occur simultaneously or in quick succession, such as conflict, governance failures, and drought. As further illustrated in Figure 1.2, the most vulnerable countries are clustered in certain geographical regions: sub-Saharan Africa, South Asia, and the Middle East and North Africa. These regions are also the least peaceful, as measured by the Global Peace Index (GPI).

FIGURE 1.2

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

Sub-Saharan Africa has the worst average ETR score, with 25 of the 45 countries in the region facing very high levels of ecological threat. The region has the highest average scores across all four ETR indicators. As shown in Table 1.1, nine of the ten countries with the highest ETR scores are in sub-Saharan Africa. Moreover, the number of people living in highly threatened countries is projected to rise significantly over the next several decades.

While no country in sub-Saharan Africa records better than a medium level of overall ecological threat, there are a few that perform well in certain indicators. Despite recent upticks in food insecurity, Botswana recorded the region's best ETR score in 2024, supported by its low demographic pressure and impact of natural events scores. Elsewhere in the developing world, there are certain countries with ETR scores near the top of the rankings. In Latin America, for example, Costa Rica, Uruguay, Chile, and Argentina all registered low levels of ecological threat last year.

By 2050, sub-Saharan Africa's population is predicted to rise to more than two billion, an increase of nearly 70 per cent, placing greater pressure on existing food and water supplies. Most countries across sub-Saharan Africa are dependent on rain-fed agriculture, making the region particularly vulnerable to changes in climatic conditions, such as prolonged droughts and seasonal floods.[3] 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.[4]

South Asia has the second worst overall ETR score. The region has the second highest scores in three out of the four ETR indicators: water risk, food insecurity, and the impact of natural events. Natural disasters – such as floods, hurricanes, and other sudden shocks – are comparatively common in the region and can exacerbate other ecological threats, particularly resource scarcity.

TABLE 1.1

Countries with the highest overall ETR scores, 2024

Nine of the ten countries with the worst overall ETR scores were in sub-Saharan Africa.

Country	Region	2024 Score	Population in 2025
Niger	Sub-Saharan Africa	4.42	25,835,933
Burundi	Sub-Saharan Africa	4.271	11,917,637
Afghanistan	South Asia	4.228	46,403,108
Uganda	Sub-Saharan Africa	4.225	52,288,952
Democratic Republic of the Congo	Sub-Saharan Africa	4.211	96,266,368
Ethiopia	Sub-Saharan Africa	4.194	113,573,763
Somalia	Sub-Saharan Africa	4.16	11,579,394
Mali	Sub-Saharan Africa	4.143	23,096,234
Liberia	Sub-Saharan Africa	4.129	6,396,520
Nigeria	Sub-Saharan Africa	4.112	224,971,672

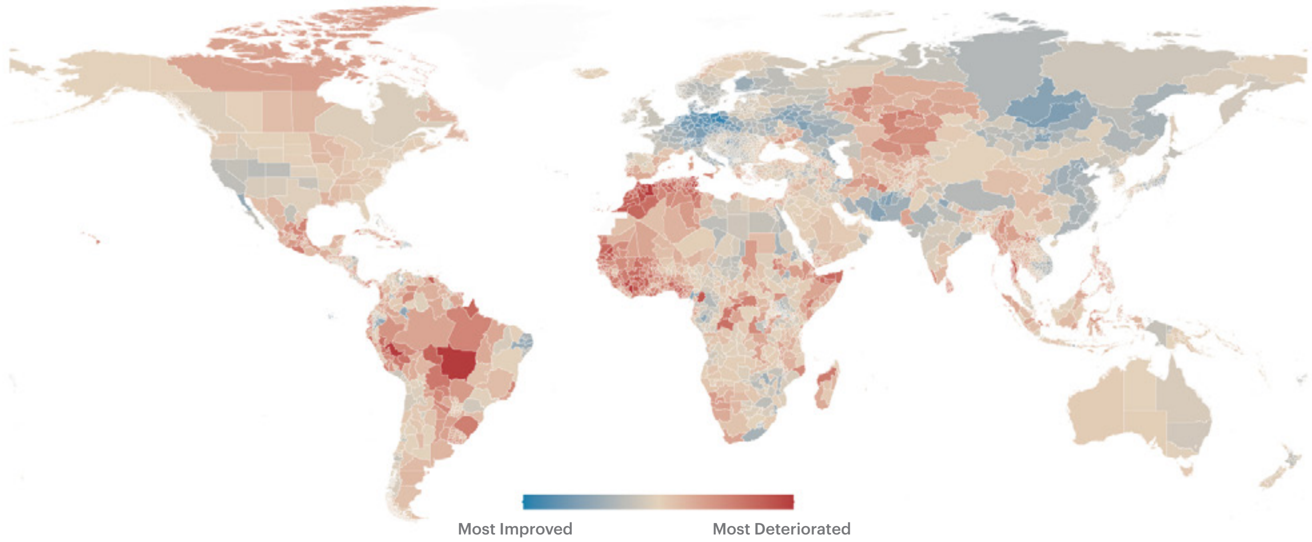
Source: IEP

Five-Year Trends

FIGURE 1.3

Subnational changes in overall ETR scores, 2019–2024

The countries stretching from northwestern Africa to coastal West Africa recorded the largest increases in ecological threat levels, while Europe recorded the largest decreases.



Source: IEP

This edition of the ETR is the first to include time series data. Covering 2019 and 2024, it demonstrates medium-term changes in levels of ecological threat around the world.

The steepest increases in ecological threat since 2019 cluster across a belt running from northwestern Africa to coastal West Africa. The deteriorations in North Africa are closely tied to surging water risk. Tunisia, Algeria, and Morocco all moved sharply upward due to a mix of prolonged drought, extreme heat, and increasingly erratic rainfall, which weakened communities' ability to store and access freshwater. However, the scale of the deteriorations in these three countries can in part be attributed to unusually favourable rainfall conditions in 2019, which set a baseline against which later deteriorations appeared more severe.

Effective water capture and storage remain a persistent challenge globally. For example, data from the Food and Agriculture Organization (FAO) shows that the average amount of country-level dam capacity has risen by more than 15 per cent since 1990. However, these gains have not kept pace with population growth, and average dam capacity per person has fallen by around 35 per cent in the same period. Moreover, around the world, most people do not get their water from dams, and groundwater supplies at least part of the drinking water for up to half of the world's population and makes up about 43 per cent of global irrigation use.

In the world's poorest regions, population growth and climatic changes are expected to intensify water insecurity. Investment in small-scale water capture projects, such as sand dams, could be transformative: for example, large sand dams can hold more than 70,000 cubic metres of water, enough to fully irrigate between six and nine hectares of land.[5] Of the thousands of sand dams in the world, most are in sub-Saharan Africa, especially East Africa, though examples also exist in southern Africa, South Asia, and parts of Latin America. However, precise global figures are lacking, as sand dams are typically built at the community level and are often poorly recorded. Filling the many knowledge gaps about the prevalence, performance, and hydrological impacts of various forms of water capture will be critical to evaluating their potential as a scalable adaptation strategy.

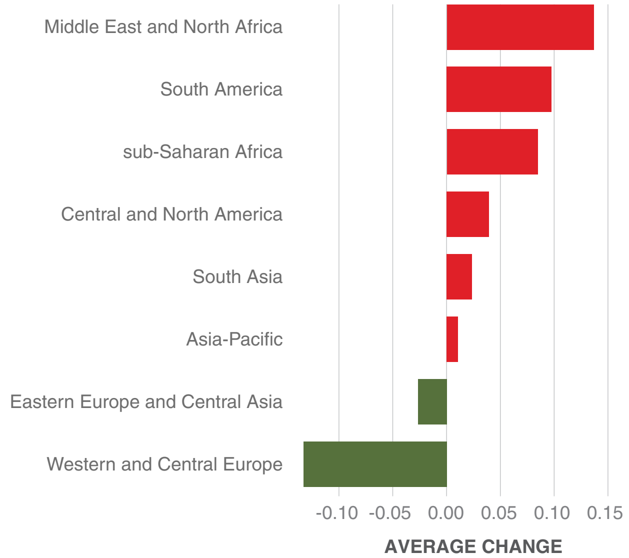
Tunisia recorded the largest increase in ecological threat levels of any country in the ETR, driven by marked increases in water risk and exposure to natural events. Of the 20 subnational areas that deteriorated the most between 2019 and 2024, nine were in Tunisia. Leading these was the city of Manouba, part of the Tunis metropolitan area. Deteriorations of this kind contributed to the Middle East and North Africa recording the greatest overall increase in ecological risk of any region between 2019 and 2024, as shown in Figure 1.4.

In contrast, Western and Central Europe showed by far the largest improvement, and this was also driven by water issues. However, in the inverse of the case of northwestern Africa, this reflected a reversion to long-term norms. Europe experienced anomalous dryness across much of the continent in the late 2010s, which set uncharacteristically poor baseline scores.

FIGURE 1.4

Regional changes in ETR scores, 2019–2024

The Middle East and North Africa recorded the most severe deterioration in ecological threat levels, while Western and Central Europe experienced by far the largest improvement.



Source: IEP

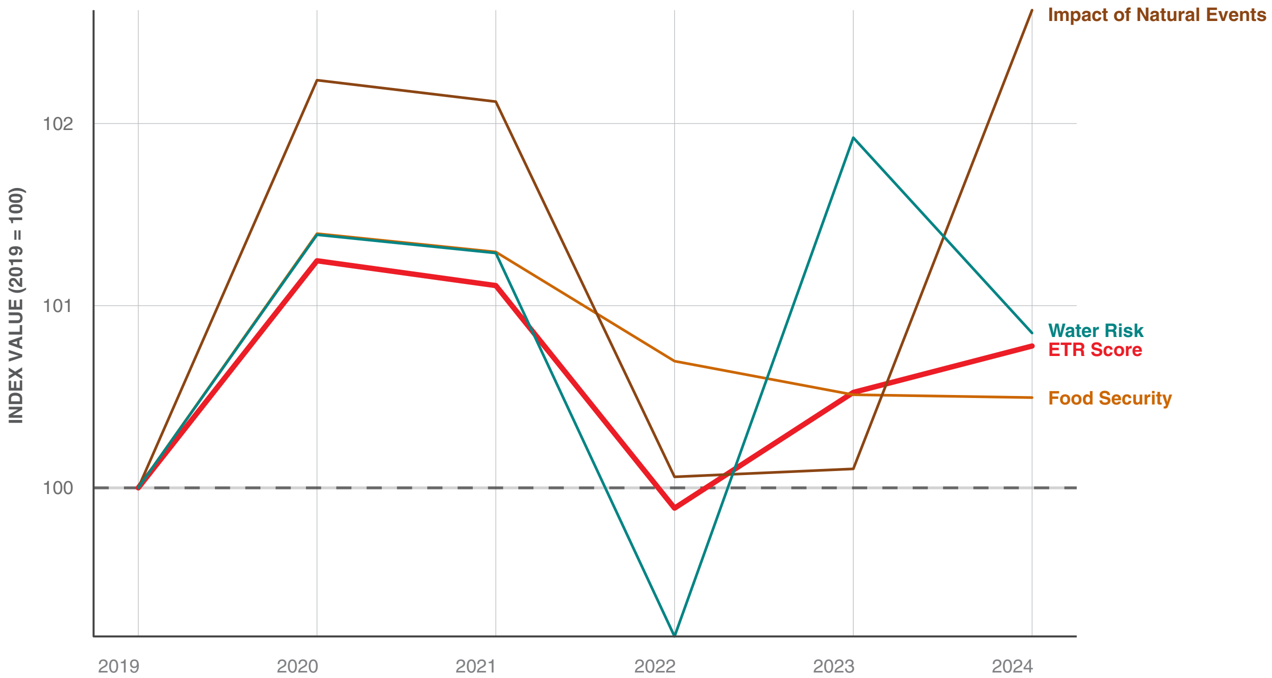
Figure 1.5 tracks the indexed global trend and shows that the overall level of ecological threat has risen by 0.8 per cent since 2019, a significant shift given the slow-moving nature of environmental systems. This was driven by a 2.9 per cent increase in the impact of natural events indicator, particularly in the form of floods, storms, and heatwaves – with 2024 declared the hottest year on record by the World Meteorological Organization. Demographic pressure is the only ETR indicator not shown in the figure, as this indicator is forward-looking and does not include time-series data.

The indexed trends demonstrate the relatively high volatility of specific indicators. Water risk and the impact of natural events, which are tied to highly variable weather systems and climatic conditions, swing from improvements to deteriorations from year to year. In contrast, food insecurity, shows a more consistent trendline. In the context of the first years of the COVID-19 pandemic, food insecurity spiked as food systems, markets, and supply chains were disrupted. But in the past few years, food insecurity has gradually reduced, though it still remains worse than its pre-pandemic levels.

FIGURE 1.5

Indexed trend in global ETR indicator scores, 2019–2024

The global level of ecological threat has risen by 0.8 per cent since 2019, though some ETR indicators – specifically the impact of natural events and water risk – show substantial year-on-year variation.



Source: IEP
Note: Demographic pressure is the only ETR indicator that does not include time series data.

BOX 1.1

Ecological Deterioration in Central-West Brazil

Between 2019 and 2024, Brazil's Central-West region recorded some of the world's sharpest deteriorations in overall ETR score, aggravated by exceptionally bad wildfires in 2024. The region encompasses the states of Mato Grosso, Mato Grosso do Sul, and Goiás, with Mato Grosso registering the second largest increase in ecological threat of any subnational area worldwide (after Manouba in Tunisia). Rising risks of natural events, water scarcity, and food insecurity have driven much of this deterioration.

The impact of natural events was most severe in Mato Grosso, which recorded the largest deterioration nationwide since 2019. In 2024, the state experienced an exceptionally severe wildfire season, with nearly 3,900 hotspots detected in the Pantanal biome during the first half of the year – more than 16 times the number observed in the same period of 2023.[6] These fires burned over 7,200 square kilometres in Mato Grosso and neighbouring Mato Grosso do Sul, the worst conditions ever recorded in the region for the first half of the year. While global average temperatures have exceeded 1.5°C above pre-industrial levels, temperatures in the Pantanal have risen by 3-4°C in recent decades, greatly intensifying fire risk.

Despite Brazil's overall progress in reducing water risk, Mato Grosso recorded the second largest deterioration nationally. This increase was driven by a prolonged drought between 2019 and 2022,[7] alongside policy changes that ended a moratorium on soybean expansion and removed forest protections to help facilitate faster agricultural growth.[8] As Brazil's largest soybean-producing state, Mato Grosso has seen rising water demands from its agricultural sector, placing further pressure on limited freshwater resources in the region.

The state has also experienced a marked decline in food security, the largest nationally. Poverty rates across Brazil have remained close to 25 per cent, but moderate to severe food insecurity increased from 20.5 per cent in 2020 to 28.4 per cent as of 2022.[9] Conditions are even more severe in rural states like Mato Grosso, where food insecurity is 1.2 times higher than in urban centres. These pressures have been exacerbated by a 37.5 per cent rise in national food prices compared with pre-pandemic levels.

Ecological Threats and Peace

There is a strong correlation between ecological threats and peacefulness. Figure 1.6 shows the correlation (r=0.58) between the GPI, which measures peacefulness at the national level, and the overall ETR score. The correlation is even higher (r=0.67) for the Safety and Security domain of the GPI. 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.

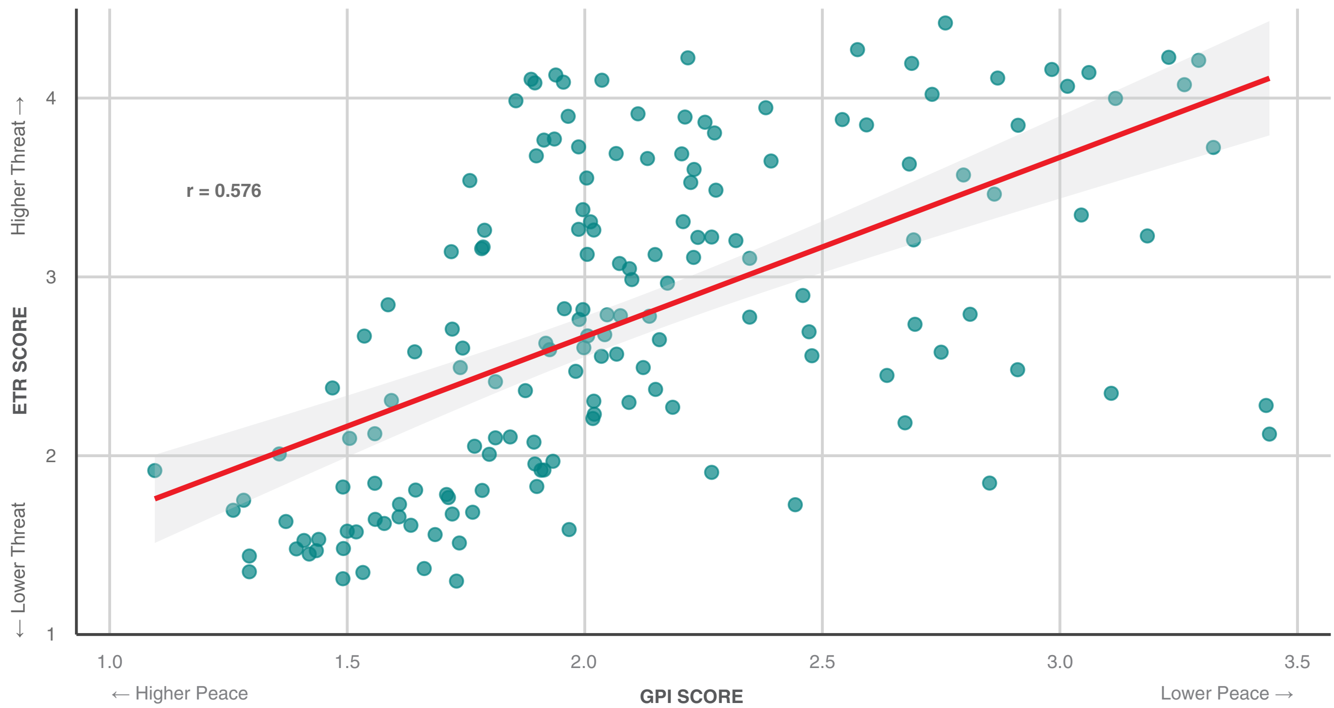
Rising ecological pressures driven by climate change carry security risks at both local and national levels. In contexts with low resilience, environmental shocks can destabilise governance and fuel political unrest. Disasters, water shortages, food insecurity, and extreme heat often trigger population movements, as people are forced to migrate in search of safety and resources. Such displacement places added strain on host communities, intensifying competition for employment, housing, and essential services.[10]

In contrast, initiatives to adapt to and mitigate ecological threats are strengthened in contexts with robust governance systems, transparent institutions, and effective disaster preparedness mechanisms. Higher levels of economic development and lower corruption attract and sustain investment in resilience – from climate-smart infrastructure to water storage and renewable energy – ensuring that resources are used efficiently and equitably to protect communities.

FIGURE 1.6

Ecological threat vs peacefulness

There is a strong correlation between ETR and GPI scores.



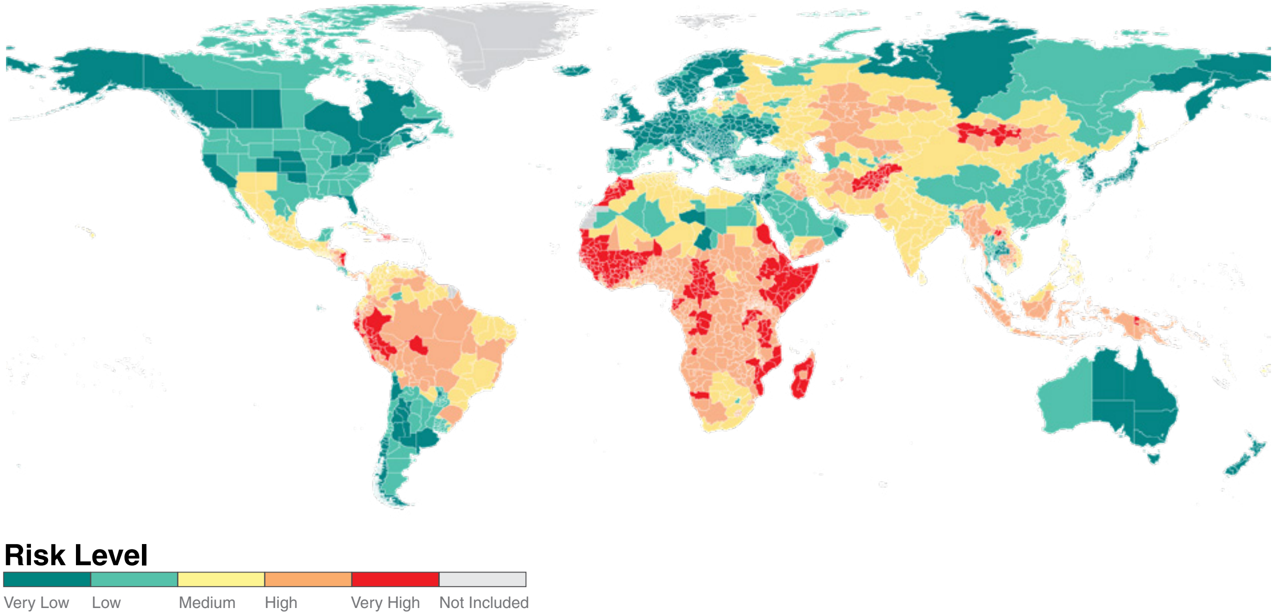
Source: IEP

Water Risk

FIGURE 1.7

Subnational water risk scores, 2024

Most high and very high water risk areas are in sub-Saharan Africa, South America, and South Asia.



Source: IEP

Issues related to water represent the key ecological challenge facing humanity, as from them flow a host of resource scarcity concerns. The ETR's water risk indicator is defined as the reliability of access to safe drinking water, combining two measures: the proportion of the population with access to clean water and the frequency of extreme monthly rainfall deficits compared with historical averages.[11] This approach captures both long-term levels of water access and susceptibility to short-term fluctuations in water availability.

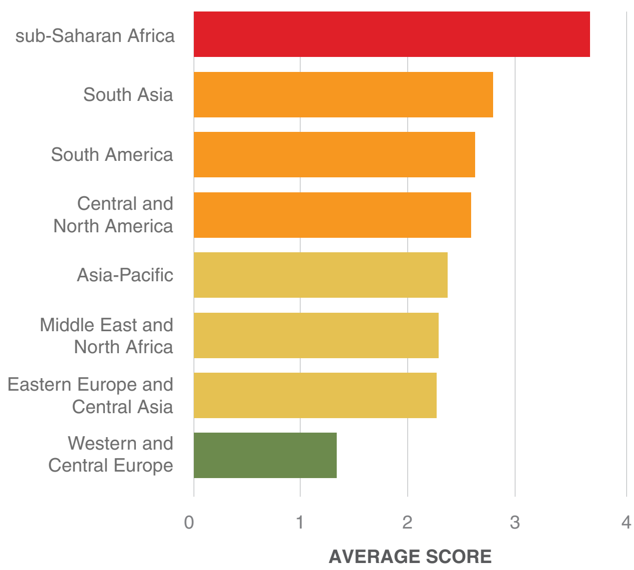
Water stress emerges from both environmental and human factors. Ecological conditions limit water availability through factors such as insufficient rainfall, seasonal variability in rainfall, or the occurrence of floods and droughts. These factors restrict communities' capacities to meet water demands for agriculture, households, and manufacturing industries. Human and economic pressures can also give rise to scarcity, often due to inadequate water management or infrastructure, despite water being potentially available. Examples include excessive groundwater extraction or outdated distribution systems, which billions of people depend on for freshwater.[12]

The 2025 ETR identifies 295 subnational areas with very high levels of water risk and a further 780 with high levels, encompassing nearly 1.9 billion people. In contrast, there are 811 subnational areas with very low water risk and 477 with low risk. In total, these latter two sets of areas are home to nearly 3.1 billion people.

FIGURE 1.8

Water risk scores by region, 2024

Sub-Saharan Africa is the only region that on average faces a high threat level in relation to water risk. In contrast, Western and Central Europe recorded low overall risk levels.



Source: IEP

Water risk is most severe in sub-Saharan Africa, South Asia, and South America, as shown in Figure 1.8. These regions account for more than 70 per cent of the global population facing high or very high levels of water risk, despite representing less than half (45 per cent) of the world's population. As seen in Table 1.2, eight of the ten most threatened countries for the water risk indicator are in sub-Saharan Africa, with Guinea-Bissau recording the highest score globally.

TABLE 1.2

Countries with the highest water risk scores, 2024

Eight of the ten countries with the worst water risk scores were in sub-Saharan Africa.

Country	Region	2024 Score	Population in 2025
Guinea-Bissau	Sub-Saharan Africa	4.396	1,837,448
Afghanistan	South Asia	4.216	46,403,108
Mauritania	Sub-Saharan Africa	4.208	4,509,587
Burkina Faso	Sub-Saharan Africa	4.169	24,359,092
Guinea	Sub-Saharan Africa	4.132	12,403,244
Senegal	Sub-Saharan Africa	4.096	14,681,570
Djibouti	Sub-Saharan Africa	4.075	935,593
Haiti	Central and North America	4.065	10,033,309
Mali	Sub-Saharan Africa	4.065	23,096,234
Somalia	Sub-Saharan Africa	4.038	11,579,394

Source: IEP

Dependence on groundwater as a freshwater resource further compounds water uncertainty. Groundwater aquifers provide drinking water to more than two billion people worldwide, with approximately 70 per cent of withdrawals used for agriculture.[13] However, over half of the world's major aquifers (21 out of 37) are being depleted faster than they can naturally be replenished. Aquifers in South Asia and East Asia are among the most threatened. The five with the highest rates of over-extraction, where use exceeds natural recharge, are the Ganges, the Indus Basin, the California Central Valley Aquifer System, the North China Aquifer System, and the Tarim Basin in China.[14] Around one billion people depend on these five aquifers for food and water, with the Indus Basin alone providing water for nearly 90 per cent of Pakistan's food production.[15]

This has severe implications for vulnerable groups, particularly children. As of 2025, more than one-third of the global child population (over 920 million children) were highly exposed to water scarcity.[16] This exposure undermines basic nutritional requirements, making children more vulnerable to severe diseases and impaired physical or cognitive development.

Five-Year Trends

Changes in water risk scores over the past five years vary greatly across regions. As shown in Figure 1.9, South America, the Middle East and North Africa, and Eastern Europe and Central Asia experienced the greatest deteriorations. Western and Central Europe recorded the largest improvement in water risk, with its regional score falling by 0.374. This progress was primarily driven by an 82 per cent increase in the share of the population living within very low risk areas, which by 2024 encompassed more than three-quarters of the region's inhabitants.

Europe's improvement reflects a recovery from its uncharacteristically high levels of water risk in 2019 (the baseline year of analysis). Around 2018-2020, the continent experienced prolonged droughts and record-breaking near-surface air temperatures, which greatly reduced water retention.[17] By 2024, however, climatic conditions had returned closer to long-term norms, resulting in notable reductions in levels of water stress. All ten countries to record the largest improvements were European. These were led by Germany, Belgium, and the Netherlands.

Moreover, the share of the global population exposed to high and very high water risk declined over the past five years, driven by modest improvements in highly populous areas stretching from northern India to Pakistan. Despite this, pressure on freshwater resources is projected to intensify in the coming decades. Population growth will drive higher demand and amplify global vulnerability. In 2024, the share of the population experiencing medium levels of water stress reached its highest level since 2020, highlighting the sensitivity of many communities to fluctuations in water availability.

South America recorded the greatest deterioration between 2019 and 2024, as seen in Figure 1.9. The number of very low risk subnational areas fell sharply, from 59 in 2019 to just 22 in 2024. Simultaneously, the population living within very high risk zones rose by more than 9.8 million.

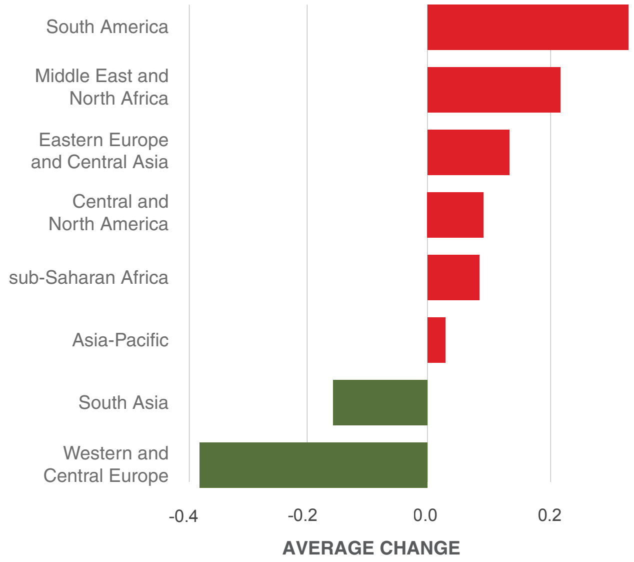
While at the regional level South America showed the greatest deterioration in water risk, the individual countries to experience the largest increases in risk were all located in northwestern Africa. Tunisia experienced the greatest increase in water risk, which drove it to also register the largest deterioration in overall ETR score of any country. Algeria and Morocco respectively recorded the second and third largest increases in water risk.

The substantial deteriorations in these three countries comes from a baseline of unusually favourable rainfall and evaporation conditions in 2019. That year, both Tunisia and Algeria had millions of inhabitants in very low risk areas. But last year these countries experienced prolonged droughts and especially high temperatures. As a result, all subnational areas in Tunisia were at medium risk levels last year, and the vast majority of Algeria's populated areas – representing 86 per cent of the country's total population – also recorded medium water risk scores. Similarly, Morocco faced severely increasing risks, with the population in very high risk areas rising by more than 24.3 million.

FIGURE 1.9

Regional changes in water risk scores, 2019–2024

South America experienced the most severe deterioration, and globally, only two regions improved.



Source: IEP

Tunisia's rise in risk has been exacerbated by the cumulative effects of deteriorating infrastructure. Chronic underinvestment and poor maintenance of pipe networks has led to extensive leakages, which depletes around 30 per cent of the country's water supply before it reaches household taps.[18] Last year's droughts and temperature increases intensified these pressures, prompting government-imposed restrictions, including water cut-offs that frequently exceeded ten hours.[19] Last year, the Tunisian Water Observatory recorded over 2,100 unannounced water supply interruptions.[20]

BOX 1.2

Water Risk Country Profile: Eritrea

Between 2019 and 2024, Eritrea recorded the largest improvement in water risk of any low-income country in sub-Saharan Africa. In 2019, it held the fourth worst water risk score globally; by 2024 it had improved to 25th. Although still classified as high risk, sustained government initiatives have expanded water access nationwide and reduced some exposure to water scarcity.

In recent decades, access to safe drinking water has risen dramatically, from just 13 per cent of the population in the early 1990s to nearly 85 per cent in 2024.[21] More than half of schools now have access to drinking water and sanitation facilities, and infrastructure investment has expanded the number of dams from 138 in 1993 to nearly 800 today. A further 17 dam projects have been planned for the country, demonstrating the government's continued commitment to improving water security.

Despite these new dams, Eritrea remains heavily dependent on groundwater, which supplies freshwater for nearly 80 per cent of the population.[22] Reliance on these sources places significant pressure on aquifers that are slow to refill, increasingly stressed, and highly vulnerable to contamination. Of 5,365 water points identified across the country, more than 4,600 are unprotected dug wells or contaminated surface water points.[23] Eritrea's rapid population growth, projected to increase by more than 50 per cent by 2050, will significantly intensify water demand and strain already scarce and unreliable freshwater resources.

Progress has also been constrained by environmental pressures. Drought across the Horn of Africa between 2020 and 2023 reduced rainfall and weakened water security across much of the country. The Debubawi Keyih Bahri region was particularly affected, with reliance on small dams and seasonal runoff leaving the population highly vulnerable to rainfall variability and rising temperatures.[24] Improvements in this region have been further hindered by Eritrea's involvement in the Tigray conflict in neighbouring Ethiopia, which has diverted resources away from rural infrastructure and ended development cooperation with the European Union.[25] As a result, sustaining advances in water infrastructure has become increasingly difficult, with many households forced to travel longer distances to secure reliable water or resort to unsafe sources.

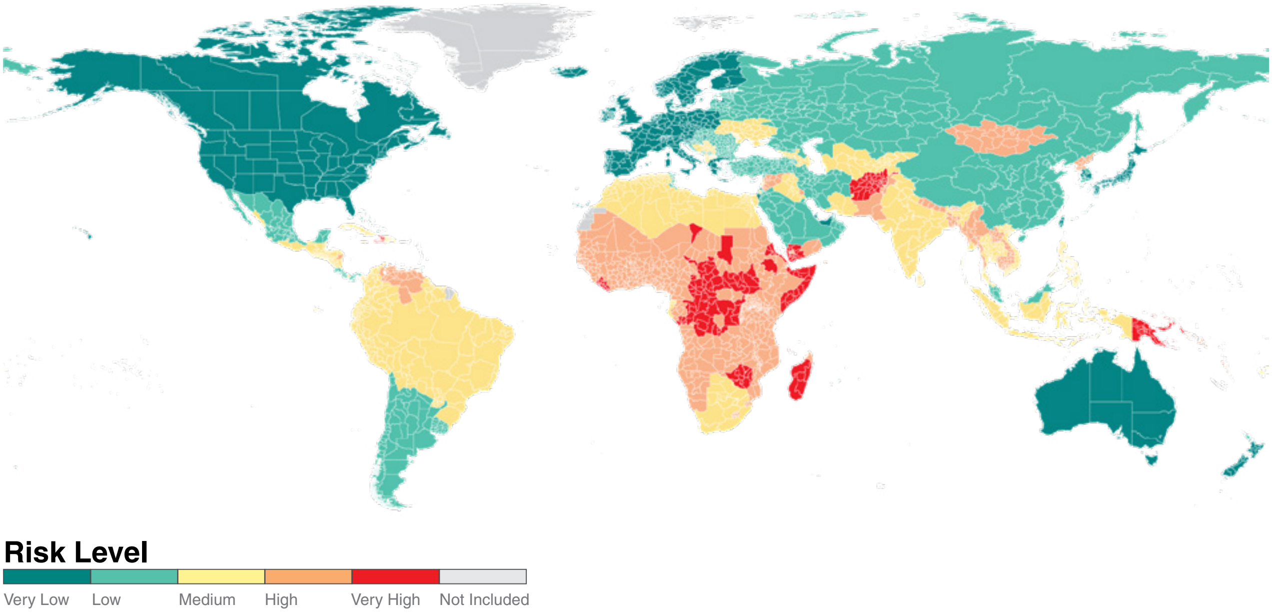
Diarrhoea, often linked to unsafe drinking water, remains one of the three leading causes of child mortality in Eritrea, where the under-five mortality rate was estimated to be 3.7 per cent in 2024.[26]

Food Insecurity

FIGURE 1.10

Subnational food insecurity scores, 2024

The highest levels of food insecurity are found in sub-Saharan Africa, though there also are pockets of acute food insecurity in several other regions.



Source: IEP

The ETR food insecurity indicator measures the likelihood that people will have sufficient food, considering availability, accessibility, affordability, and the risks posed by conflict and violence to supply chains. The indicator examines both national conditions and subnational disparities, capturing overall food supply, household purchasing power, and the effects of inequality and conflict, which disrupt markets and restrict people's ability to obtain food.

As of 2024, the ETR identifies 208 subnational areas with very high levels of food insecurity and a further 696 with high risk levels, representing nearly a third of all subnational areas. Furthermore, around three billion people currently reside in medium risk areas, making up approximately 39 per cent of the global population.

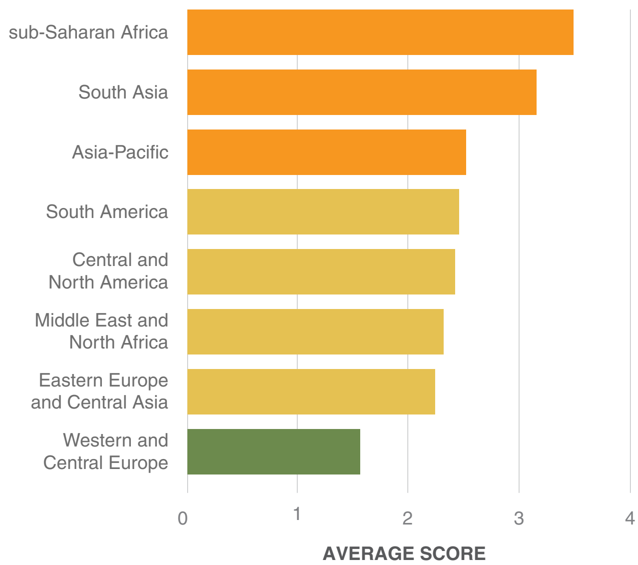
Complementing these findings, the FAO estimates that between 638 and 720 million people experienced hunger in 2024, with the largest shares in Africa and Asia.[27] Around 28 per cent of the global population faced moderate or severe food insecurity.

As shown in Figure 1.11, there are significant disparities in ETR food insecurity scores: sub-Saharan Africa recorded the worst scores and is home to more than half of the global population living in very high risk areas. In South Asia, food insecurity is also pronounced: 82 per cent of the population resides in medium risk areas, and the region is the only one without any subnational areas classified as low or very low risk. By contrast, Western and Central Europe is the only region classified as low risk and has no subnational areas classified as high or very high risk. Nearly 92 per cent of its population is considered very low risk, with only small shares residing in low to medium risk areas.

FIGURE 1.11

Food insecurity scores by region, 2024

Since 2022, no regions have registered severe threat levels for food insecurity.



Source: IEP

As shown in Table 1.3, the highest levels of food insecurity tend to be seen in fragile and conflict-affected countries. Somalia and South Sudan recorded the most severe conditions, followed by the Central African Republic and Afghanistan. In each of these cases, protracted conflict has directly disrupted food systems.
In South Sudan, fighting around key agricultural areas such as Jonglei and Upper Nile has disrupted harvests and displaced farming communities. Ongoing clashes along the Nile and Sobat rivers have blocked river transport, cut off humanitarian access, and prevented vital food aid from reaching tens of thousands of people in Upper Nile, where malnutrition rates are among the highest in the country.[28]

In Afghanistan, heavy reliance on imported staples such as wheat flour and cooking oil has been compounded by restrictions on aid delivery and insecurity along transport corridors. Humanitarian agencies report that evolving regulations and political interference continue to delay or block assistance, leaving vulnerable populations with limited access to basic food supplies.[29]

TABLE 1.3

Countries with the highest food insecurity scores, 2024

The East African countries of Somalia and South Sudan have the worst ETR food insecurity scores.

Country	Region	2024 Score	Population in 2025
Somalia	Sub-Saharan Africa	4.356	11,579,394
South Sudan	Sub-Saharan Africa	4.323	11,540,140
Central African Republic	Sub-Saharan Africa	4.177	5,511,810
Afghanistan	South Asia	4.078	46,403,108
Eritrea	Sub-Saharan Africa	4.069	7,607,521
Haiti	Central and North America	3.963	10,033,309
Papua New Guinea	Asia-Pacific	3.884	8,390,325
Zimbabwe	Sub-Saharan Africa	3.833	13,211,017
Madagascar	Sub-Saharan Africa	3.829	29,252,622
Yemen	Middle East and North Africa	3.829	35,521,135

Source: IEP

BOX 1.3

Food Insecurity Country Profile: Somalia

Somalia has consistently recorded the highest levels of food insecurity globally between 2019 and 2024. These persistently high levels reflect the interaction of ecological stress, climatic extremes, conflict and chronic governance gaps.

Recurrent droughts, erratic rainfall, and flooding have disrupted ecosystems and livelihoods. This has been further aggravated by ongoing conflict since the late 1980s. Dependence on rain-fed agriculture and livestock leaves the country highly vulnerable to rainfall variability. Repeated climate shocks have reduced crop yields, undermined livestock health, and depleted water sources, heightening vulnerability among farming and pastoralist households. These pressures are compounded by conflict, displacement, and disrupted markets, all of which limit access to food and humanitarian aid.

Conflict in Somalia has also accelerated environmental decline. For example, the country's mostly arid rangelands and scrub-savanna rely on hardy acacia trees, a slow-growing hardwood used for fodder, shade, and soil protection (it helps retain moisture and reduce runoff). In the context of decades of conflict, an illicit charcoal economy has flourished, with armed groups and traders financing themselves by cutting acacia for charcoal, accelerating deforestation. Even after the UN Security Council banned Somali charcoal imports in 2012, enforcement gaps and insecurity let the trade persist.

The result is rapid loss of woody cover around towns and along transport corridors, thinning rangeland, more erosion and dust, and fewer drought buffers for pastoralists and agropastoralists. This has been aggravated by water and soil conservation works that have gone unmaintained, rangelands being overgrazed, and the lapse of land-degradation controls, worsening erosion and desertification.[30]

Humanitarian assessments projected that nearly 4.4 million people – around a quarter of the population – would face crisis-level food insecurity between April and June 2025.[31] Displaced populations within the country, pastoralist communities, and households with exhausted reserves will be the most affected by this food insecurity. This threat has been exacerbated by below-average rainfall and flooding in key agricultural zones in late 2024, which has increased regional food prices and reduced the country's water supply.

As a result, Somalia faces severe risks of child malnutrition. An estimated 1.7 million children under five, around five per cent of the population, are projected to suffer from acute malnutrition in 2025, including 466,000 with severe acute malnutrition, mainly concentrated within southern regions.[32]

Five-Year Trends

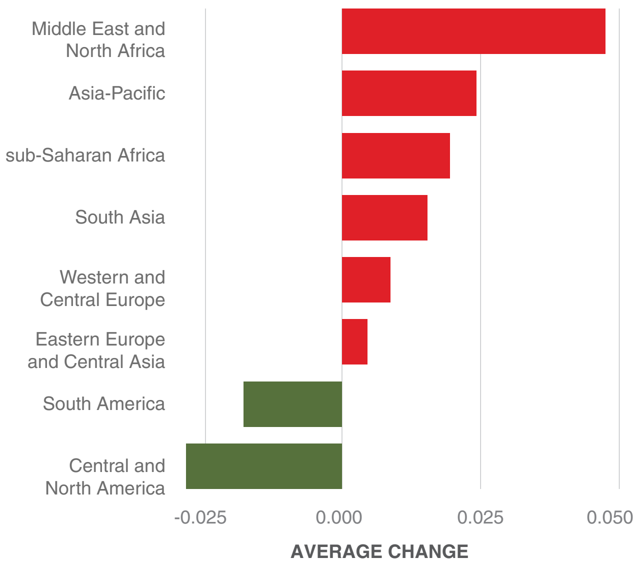
Food insecurity has increased around the world since 2019, with most regions deteriorating, as shown in Figure 1.12. The greatest deteriorations were concentrated in the Middle East and North Africa, which registered more than twice the rate of decline of Asia-Pacific, the second worst-affected region. Many of these changes are attributable to the COVID-19 pandemic, which disrupted global food production and supply chains, leading to sharp increases in food prices and widespread market volatility. The average cost of a healthy diet was estimated to reach 4.46 PPP dollars per person per day in 2024, an increase of more than 35 per cent over the past five years. These shocks pushed millions into food insecurity, reversing years of progress in reducing hunger and leaving many low-income households particularly vulnerable.

However, following the sharp setbacks seen at the height of the pandemic, most countries have at least partially recovered. Since 2021, 122 have improved in food security while only 50 have deteriorated. Moreover, those hardest hit during the height of the pandemic have tended to record the strongest rebounds. For example, Rwanda and Malawi recorded the 11th and 24th steepest deteriorations in food insecurity scores between 2019 and 2021, but they recorded the largest improvements over the past three years. Notably, the ten biggest recoveries have all occurred in low- and middle-income countries. This underscores both that wealthier countries were comparatively less affected during the crisis and that their subsequent bounce-backs have been more modest. And while progress has been achieved in the past three years, it has generally been uneven, and most places have not seen returns to pre-pandemic conditions.

FIGURE 1.12

Regional changes in food insecurity scores, 2019–2024

Six of eight global regions registered deteriorations in food security over the past five years.



Source: IEP

As a net food-importing region, the Middle East and North Africa has a structural reliance on imported staples, especially wheat and vegetable oils, which amplified its exposure to global price spikes, exchange-rate pressures, and supply-chain disruptions.

Western and Central Europe was also among the regions to deteriorate in food security, which is striking given that it recorded the largest regional improvement in water risk score. This divergence reflects that changes in the food insecurity indicator are closely tied to economic conditions and food affordability, while water risk is shaped more directly by shifting rainfall patterns. In poorer and more agrarian countries, rainfall disruptions would tend to affect food production directly and therefore have a much stronger impact on food security outcomes. But in wealthier countries – particularly those with an overall abundance of water – climate shocks may have less direct impacts, as these economies possess greater coping capacity and can draw on imports or infrastructure to buffer against local shortages.

Despite the significant impacts of the pandemic, average levels of food insecurity eased in the Americas, particularly in the Central and North America region. Of the ten countries to register the largest improvements in food insecurity scores between 2019 and 2024, five were in Latin America. Given that the ETR food insecurity indicator incorporates both economic conditions and societal dynamics that shape reliable access to food, much of these gains were tied to economic stabilisation efforts. Policy- and price-level measures – including inflation moderation and exchange rate stabilisation after the 2021–22 commodity shock, targeted subsidies for staples, grain reserves, and diversification of imports – underpinned improvements. Such examples highlight how recovery can be supported by decisive governmental action to stabilise food prices and ensure continuity of agricultural production and trade.

Venezuela recorded the largest single gain. However, this comes off a high baseline caused by hyperinflation and food shortages associated with a particularly acute period in the country's ongoing socioeconomic and political crisis. Even in less extreme cases, Peru, Costa Rica, Bolivia, and El Salvador also ranked among the top ten, supported by tighter price management, smoother logistics, and steadier imports. In El Salvador's case, plummeting rates of lethal violence further contributed to an improvement in score by easing conflict-related pressures on food systems and supply chains.

These patterns align with FAO estimates, which indicate that Latin America has experienced the largest recovery of any region in food security globally since the pandemic. The prevalence of food insecurity rose from 26 per cent in 2019 to 31.9 per cent in 2021, before falling to 23.3 per cent in 2024. In absolute terms, the number of people facing moderate or severe food insecurity climbed from 156 million in 2019 to 193.5 million in 2021, but has since dropped by nearly 50 million, to 144 million in 2024. Within this group, the number of undernourished people – a subset of food insecurity characterised by caloric deficiencies – has also steadily declined, from 29.1 million in 2019 to 25.9 million in 2024. Improvements were visible across all Latin American subregions, though most dramatic in South America, where the prevalence of food insecurity fell by nearly ten percentage points between 2021 and 2024.

At the national level, Somalia has consistently recorded the highest levels of food insecurity over the past five years. However, the steepest deteriorations between 2019 and 2024 were observed in Lebanon, Botswana, and Colombia. In Lebanon, food insecurity rose as a result of a prolonged financial crisis that precipitated extreme inflation and the collapse of the national currency, pushing food prices beyond the reach of many households. Botswana's deterioration was linked to an extreme agricultural drought of the past few years, during which crop yields fell sharply and more than ten per cent of the population faced food and nutrition insecurity. And in Colombia, food insecurity worsened as persistent armed violence and widespread displacement severely disrupted agricultural production and supply chains, intensifying existing vulnerabilities across the country.

Rising Prices and Low-Income Vulnerability

Global food price inflation accelerated from late 2020, peaking at more than 14 per cent in January 2023 before moderating, though prices remain above pre-pandemic levels.[33] Food prices rose faster than overall consumer prices, intensifying pressure on net food-importing countries. In sub-Saharan Africa, where food accounts for 50 to 60 per cent of household spending, these increases directly reduced dietary adequacy.[34]

As shown in Figure 1.13, the number of undernourished people increased sharply from 584 million in 2019 to a more than ten-year high of 697 million in 2021, before easing slightly to an estimated 673 million in 2024.[35] While this indicates some recovery, global levels remain well above those of 2019, suggesting a lasting upward shift. The prevalence of undernourishment has stabilised at around eight to nine per cent of the world's population, compared with 7.5 per cent before the pandemic.[36]

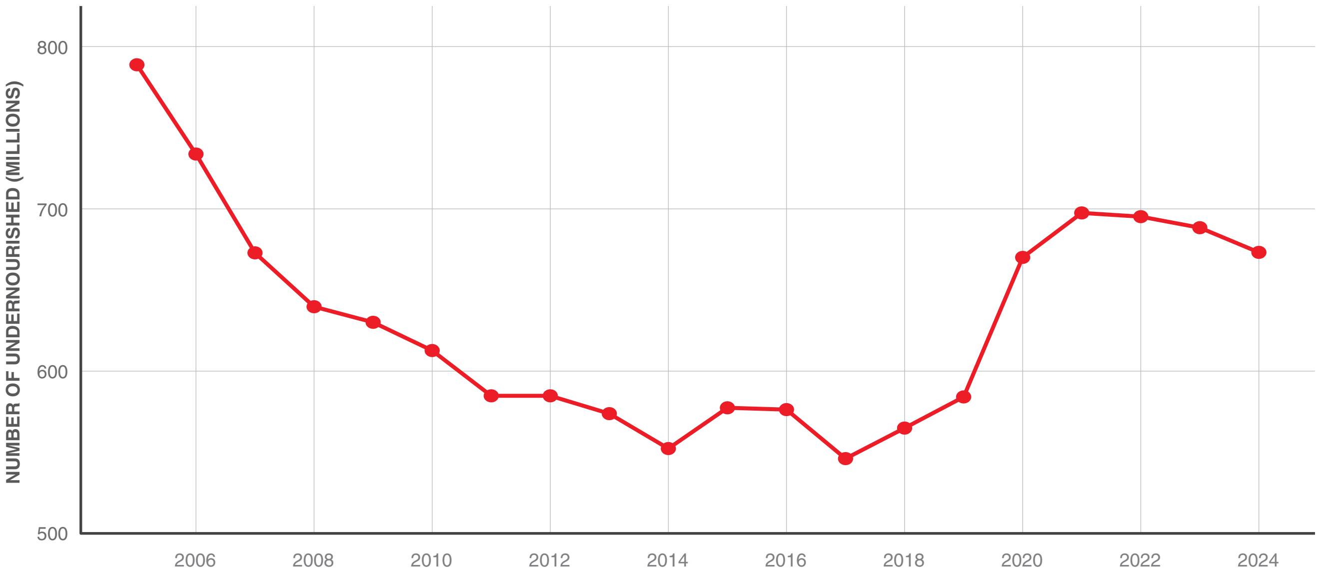
Comparable trends are apparent in the FAO's measures of global food insecurity. Around the world, the share of people experiencing moderate or severe food insecurity climbed from 25 per cent in 2019 to nearly 29 per cent in 2020-2021, before dropping only marginally to 28 per cent in 2024. In absolute terms, the number of food-insecure people rose by more than 300 million between 2019 and 2021, reaching almost 2.3 billion, and has remained at roughly that level since. Of these, 797.2 million were in sub-Saharan Africa and 791.1 million were in South Asia, each therefore accounting for roughly 35 per cent of the total. In such settings, gains made in nutrition and food security over the past two decades are particularly fragile. As many wealthy nations have announced and begun implementing cuts to Official Development Assistance (ODA) around the world, there are rising risks that not only could further improvements be halted, but higher levels of food insecurity could become entrenched worldwide.

This elevated baseline is compounded by conflict-related shocks. Ongoing crises in Sudan, Gaza, and Ukraine continue to disrupt supply chains and agricultural production, displace populations, and restrict humanitarian access. These disruptions are not fully captured in conventional measures but are contributing to persistent and in some cases crisis levels of hunger.

FIGURE 1.13

Undernourished people globally, 2005–2024

After years of uneven decline, the number of undernourished people worldwide rose notably in 2020 and 2021 in the context of the COVID-19 pandemic. It has only marginally decreased in the years since.



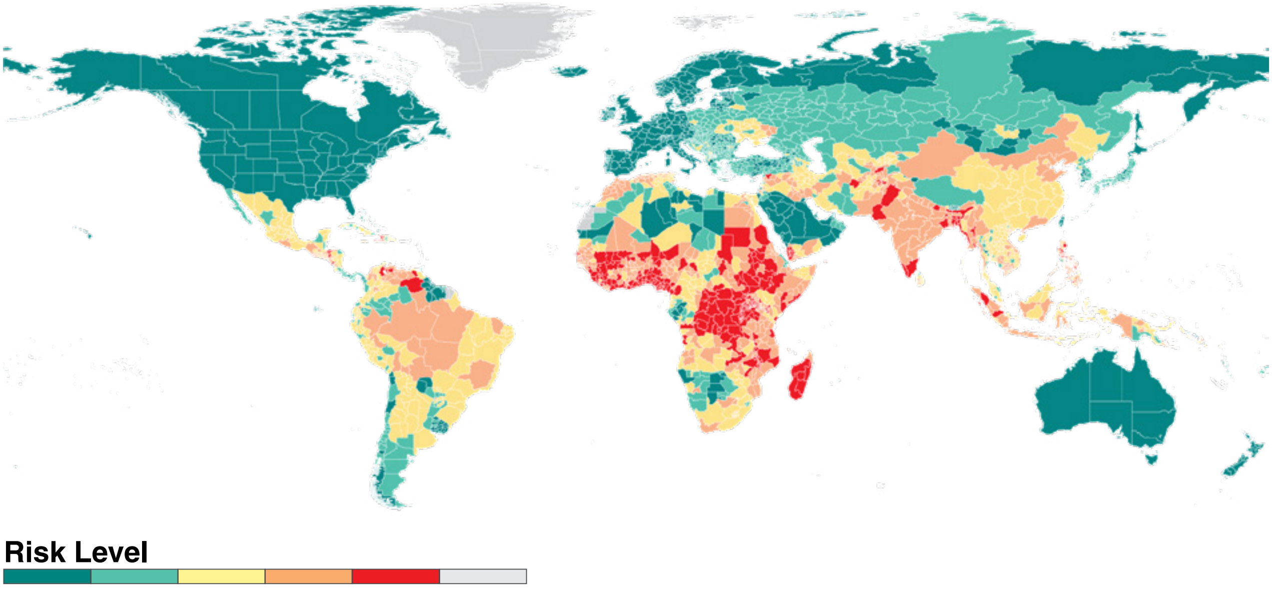
Source: FAO

Impact of Natural Events

FIGURE 1.14

Subnational impact of natural events scores, 2024

Europe and North America face the lowest levels of risk from the impact of natural events, while sub-Saharan Africa and South Asia face the highest levels of risk.



Source: IEP

The ETR impact of natural events indicator measures how dangerous climate-related disasters – such as floods, storms, or heatwaves – are likely to be for populations. It accounts not only for the severity of environmental hazards but also for how many people are exposed and how well they are able to cope. The measure combines three elements at the subnational level: climate risk, population density, and poverty levels. This approach recognises that the consequences of natural hazards are shaped both by the scale of exposure and by the resources available to respond.

Hazardous natural events have caused over 260 million internal displacements worldwide since 2015. The number of such movements has grown over this period, driven partly by more frequent and intense hazards but also by stronger national reporting and improved global monitoring. In 2024 alone, natural hazards caused 45 million displacements across 163 countries – the highest annual total since at least 2008. Storms and floods made up the vast majority of these displacements, affecting wealthy and poorer countries, though their long-term impacts were most severe in low-income settings. By the end of 2024, 9.8 million people remained displaced as a result of disasters.[37]

It is noteworthy, however, that natural disasters tend to cause more temporary displacements than conflict. In comparison to the over 45 million new disaster displacements in 2024, conflict caused about 20 million new movements last year. However, while the stock of those displaced by disaster was 9.8 million at year's end, the stock of those displaced by conflict stood at 73.5 million, reflecting a build-up over many years of people unable to return home.[38]

The 2025 ETR identifies 336 subnational areas with very high levels of exposure to the impact of natural events and a further 616 with high levels, encompassing more than half of the global population. This year marks the highest share of the global population exposed to very high risk, with the number of people living in these areas rising by 55 per cent in the last five years.

As shown in Figure 1.15, sub-Saharan Africa and South Asia faced the highest risks from natural events, driven by a combination of high climate vulnerability, dense populations, and limited adaptive capacity. In these regions, floods, droughts, and storms are more likely to escalate into humanitarian crises. In contrast, Western and Central Europe recorded much lower levels of risk, reflecting stronger infrastructure and more effective governance, which enhance their capacity to withstand and recover from environmental shocks.

As shown in Table 1.4, Burundi recorded the highest risk score in impact of natural events indicator, with all its subnational areas recording very high risk levels in 2024. With most of its population reliant on rain-fed farming, the recent experiences of recurrent floods, droughts, and soil erosion have had direct impacts on food supply and livelihoods. This dependence is intensified by severe land degradation, leaving households with little capacity to absorb environmental shocks.

TABLE 1.4

Countries with the highest levels of risk from the impact of natural events, 2024

All of the countries with the highest risk levels are in sub-Saharan Africa.

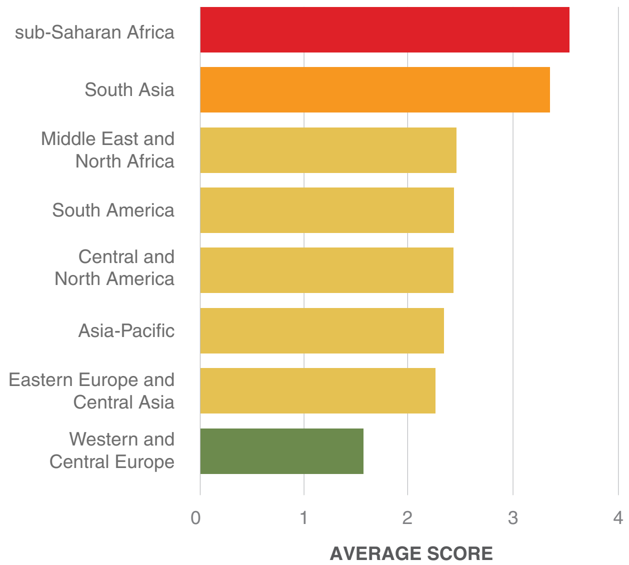
Country	Region	2024 Score	Population 2025
Burundi	Sub-Saharan Africa	4.929	11,917,637
Rwanda	Sub-Saharan Africa	4.662	15,126,168
Democratic Republic of the Congo	Sub-Saharan Africa	4.633	96,266,368
Ethiopia	Sub-Saharan Africa	4.631	113,573,763
Sierra Leone	Sub-Saharan Africa	4.491	7,586,550
The Gambia	Sub-Saharan Africa	4.485	1,881,345
Togo	Sub-Saharan Africa	4.416	7,546,494
Madagascar	Sub-Saharan Africa	4.285	29,252,622
Mali	Sub-Saharan Africa	4.249	23,096,234
Uganda	Sub-Saharan Africa	4.236	52,288,952

Source: IEP

FIGURE 1.15

Impact of natural events scores by region, 2024

Sub-Saharan Africa and South Asia have the highest levels of risk associated with natural events.



Source: IEP

BOX 1.4

Impact of Natural Events Country Profile: Ethiopia

Ethiopia ranks as the fourth highest at-risk country in the impact of natural events indicator, with over 80 per cent of its population residing in very high risk areas. The country's geography and climate make it particularly vulnerable to droughts, floods, and other environmental shocks, which intersect with existing challenges such as food insecurity, conflict, and poverty. These compounding risks affect communities across both rural and urban areas, straining livelihoods, infrastructure, and essential services.

The country's risk profile is shaped by a combination of factors, including extensive reliance on rain-fed agriculture, high levels of land degradation, rapid population growth, and limited adaptive capacity. Ethiopia has faced recurrent droughts that devastate agricultural production and livestock, leading to widespread displacement and heightened food insecurity. Flooding, particularly in river basins and low-lying areas, further threatens already fragile ecosystems and communities, destroying crops, contaminating water sources, and triggering outbreaks of disease.

In the Tigray region, the 2020-2022 conflict has reversed years of ecological recovery and intensified environmental degradation. Satellite analyses show conflict-driven loss of woody vegetation in hotspots across the region, as communities increasingly relied on fuelwood and timber under siege and electricity blackouts. Established soil and water conservation measures deteriorated or were abandoned during active fighting, allowing erosion and topsoil loss to accelerate. In areas where ecosystem restoration had been progressing over recent decades, that progress has been undermined, weakening natural buffers against drought and flood events.[39]

Displacement adds another layer of vulnerability. Ethiopia hosts the third-largest refugee population in Africa, which by 2021, stood at more than 725,000 people – primarily from South Sudan, Somalia, and Eritrea – hosted in 24 camps.[40]

Located in remote areas, they frequently lack durable infrastructure and adequate drainage, making them highly exposed to climate-related hazards such as flooding. A risk assessment of these camps found that, while not necessarily life-threatening in the short term, floods had the potential to contaminate water sources and spread disease, compounding the challenges faced by camp residents. For example, the Tierkidi camp in Ethiopia's Gambella Region was identified as the most exposed, with nearly 29,000 residents – almost half of its population – facing significant flood risk.[41]

Ethiopia's refugee camps illustrate the heightened vulnerability created by the displacement–natural hazard nexus.

Investment in disaster risk reduction, early warning systems, better water management, and other climate adaptation strategies will be essential for protecting not only displaced populations but also the wider society. Without coordinated action, Ethiopia's overlapping risks will continue to amplify the impact of natural events at a national scale.

Five-Year Trends

Over the past five years, countries have experienced diverging trajectories in their exposure to natural hazards. Nine of the ten largest deteriorations were concentrated in West Africa, where rapid population growth and limited infrastructure heighten the impact of natural events. Liberia, Burkina Faso, and Nigeria recorded the biggest deteriorations, with rising scores indicating greater vulnerability to floods, storms, and droughts. Conversely, the largest improvements were not specific to any region, with Guyana, North Korea, and Russia registering the largest improvements, alongside advanced economies such as Spain and Australia.

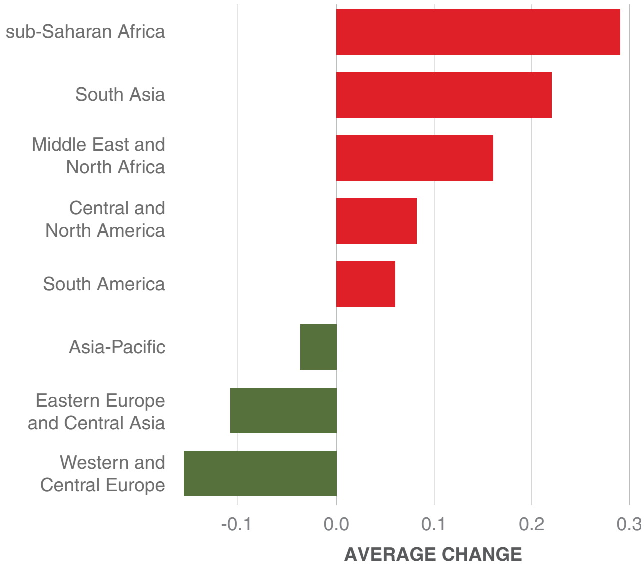
At the regional level, sub-Saharan Africa recorded the largest deterioration in the impact of natural events between 2019 and 2024, as shown in Figure 1.16. It was followed by South Asia and the Middle East and North Africa. Environmental pressures are intensified by poverty, fragile governance, and rapid population growth, increasing the likelihood that hazards translate into disasters.

In contrast, Western and Central Europe recorded notable improvements. These changes mirror the region's improvements in water risk, where an unusually severe 2019 baseline of heatwaves and drought made subsequent conditions in 2024 appear far more favourable as they returned closer to historical norms. In addition, these patterns may also suggest the widening gap between risks in low-income countries, which remain extremely vulnerable to climate hazards, and higher-income regions where risks are stabilising or even declining. In some ways this is to be expected as rich countries with good governance and high societal resilience scores are more likely to better manage their ecological weaknesses.

FIGURE 1.16

Regional changes in impact of natural events scores, 2019–2024

Sub-Saharan Africa experienced the most severe deterioration, and globally, deteriorations were almost three times greater than improvements.



Source: IEP

Since the 1980s, the number of documented climate-related disasters has more than doubled, according to the records of the Emergency Events Database (EM-DAT). In 1980, just over 100 climate-related disaster events were recorded, but by 2023, this figure had risen to more than 370. As shown in Figure 1.17, most of this increase has been driven by increases in floods and storms, which together accounted for more than 80 per cent of all climate disasters recorded in 2023. However, since 2005 the number of events has roughly remained the same.

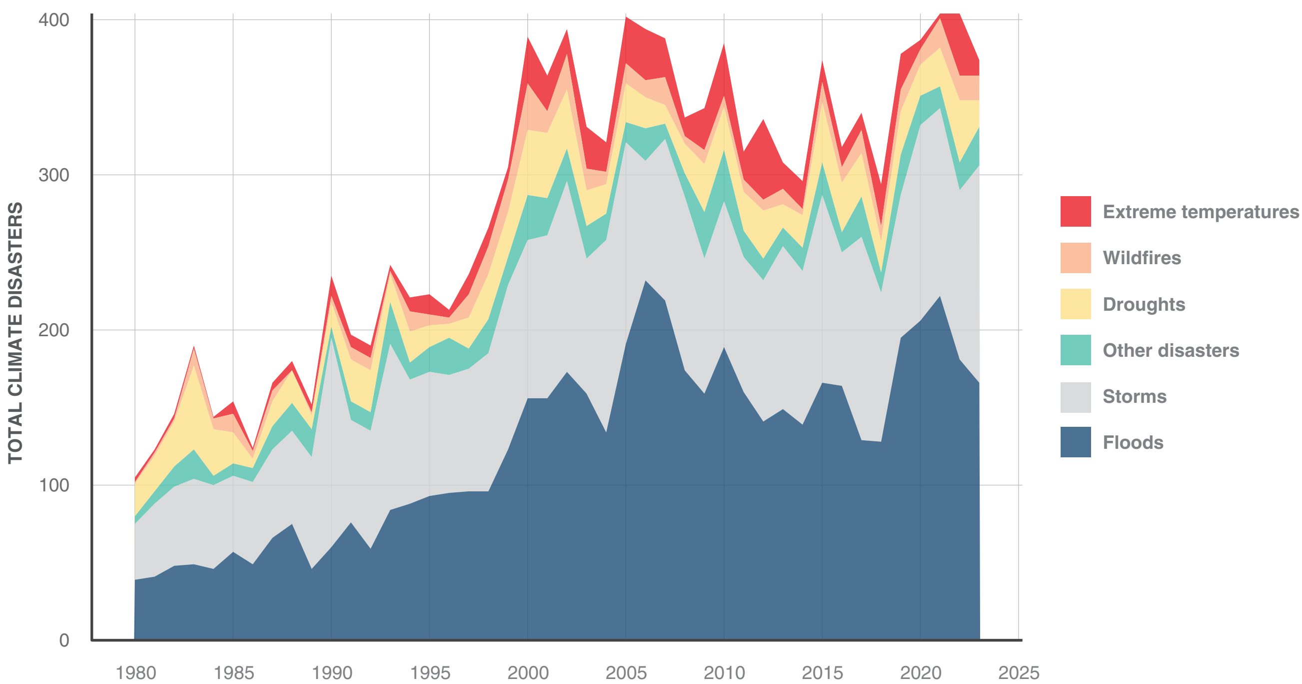
It is important to note that some of the observed increase in recorded disasters in recent decades may be the result of improvements in monitoring and reporting. Coverage in earlier periods was patchy, with smaller and medium-sized events often going unrecorded. The steep increase in numbers during the late 20th century coincided with advances in communication technologies, the creation of dedicated disaster databases, and greater institutional interest in compiling records.[42]

Moreover, with these improvements in monitoring and reporting, evidence suggests that natural disasters have become significantly less deadly. Despite population growth and climate change, the likelihood of dying in a storm, flood, or drought is now far lower than it was in the 20th century. Research has found that global disaster deaths have fallen from a rate of more than 25 annual deaths per 100,000 people a century ago to fewer than 0.5 annual deaths per 100,000 people today. In Bangladesh, for example,

FIGURE 1.17

Climate-related disasters, 1980–2023

The annual number of recorded natural disasters has more than doubled since the 1980s, driven by increases in the number of floods and storms around the world, though they have remained relatively steady since 2005.



Source: EM-DAT, CRED

Note: Not included are earthquakes and volcanic activity. "Other disasters" include events like landslides and glacial lake outbursts.

cyclones that once killed hundreds of thousands in the 1970s and 1980s now claim only a fraction of that toll, thanks to advances in forecasting, early warning systems, community preparedness, and stronger infrastructure. Globally, similar improvements in agriculture, public health, and governance have reduced vulnerability. This demonstrates that while hazards themselves have not disappeared – and in many cases have become more severe – investment in resilience saves lives on a massive scale.[43]

In view of the reporting complications prior to 2000, the trends in climate-related disasters over the past two decades are further outlined in Table 1.5. The table highlights just how variable the profile of climate-related disasters has been in the 21st century. Floods are by far the most common, with more than 200 recorded events in several years, including peaks in 2006, 2007, and 2021. Storms are the second most frequent, consistently numbering between 80 and 140 events per year, while droughts, wildfires, and extreme temperature events are recorded far less often but still show important spikes – such as droughts in 2015 and 2022, or extreme heat events in 2012 and 2022. The pattern suggests both an overall upward trend in reporting and a shifting mix of hazards, with floods and storms accounting for the majority, but heatwaves and droughts increasingly punctuating the record in recent years. This evolving distribution underlines how multiple climate hazards are now interacting, creating complex risks for governments and communities alike.

TABLE 1.5

Climate-related disasters, 2000–2023

Since 2000, recorded climate-related disasters have remained dominated by floods and storms, but with periodic spikes in droughts, wildfires, and extreme heat events that point to an increasingly varied mix of hazards.

	Floods	Storms	Droughts	Wildfires	Extreme temperatures	Other disasters
2000	156	102	42	30	30	29
2001	156	105	42	14	23	24
2002	173	123	38	23	16	21
2003	159	87	23	14	27	21
2004	134	124	19	8	19	17
2005	191	130	25	13	30	13
2006	232	77	20	11	33	21
2007	219	104	12	18	25	10
2008	174	112	19	5	12	15
2009	159	87	31	9	27	30
2010	189	94	28	7	34	33
2011	160	87	25	8	18	17
2012	141	91	31	7	52	14
2013	149	105	15	10	17	12
2014	139	99	21	4	18	15
2015	166	121	39	13	14	21
2016	164	86	32	10	13	13
2017	129	131	28	15	11	26
2018	128	96	20	10	27	13
2019	195	92	28	14	23	26
2020	206	126	20	10	6	19
2021	222	121	25	19	3	14
2022	181	109	40	16	40	18
2023	166	140	17	16	10	25

Source: EM-DAT, CRED

Note: Not included are earthquakes and volcanic activity. “Other disasters” include events like landslides and glacial lake outbursts.

The costs of climate-related disasters to the global economy have been substantial. Between 2000 and 2019, climate-related disasters generated nearly $3 trillion in losses, with multi-hazard events – such as cyclones that simultaneously destroy cropland, trigger flooding, and spark disease outbreaks – responsible for almost 60 per cent of damages.[44] Such impacts are not merely additive but compounding, as overlapping crises can overwhelm institutions and stretch recovery capacities.

The humanitarian toll is also severe. Floods and cyclones disrupt water and sanitation systems, heightening the spread of diseases such as cholera and diarrhoea. Heatwaves and prolonged droughts erode agricultural production, exacerbating malnutrition and threatening food security in fragile states. Repeated shocks drive households into cycles of debt, asset loss, and displacement. Pastoralist communities may lose entire herds during extended droughts, while coastal populations confront declining fisheries and infrastructure damage from storm surges.[45] These cumulative effects reduce resilience and magnify the difficulty of recovery after each successive disaster.

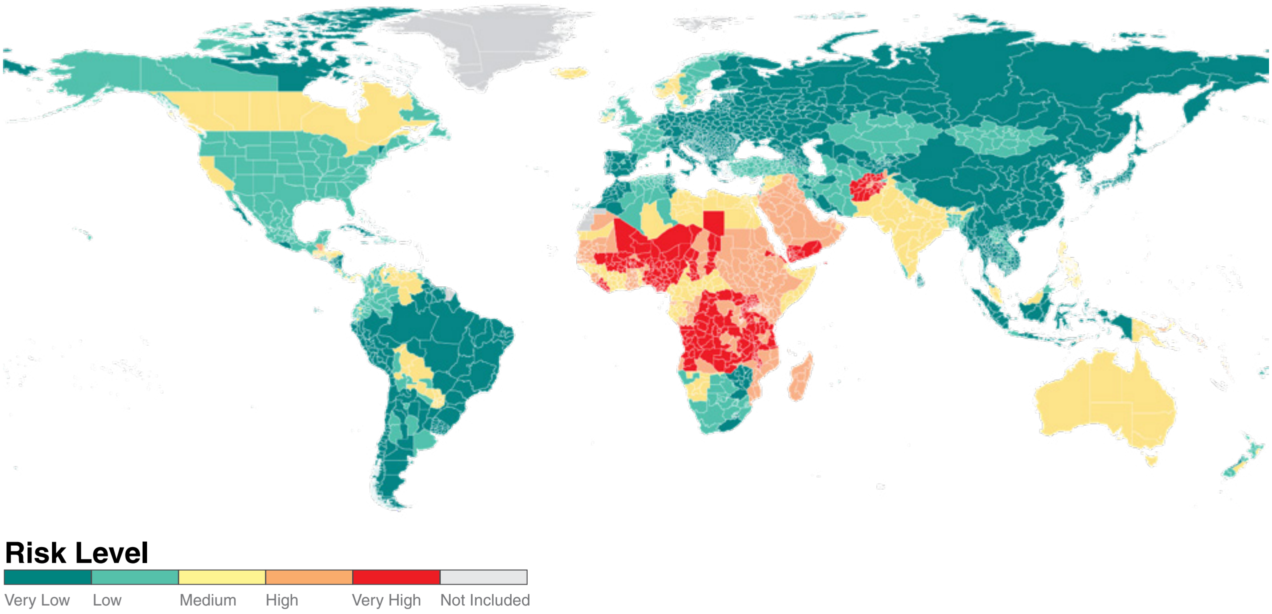
Collectively, these effects demonstrate that natural events should not be seen as isolated shocks, but as catalysts of longer-term developmental decline. Building resilience requires more than physical protection; it demands integrated investments in health systems, food security, and livelihoods that can withstand repeated and compounding pressures.

Demographic Pressure

FIGURE 1.18

Subnational demographic pressure scores, 2024

Populations are projected to grow most in sub-Saharan Africa.



Source: IEP

The ETR demographic pressure indicator is based on projected population increases between 2025 and 2050. It is a forward-looking measure that aims to capture the ways in which rapid population growth could exacerbate existing stresses in social and natural environments. Population growth has been strongly linked to environmental degradation, particularly in areas that are already overpopulated and suffering from stretched natural resources.

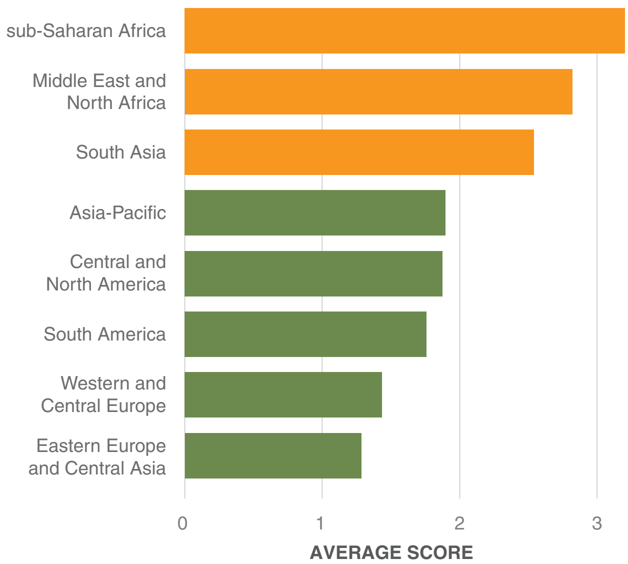
Of the 3,125 subnational areas assessed in the 2025 ETR, 304 have very high levels of demographic pressure, with population growth projected to exceed 50 per cent in the next 25 years. A further 337 subnational areas are facing high demographic pressure, with projected growth of around one-third. The total population in these two categories is projected to increase by more than 646 million, representing over half of the world's population projected increase by 2050, despite comprising only around 15 per cent of the global population in 2025.

As shown in Figure 1.19, demographic pressures are most concentrated in sub-Saharan Africa and the Middle East and North Africa, where populations are projected to grow by 49 and 28 per cent respectively by 2050. The ten countries projected to record the fastest population growth will collectively add more than 339 million people, accounting for over a quarter of global population growth between 2025 and 2050.

FIGURE 1.19

Demographic pressure scores by region, 2024

The highest levels of risk from demographic pressure were in sub-Saharan Africa and the Middle East and North Africa.



Source: IEP

As Table 1.6 highlights, eight of these ten countries are in sub-Saharan Africa, led by Niger, Uganda, and Malawi, where populations are expected to nearly double. This rapid expansion will intensify stress on food systems, water resources, and infrastructure in regions already facing high ecological and social vulnerabilities.

At the same time, population dynamics are diverging in other parts of the world. The Asia–Pacific region is projected to contract by 2.7 per cent by 2050, largely due to an eight per cent decline in China's population, equivalent to more than 114 million people. Japan and Taiwan are also projected to shrink by 11 and nine per cent respectively. In Eastern Europe and Central Asia, several states are projected to experience some of the steepest contractions worldwide, including Moldova, Georgia, and Lithuania. Collectively, the ten countries projected to see the largest declines will lose more than 20 million people by mid-century, with seven of them located in this region.

In general, lower population pressure reduces competition for finite resources such as food, water, and land. With fewer mouths to feed, global food demand would decline over time, potentially shrinking the farmland area required. This would in turn ease pressure on rivers and aquifers, helping to stabilise groundwater levels and curb over-extraction.

While slowing or negative growth may ease direct pressure on ecological resources, it brings new challenges. Ageing societies will face shrinking labour forces, rising old-age dependency ratios, and mounting demands on health care, pensions, and other public services. By the 2050s, older adults will far outnumber children, reversing a demographic balance that has persisted for centuries. This transition risks constraining economic growth and fiscal capacity, making it harder to finance adaptation and resilience measures at the very moment when ecological threats are intensifying. Demographic pressure, therefore, is not only about growth in fragile regions but also about the vulnerabilities created by decline and ageing in wealthier ones.

TABLE 1.6

Countries projected to grow and shrink the most in population by 2050

The countries with the highest projected population growth are concentrated in sub-Saharan Africa, while those projected to contract the most are predominantly in Eastern Europe and Central Asia.

Greatest projected growth					
Country	**Region**	**2024 Score**	**Population 2025**	**Projected 2050 Population**	**Population Change (%)**
Niger	Sub-Saharan Africa	4.979	25,835,933	50,812,311	97%
Uganda	Sub-Saharan Africa	4.535	52,288,952	92,324,420	77%
Malawi	Sub-Saharan Africa	4.512	22,670,320	39,612,170	75%
Liberia	Sub-Saharan Africa	4.311	6,396,520	10,600,294	66%
Nigeria	Sub-Saharan Africa	4.252	224,971,672	368,395,672	64%
Afghanistan	South Asia	4.179	46,403,108	75,294,615	62%
Burkina Faso	Sub-Saharan Africa	4.05	24,359,092	38,470,660	58%
Zambia	Sub-Saharan Africa	4.019	19,113,469	30,034,440	57%
Yemen	Middle East and North Africa	4.007	35,521,135	55,735,938	57%
Tanzania	Sub-Saharan Africa	3.962	63,992,319	99,674,768	56%
Greatest projected declines					
Country	**Region**	**2024 Score**	**Population 2025**	**Projected 2050 Population**	**Population Change (%)**
Moldova	Eastern Europe and Central Asia	1	3,011,042	2,188,704	-27%
Georgia	Eastern Europe and Central Asia	1	3,911,011	3,181,072	-19%
Cuba	Central and North America	1	9,905,971	8,377,362	-15%
Lithuania	Western and Central Europe	1	3,056,658	2,657,576	-13%
Romania	Eastern Europe and Central Asia	1	20,165,410	17,607,162	-13%
Armenia	Eastern Europe and Central Asia	1	3,000,368	2,637,706	-12%
Latvia	Western and Central Europe	1	1,943,221	1,717,222	-12%
Japan	Asia-Pacific	1	111,951,149	99,276,602	-11%
Bosnia and Herzegovina	Western and Central Europe	1	3,648,421	3,285,823	-10%
Belarus	Eastern Europe and Central Asia	1	9,033,539	8,150,101	-10%

Source: IEP

Human Population Projections

The United Nations publishes its World Population Prospects report biennially, providing demographic estimates from 1950 to 2100. The most recent edition, released in 2024, projects that the global population will peak at nearly 10.3 billion in 2084 before declining slightly to around 10.2 billion by 2100.[46] The report also forecasts that the global fertility rate will fall below the replacement rate of 2.1 births per woman by 2050, the threshold required for each generation to replace itself.

As shown in Figure 1.20, UN projections of future population size have been revised downward over the past decade, driven largely by faster-than-expected declines in fertility rates, particularly amongst many Asian and European countries.[47] Falling fertility has substantially reduced the annual rate of global population growth, which peaked in 1963 at around 2.3 per cent and has since declined to an estimated 0.8 per cent in 2024. Growth is projected to turn negative in 2085, with the global population expected to contract by around 0.13 per cent annually by the end of the century.

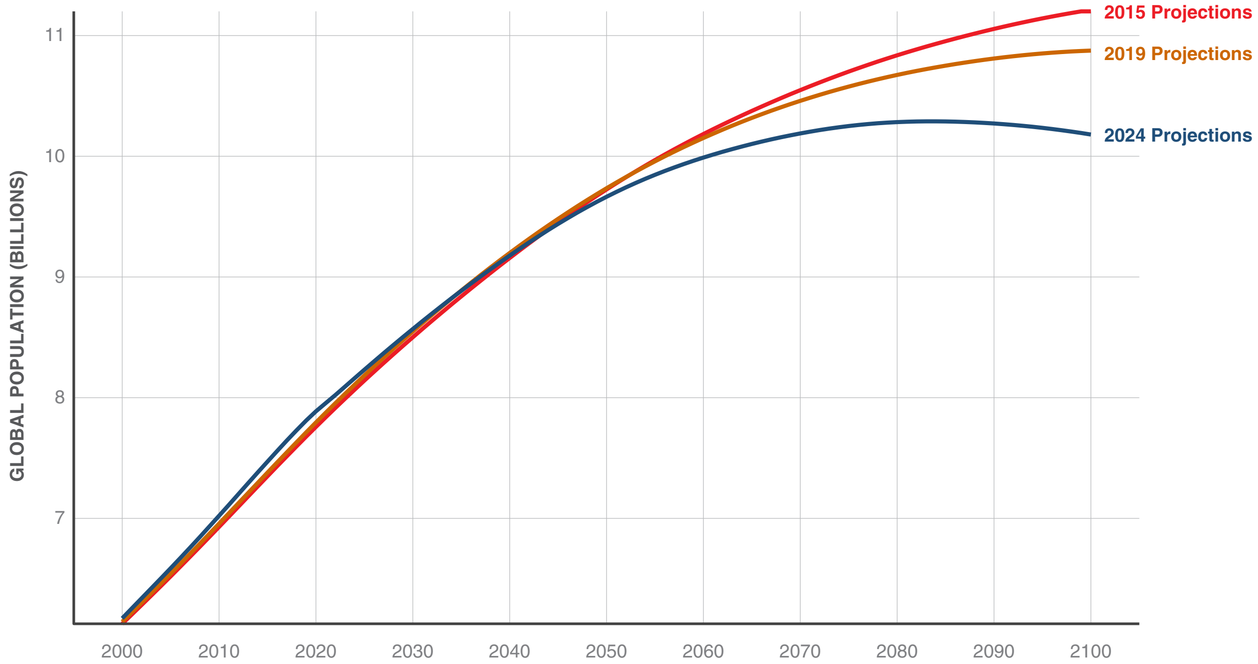
The number of people aged over 60 is projected to keep rising throughout the century, eventually surpassing three billion people. During much of the 20th century, children under five outnumbered adults over 60, but this trend reversed in 2002, as shown in Figure 1.21. Global life expectancy is currently estimated at around 73 years but is projected to rise substantially in the coming decades.[48] By contrast, the population of children under five peaked in 2017 at around 698 million and is expected to decline by nearly 27 per cent by the end of the century.

This inversion of the age pyramid will create new vulnerabilities. Labour shortages may undermine productivity, while pension and health systems face unprecedented strain. At the same time, fiscal space for climate adaptation and resilience could narrow. While sub-Saharan Africa and South Asia contend with the pressures of rapid population growth, wealthier regions must manage the fragilities of shrinking and ageing populations – two divergent trends that together highlight why demographic change is central to future ecological and social stability.

FIGURE 1.20

Comparison of recent population projections to 2100

Each new UN projection has pointed to increasingly slowing growth, with the 2024 projection having the lowest estimate yet.

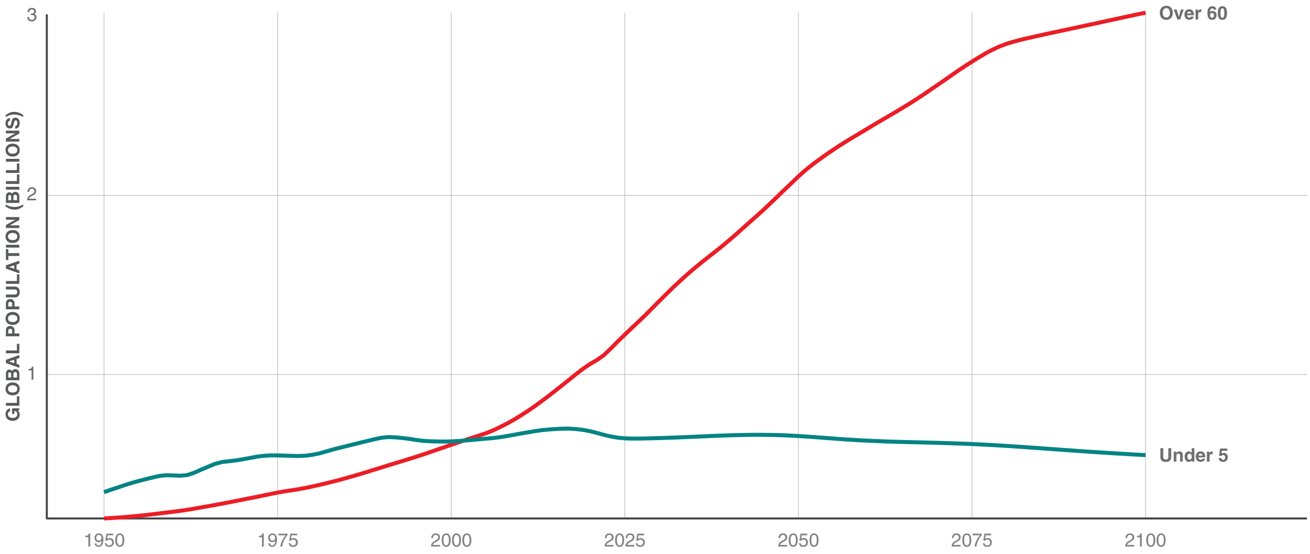


Source: UN World Population Prospects

FIGURE 1.21

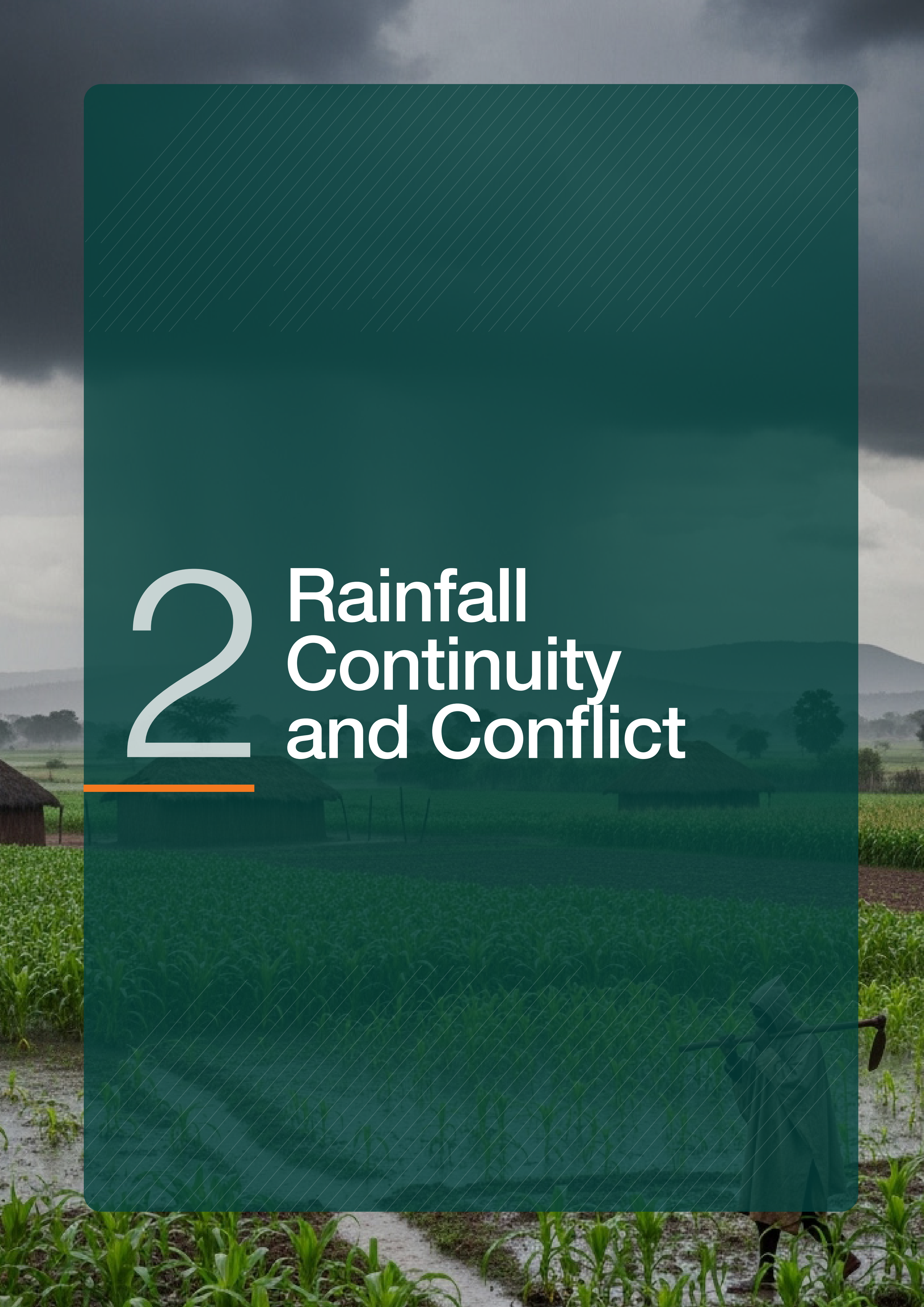
United Nations population projections for people over 60 and under five, 1950–2100

The population of individuals over 60 surpassed the population of children under five in 2002, and in the coming decades the discrepancy will



grow much larger.

Source: UN World Population Prospects



2 Rainfall Continuity and Conflict

80%

More than 80 per cent of the world's cultivated land does not use irrigation. Increasingly unpredictable rainfall puts food production at higher risk in these areas. Sub-Saharan Africa has the lowest irrigation rates in the world, with less than two per cent of its cultivated land currently irrigated.

Irrigated land is twice as productive as unirrigated land. 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.

Disruptions in rainfall patterns and water availability can raise the threat of conflict, but the relationships are multifaceted and nonlinear, with water issues tending to aggravate existing conflict risks, rather than cause them.

Conflict risks from changing precipitation are higher with rainfall-dependent food production.

In many places around the world, net annual rainfall has changed comparatively little in recent years, but wet seasons are becoming wetter and dry seasons are becoming drier.

Research has found that this heightened seasonality and variability in rainfall raises the risk of conflict.

These effects can be most dramatic in the case of precipitation shocks such as droughts and floods, which can negatively affect agricultural production and economic activity.

Increases in wet-season rainfall can be harmful to crops and produce more conflict.

Globally, the rate of conflict deaths is more than 50 per cent higher in areas where rainfall is becoming increasingly concentrated in fewer months of the year, as compared to places where rainfall seasonality is decreasing.

In sub-Saharan Africa, IEP analysis finds that changes in rainfall seasonality alone are not statistically linked to conflict. However, when combined with rapid population growth, the risk of fatalities can rise sharply – adding as many as six additional deaths per year for every 100,000 people.

Across non-desert areas in sub-Saharan Africa, the Karamoja Cluster in northwest Kenya and northeast Uganda has been the site of the greatest increase in rainfall seasonality since the late 2000s.

In East Africa, healthier vegetation and more stable rainfall have both been linked with reduced conflict risk, along with reduced likelihood of household food insecurity.

Rising food prices contribute to instability in Africa. An evaluation of more than one hundred subnational areas on the continent found that a doubling of food prices was linked witha 13 per cent rise in the number of conflict occurrences one year later.

44%

Since 2017, the cost of a healthy diet in East Africa has risen by 44 per cent, leaving an additional 58 million people unable to afford it.

Climate impacts could displace up to 38.5 million people from arid and semi-arid zones in East Africa, with a substantial share of this movement directed toward the Lake Victoria Basin.

The Rainfall-Conflict Nexus

This section finds that the relationship between rainfall and conflict is complex. Changing patterns in rainfall do not create conflict, but they can act as a major stress factor where the conditions for conflict already exist.

IEP analysis finds that places experiencing increased rainfall "seasonality" tend to experience higher levels of conflict. This is where rain falls in shorter periods during the year. While shifting climatic conditions alter overall rainfall amounts, in many places their greatest impacts have been on the seasonal distribution of rain. Generally, wet seasons are becoming shorter and more intense, while dry seasons are growing longer and drier.[1] These changes have implications for the reliability of rainfall, with dry regions in particular experiencing rising uncertainty over when rains will arrive and how long they will last.[2] According to IEP analysis, places experiencing the most severe increases in rainfall seasonality have, on average, also registered the highest conflict fatality rates in recent years.

These relationships, however, are far from uniform. While the global analysis shows strong correlations between heightened rainfall seasonality and conflict risk, the strength of this link weakens once differences between countries are accounted for. This asymmetry means that simple correlations between climate variables and violence can be misleading. Rainfall changes do not operate in isolation; they interact with political, economic, and demographic conditions that determine whether stress translates into instability or adaptation. In regions such as sub-Saharan Africa, for example, seasonality alone does not predict higher conflict risk, but when coupled with rapid population growth, the risk of violence can rise sharply. This underscores how, when studying distinct geographies, prevailing social conditions determine the scope of the impacts of rainfall disruptions.

Beyond rainfall seasonality, multiple studies have identified links between other rainfall patterns and conflict, including the related concept of rainfall variability. But these studies also find that the influence of rainfall usually operates at the margins, shaping risk conditions rather than acting as a core driver. Moreover, one study found that rainfall's effects were only discernible at the monthly scale, and annual rainfall variability showed no statistically significant impact. This indicates that yearly averages mask the influence of short-term shocks, such as the timing of rains critical for planting and harvesting.[3]

Rainfall shifts interact with local livelihoods in ways that can fuel tension. For instance, in sub-Saharan Africa's mixed pastoral and agricultural zones, reduced rainfall in pastoral areas has been found to increase conflict in neighbouring farming lands, especially during the wet season when crops are most vulnerable.[4] Local economies are therefore a channel through which rainfall shocks play out. A study found that African districts hit by drought saw lower economic activity and higher extremist violence, with the strongest impacts in places that suffered repeated dry spells.[5]

This is largely because seasonal cycles of work can matter as much as rainfall itself. In farming societies around the world, harvests create one of the largest temporary boosts to employment. Evidence from Afghanistan, Iraq, and Pakistan shows that the onset of harvest usually reduces insurgent attacks, consistent with the idea that better income and work reduce the appeal of fighting.[6] Water storage and access are also critical. One study found that a drop in local water mass linked to drought more than tripled the likelihood of social conflict, while groundwater and surface water access helped to offset the risk.[7]

Other findings point to how seasonal extremes cut in different directions. In the Philippines, more dry-season rainfall improved harvests and thereby reduced conflict, while heavier wet-season rainfall damaged crops and raised conflict risks. As a result, even when total annual rainfall remains stable, wetter wet seasons and drier dry seasons are likely to lead to more civil conflict.[8]

Taken together, this research shows that climate is a risk multiplier rather than a single cause of conflict. Establishing a direct link between rainfall and violence is inherently difficult, since rainfall is widespread while armed conflict is rare and highly context dependent. However, changes in rainfall seasonality and water availability can influence livelihoods, food prices, migration, and local politics in ways that can either heighten or ease tensions. In the context of rising rainfall seasonality and variability worldwide, the need for effective water capture and distribution is becoming increasingly critical.

While research on the links between rainfall variability and conflict has produced complex results, the importance of rainfall to human life and livelihoods cannot be overstated. Around the world, agriculture still depends heavily on seasonal rains, with only 19.3 per cent of global cultivated land irrigated, as shown in Figure 2.1. Despite representing less than one-fifth of global cropland, these lands produce 40 per cent of the world's food, further underscoring their disproportionate importance for agricultural production in the context of rising rainfall variability.

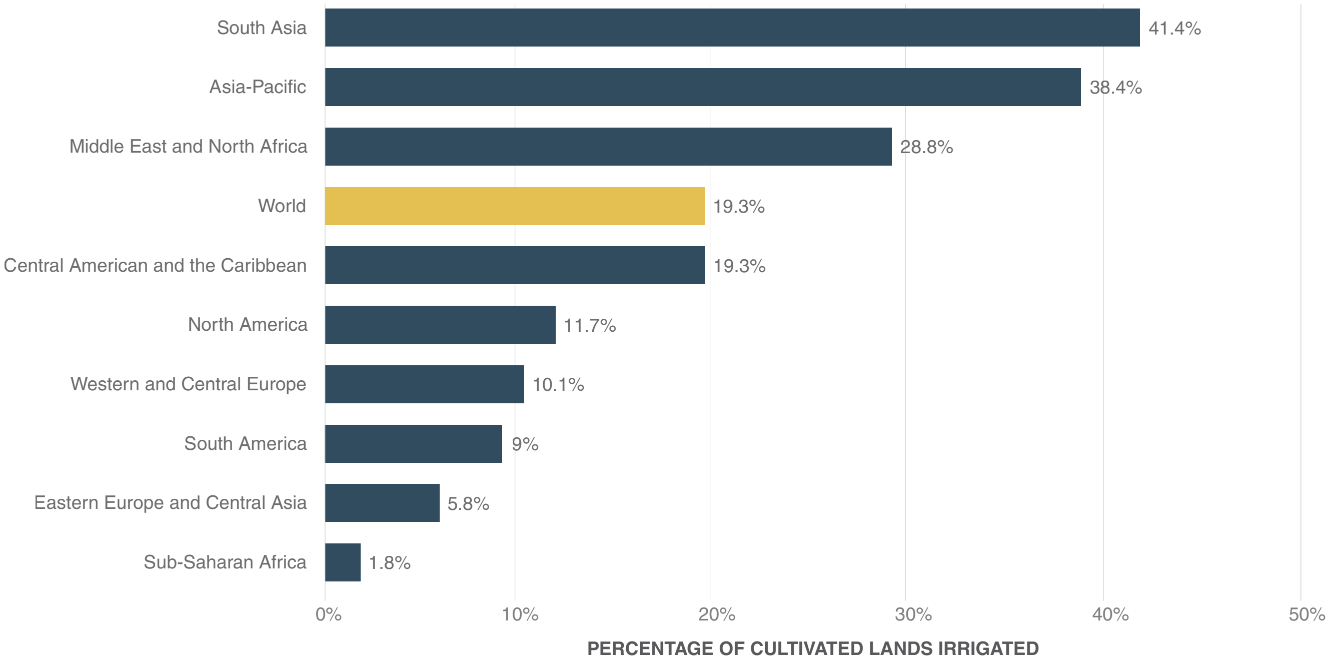
"

IEP analysis finds that places experiencing increased rainfall "seasonality" tend to experience higher levels of conflict.

FIGURE 2.1

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.

Nowhere is the lack of irrigation more severe than in sub-Saharan Africa, where only 1.8 per cent of cultivated land is irrigated. This means most farmers are entirely dependent on rainfall. In contrast to some other regions, such as most of North America and Europe, where rainfall levels make the expansion of irrigation unnecessary, many places in sub-Saharan Africa would benefit greatly from irrigation. In the region, disruptions to expected precipitation patterns – whether in timing, intensity, or duration – can threaten harvests, herding patterns, and, ultimately, survival. This vulnerability is magnified by the fact that two out of every three people in the region are already food insecure, and the population is expected to nearly double by 2050.[9]

Despite these pressures, the region has substantial untapped water resources, with an estimated 34.2 million hectares of land suitable for irrigation that could be developed using less than six per cent of its renewable water. The greatest obstacle is therefore not water scarcity but the lack of infrastructure to capture and distribute it effectively.[10] The situation is further exacerbated by poor governance, untitled land ownership, and farms smaller than half a hectare, which often lack the resources to install and maintain irrigation infrastructure.

With adequate structures and investment, sub-Saharan Africa could bring its agricultural water use in line with global rates while still maintaining more than 4,500 cubic metres per annum of water per person for other needs. Research from East Africa shows that increases in rainfall and vegetation lower the likelihood of household food shortages and reduce the risk of violent conflict substantially. This highlights how improved water management could simultaneously strengthen food security and reduce conflict risk, offering one of the most promising pathways to resilience in the face of climate variability.[11]

Rainfall Variability and Seasonality

Rainfall variability refers to how much rainfall fluctuates over time – either from year to year or within a given season. It captures the degree of unpredictability in rainfall amounts or timing. A region experiencing rainfall that varies from 200 millimetres of rain one year to 1,000 millimetres the next – despite having a long-term average of 500 millimetres – would be said to have high rainfall variability. This concept is essential for understanding exposure to climate shocks, such as droughts or floods, because it quantifies how unstable and inconsistent the rainfall pattern is. Variability is typically measured using metrics like the coefficient of variation, standard deviation, or anomalies from the mean.

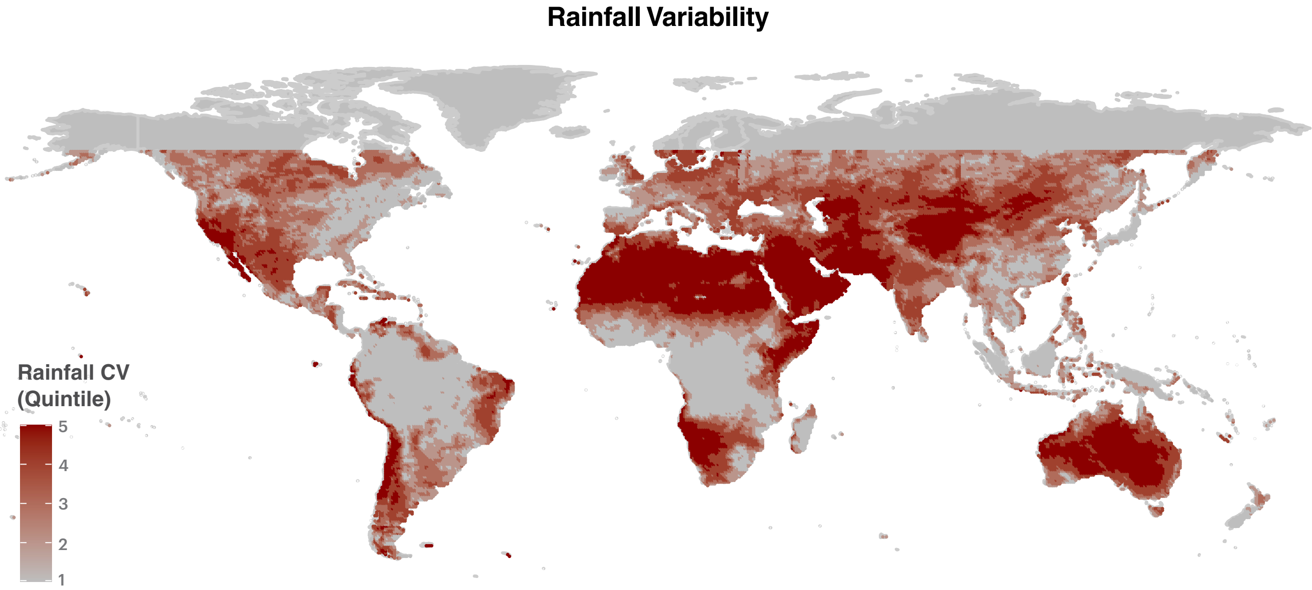
A related concept is rainfall seasonality, which describes how rainfall is distributed across the months of a calendar year. It assesses whether rainfall occurs evenly across the year, or whether it is concentrated in just a few months – such as in a monsoon or short wet season. High seasonality means rainfall is focused within a narrow period, while low seasonality implies more consistent rainfall year-round. Seasonality is generally measured using indices like the Seasonality Index (SI) that help explain the predictable rhythms of ecosystems and farming systems. While variability reflects unpredictability, seasonality reflects the cyclical structure of rainfall within a typical year.

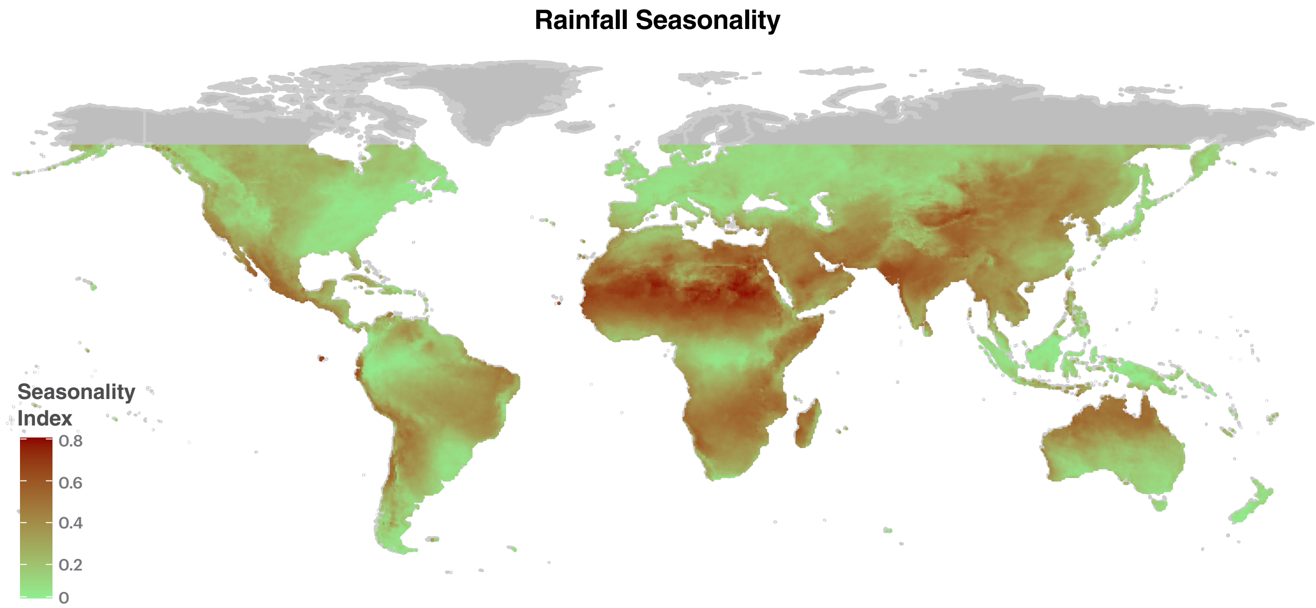
The maps in Figure 2.2 show rainfall variability and seasonality globally over the past two decades. As can be seen, both variability and seasonality tend to be highest in deserts and highly arid areas, where rainfall is generally uncommon, but which occasionally receive bursts of rain.

FIGURE 2.2

Global rainfall variability and seasonality, 2005–2025

Both variability and seasonality tend to be most severe in deserts and other highly arid areas, while it is often least severe in tropical and temperate zones.





Source: CHIRPS, IEP

Note: The CHIRPS rainfall dataset excludes regions north of 50°N and south of 50°S.

Rainfall Seasonality as a Livelihood and Conflict Threat

Communities across the globe have developed intricate knowledge systems around local rainfall regimes. These patterns govern when to plant, when to harvest, and when to migrate livestock. But climate change is disrupting these centuries-old expectations. Roughly 60 per cent of single wet-seasons areas and 83 per cent of dual wet-seasons areas have experienced shortened rainy seasons, despite total annual rainfall remaining constant.[12]

According to IEP analysis, about two-thirds of the earth's land surface has become more seasonal in the past two decades. As shown in the map in Figure 2.3, while the majority of these changes are marginal, about 35 per cent of land area has experienced a moderate or severe increase in seasonality. In regions without robust infrastructure to capture or store water, such as sub-Saharan Africa, this heightened seasonality can have severe implications. The problem is not just about droughts or floods, but rather about unpredictability, and how that unpredictability destabilises human systems built around consistency.

Where wet seasons become wetter, dry seasons become drier, and the predictability of seasonal transitions increasingly break down, the risk of conflict can rise. This intensification of the seasonal cycle – sometimes referred to as "amplified seasonality" – may not be fully captured by rainfall variability metrics, which focus on dispersion rather than structure. In contrast, seasonality detects shifts in the concentration and timing of rainfall, providing insight into how ecosystems and agricultural systems may be stressed by increasingly extreme intra-annual cycles. As such, it offers a critical lens into climate-driven pressures that can trigger cascading effects on food security, migration, and conflict.

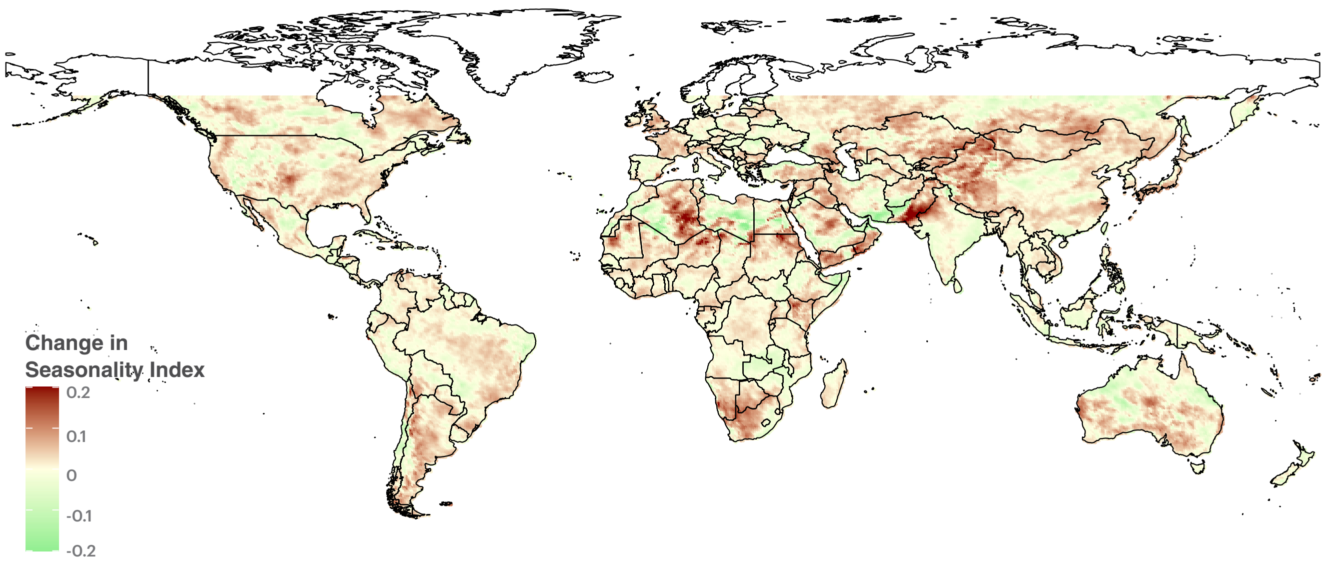
There is a striking relationship between changes in rainfall seasonality and conflict fatality rates. According to ACLED records, the world has registered more than 1.7 million conflict-related fatalities since 2018, equating to a global annual rate of about 2.8 conflict deaths per 100,000 people. However, areas of increasing seasonality are far larger – in terms of both land area and in the number of people living in them – than places of decreasing seasonality. The areas of increasing seasonality are also more prone to conflict. The rate of conflict deaths is more than 50 per cent higher in areas of increasing seasonality than they are in places of decreasing seasonality.

Figure 2.4 breaks this relationship down further by looking at the average conflict death rates in four groupings of seasonality change over the past 15 years. When averaged at the subnational unit level around the world, areas where the seasonality index scores increased by more than 0.05 points are classified as having a *severe increase*; those with an increase between 0.025 and 0.05 points as having a *moderate increase*; those with shifts within 0.025 points of their original value are considered *stable*; and those with decreases at least 0.025 points are classified as registering a *decrease*.

FIGURE 2.3

Change in rainfall seasonality index, 2020–2025 vs 2005–2010

Seasonality is increasing in most of the world.

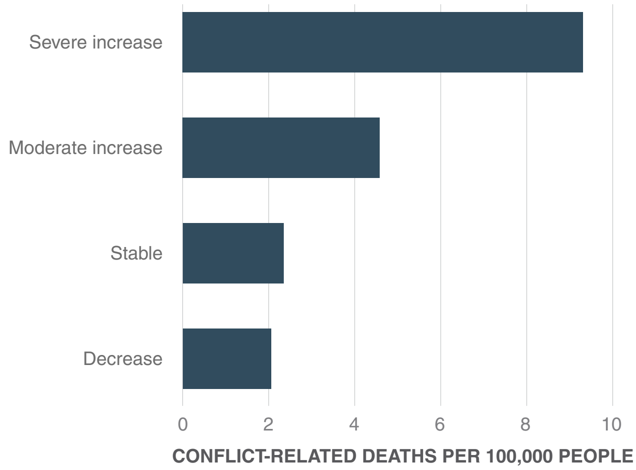


Source: CHIRPS, IEP
Note: The CHIRPS rainfall dataset excludes regions north of 50°N and south of 50°S.

FIGURE 2.4

Average subnational conflict fatality rates, by seasonality trend, annual averages for 2018–2025

Globally, places experiencing the most severe increases in seasonality tend to have the highest conflict fatality rates.



Source: CHIRPS, ACLED, IEP

Note: Outliers more than three standard deviations away from the mean have been excluded from the averages.

The gradient in conflict risk becomes especially clear when comparing across the four categories of seasonality change. Subnational areas where rainfall seasonality has decreased or remained stable record relatively low fatality rates, averaging around 2.1 and 2.4 conflict deaths per 100,000 people per year. These rates more than double in areas of moderate increase, rising to 4.6, and surge to nearly 9.4 deaths per 100,000 in areas of severe increase. In this categorisation, two-thirds of humanity live in relatively stable areas while less than one-tenth live in areas of at least moderate decreases in seasonality. In contrast, around one-fourth of people live in areas characterised by moderate to severe increases in seasonality, equivalent to around two billion people.

This correlation between changing rainfall patterns and conflict dynamics is supported by statistical analysis, but with important caveats. At the global level, places where rainfall has become more seasonal also tend to experience more deadly conflict, even after taking into account factors like population density. Moreover, the analysis shows that population growth acts as a force multiplier, intensifying the link between rising seasonality and deadly conflict. Yet once differences between countries are accounted for, both the direct and interactive relationships weaken considerably, underscoring how difficult it is to isolate climate effects from country-specific social, political, and economic factors that drive conflict risk.

In sub-Saharan Africa, distinct dynamics emerge, with the interaction between heightened seasonality and population growth substantially greater than at the global level. Unlike the global results, shifts in rainfall seasonality alone do not appear to drive higher conflict risks in the region. But where rainfall seasonality is worsening and population growth is rapid – above about two to three per cent per year – the likelihood of conflict rises markedly. In these high-growth settings, the effect of more erratic rainfall shifts from neutral or even negative to clearly positive. The analysis indicates that in areas with the fastest demographic expansion, more seasonal rainfall can make conflicts far more lethal – adding roughly six additional deaths per year for every 100,000 people. As with the global results, the sub-Saharan Africa models show that country-specific political and social conditions remain the decisive factors. Yet within the region, the evidence points to a threshold effect: rapid demographic growth magnifies the destabilising effects of more seasonal and unpredictable rainfall.

While most of sub-Saharan Africa has seen rainfall become increasingly seasonal over the past two decades, there are notable exceptions. A handful of countries – including Somalia (particularly the contested lands of Somaliland), Zambia, and Malawi – have registered declines in rainfall seasonality. These shifts mean that rains in these places have become more evenly distributed throughout the year, easing the pressure that comes with extreme wet and dry cycles. In the broader African context, where heightened seasonality has been linked with food insecurity and elevated conflict risk, these areas stand out as places of relative climatic improvement.

The magnitude of the change is also significant. In several subnational areas within these countries, rainfall seasonality has fallen by more than five per cent. This is substantial, given the slow-moving nature of climatic systems and the fact that most regional changes worldwide are only marginal. Such declines suggest that these areas are not only diverging from continental trends but may also enjoy an important buffer against some of the volatility observed elsewhere in Africa. Because rainfall regimes shape ecosystems, agriculture, and pastoral systems across wide geographic areas, even modest improvements in predictability can translate into meaningful gains for local resilience.

These conditions position parts of Somaliland, Zambia, and Malawi as potential sites for investment in resilience-building, development, and conflict prevention. In contexts where other ecological and social pressures are acute, improvements in rainfall stability can help sustain livelihoods, reinforce food security, and reduce the likelihood of localised violence. By prioritising support to these areas, policymakers and development partners may be able to amplify positive climatic shifts, helping to consolidate gains and demonstrate what can be achieved when environmental and social factors align more favourably. In this sense, these subnational improvements are not just anomalies, but opportunities for charting a more stable and prosperous path forward.

“

At the global level, places where rainfall has become more seasonal also tend to experience more deadly conflict, even after taking into account factors like population density.

Rainfall, Food Insecurity and Conflict in the Karamoja Cluster

Among the non-desert regions of sub-Saharan Africa, the Karamoja Cluster in East Africa has experienced the greatest increases in rainfall seasonality since 2005, as seen in the map in Figure 2.5. The Karamoja Cluster – particularly Turkana County in Kenya – has had relatively stable levels of annual rainfall, but its distribution, intensity, and timing have changed. These climatic shifts are making rainfall more erratic, intensifying both drought and flood risks.

Because of these dynamics, the Karamoja Cluster offers a particularly revealing lens into how shifting rainfall patterns interact with fragile livelihoods and long-standing social tensions. The region's extensive reliance on agropastoral and pastoral systems makes it highly sensitive to changes in the timing and distribution of rainfall. Scarce resources such as water, arable land, and livestock are already central to community survival, and shifts in rainfall patterns intensify competition over them. This has historically fuelled cycles of violence, from cattle raiding to wider intercommunal clashes, meaning the impacts of rising seasonality are felt not only through food insecurity but also through security risks.

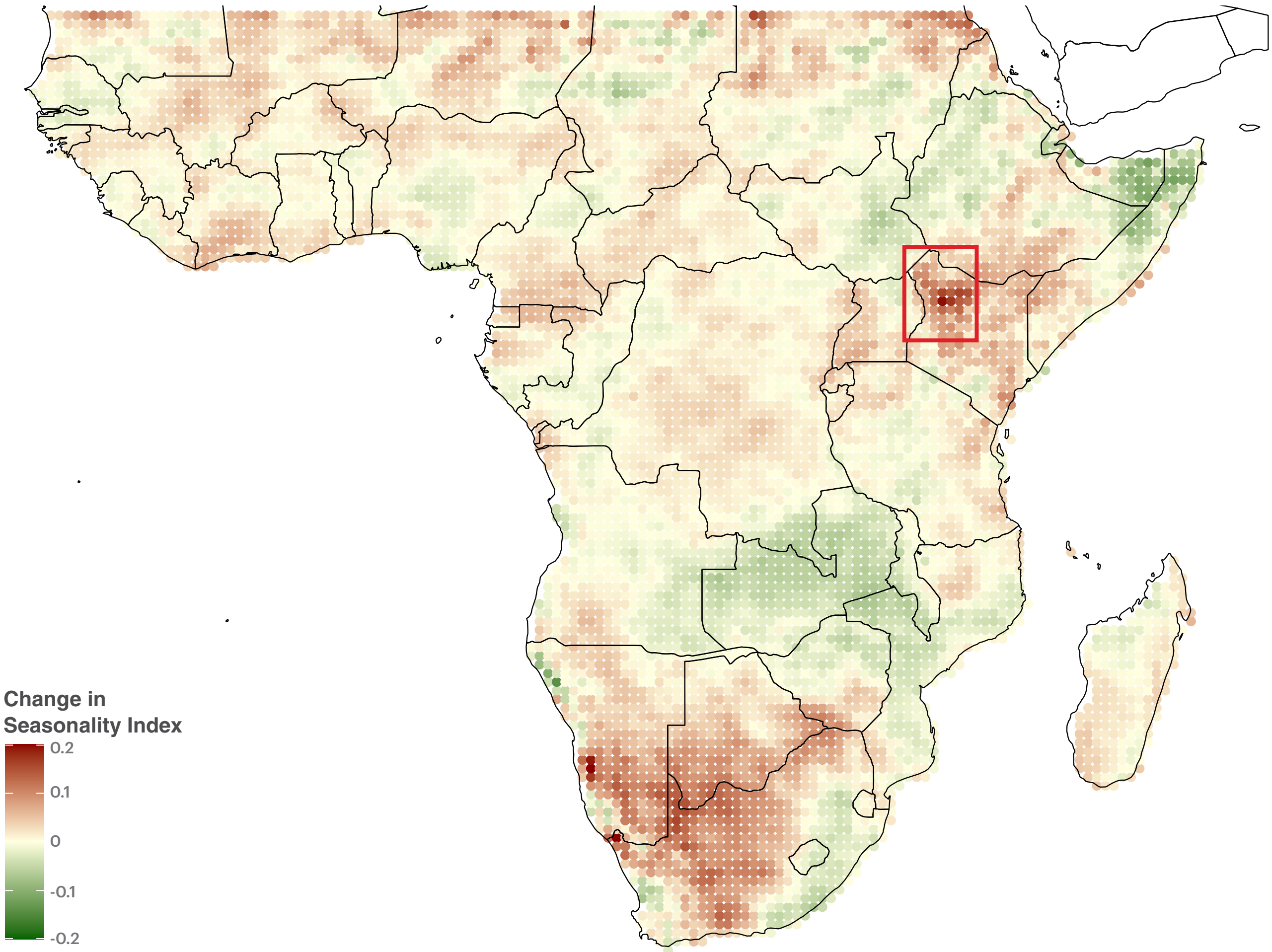
Across East Africa, steady rainfall is essential for maintaining vegetation health and quality, a key contributor to both pastoralism and agriculture. Higher vegetation health, measured by the Normalised Difference Vegetation Index (NDVI), is positively correlated with food security. Specifically, a ten per cent increase in NDVI in East Africa was found to decrease the likelihood of household food insecurity by 12 per cent, to decrease primary caregivers missing meals by seven per cent, and to reduce the number of days in which children did not eat by six per cent.[13]

Within pastoralist communities, it was directly correlated with an 18 per cent increase in lactating livestock and a 23 per cent rise in milk production. Vegetation health and rainfall have also been linked to changes in conflict risk. In East Africa, a 0.2-point increase in NDVI was associated with a 12 per cent decline in the likelihood of physical conflict in the following month.[14]

FIGURE 2.5

Change in seasonality in sub-Saharan Africa, 2020–2025 vs 2005–2010

In the Karamoja Cluster in East Africa, rainfall is becoming increasingly concentrated in fewer months of the year.



Source: CHIRPS, IEP

Furthermore, areas that received an additional inch of rainfall saw eight per cent reductions in the likelihood of conflict in the following month.

The Karamoja Cluster is a semi-arid cross-border region that is centred on northeastern Uganda and northwestern Kenya, with extensions into southeastern South Sudan and southwestern Ethiopia.[15] It is home to an estimated 4.5 million people. Distinct agroecological conditions within the region support some large-scale agriculture, although agropastoralism, a livelihood combining sedentary farming and herding, is more common. Pastoralism is the prevailing livelihood among certain ethnic groups, such as the Karamojong, Turkana, Pokot, Jie, Topotha, and Nyangatom.

FIGURE 2.6

Map of the Karamoja Cluster

The cluster stretches across parts of Uganda, Kenya, Ethiopia, and South Sudan.

Source: FAO

Neighbouring pastoral communities in the Karamoja Cluster share similar language, lineage, and many traditions. For centuries, relations between groups have been complex and dynamic, with cattle raiding representing a longstanding form of inter-group competition. Cattle raiding was also embedded in social life, especially for young men whose status and identity have been tied to courage, skill in livestock husbandry, and success in the bush. In many pastoral societies, cattle raiding has historically functioned as a way to redistribute wealth – particularly in the aftermath of drought, livestock disease, or previous raids. In Karamoja, raids traditionally followed established customs and often reciprocal patterns rather than wanton warfare. Before firearms became widespread, raids tended to be planned and constrained by rules set by elders, with fighters observing ritualised practices and prohibitions on harming women, children, and the elderly, which helped limit casualties.[16]

Some of these guardrails were disrupted during the colonial era and into statehood, as a result of more lethal weaponry and new administrative practices. Colonial authorities attempted to contain raiding and weapons flows with security and political measures, but these moves often clashed with seniority-based authority and did not durably curb violence. After independence, the practice evolved significantly following the 1979 collapse of Idi Amin's regime in Uganda, when the proliferation of small arms escalated both the frequency and lethality of cattle raids, causing thousands of deaths in the late twentieth century.[17] Such raids increasingly violated traditional taboos.[18]

In the 2000s, violence remained extreme, with studies showing that raiding was the leading cause of adult male mortality. The severity was linked to fractured alliances, erosion of elder control, and weak state governance. As of 2005, the intensity of small arms violence within Karamoja led to an estimated *homicide rate* of 60 deaths per 100,000 people. Between 2003 and 2008, there were more than 1,600 recorded incidents of communal violent conflict and over 2,800 deaths.[19]

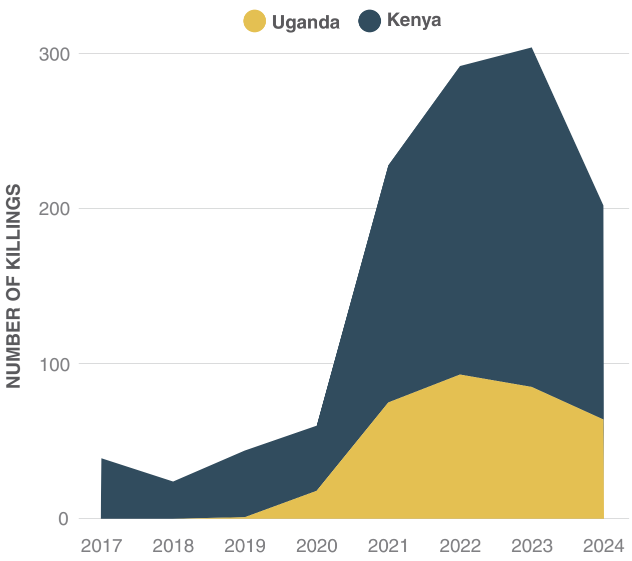
However, the period from 2010 to 2019 is considered a time of relative peace. In 2010, the Ugandan government enacted the Karamoja Integrated Disarmament and Development Programme, which improved security for communities and traders, and increased investment in infrastructure such as roads, electricity, and irrigation.[20] Security improvements restored mobility and markets, and locally forged resolutions and rules re-empowered elders to sanction youth and deter theft.

However, since 2019, violent incidents have resurged, with organised thefts, road ambushes, and gun deaths all increasing. Climatic extremes, including a severe drought in 2017 and devastating floods in 2018, caused significant losses to livestock and disrupted regional food systems.[21] This instability aggravated regional tension and incited conflicts which killed hundreds of people in the following years, as seen in Figure 2.7. It also resulted in more than 30,000 arrests during state security operations.[22]

FIGURE 2.7

Killings attributed to pastoralist groups, Kenya and Uganda, 2017–2024

There was a sharp increase in recorded killings after 2019.



Source: ACLED

The renewed violence of the 2020s has also been linked to the growing commercialisation of raiding, with stolen animals moved rapidly into markets and profits retained by raiders rather than distributed through customary channels. There have also been rising disputes over minerals and land that have shifted authority away from elders and opened space for external actors, which has been compounded by the breakdown of cross-border agreements and abuses by security forces.[23]

Among Karamoja's pastoralist communities, national borders have limited significance, having been drawn across long-standing ethnic territories. Nonetheless, these boundaries have influenced communal mobility, with many attributing the resurgence of violence to increased migration of Turkana herders from Kenya seeking water and pasture amid shortages on the Kenyan side of the border. This transboundary movement is particularly impactful within Uganda. This migration was long regulated by a Memorandum of Understanding between Kenya and Uganda, but the collapse of the agreement has reignited competition between rural communities over control of scarce natural resources.[24]

Climate Stressors and Rainfall Seasonality in Karamoja

As discussed above, significant changes in rainfall patterns have been repeatedly found to intensify existing tensions within conflict-affected areas.[25] These effects are most acute in regions dependent upon rain-fed agriculture and pastoralism, such as East Africa, where irrigation infrastructure and resilience to rainfall shocks is limited.

Five consecutive failed rainy seasons between 2020 and 2022 greatly undermined pastoral livelihoods, leaving nearly 120 million people across eastern Africa in acute food insecurity and forcing widespread reliance on relief grain.[26] These droughts highlight the risk of imposing sedentary agriculture in environments where rainfall seasonality is highly variable and infrastructure to support irrigation or soil management is minimal.

Across the four countries with lands in the Karamoja Cluster, only about 1.8 per cent of the cultivated land is equipped for irrigation, with even less in functional use, as shown in Table 2.1.[27] The lack of resilient infrastructure makes Karamoja's ecological and economic systems highly sensitive to rainfall deviations. This is particularly evident in arid and semi-arid lands, most notably in the Kenyan districts of Marsabit, Isiolo, and Turkana, which face some of the worst ETR water risk scores in the country.

In Kenya and Ethiopia, over 25 per cent of national freshwater resources are withdrawn by the agricultural sector.[28] This means that delayed onset or early cessations of rainy seasons can greatly reduce the availability of pasture and water, forcing displacement and heightening resource competition. This has placed significant stress on available freshwater resources in the lowlands and driven many communities into the Lake Victoria Basin for more consistent rainfall. Once a traditional adaptive strategy, such migration has increasingly become involuntary, fuelling intercommunal tensions with the receiving populations.

Between 2020 and 2022, droughts across the Horn of Africa caused the deaths of 9.5 million livestock and displaced 1.7 million people.[29] In Kenya, 74 per cent of the country was drought-affected, forcing over one million people to abandon pastoralist lifestyles.[30] Projections indicate that climate impacts could displace up to 38.5 million people from arid and semi-arid zones in eastern Africa, with a substantial proportion of this movement directed toward the Lake Victoria Basin.[31] This shift is expected to place a substantial strain on host communities, deepening existing socioeconomic vulnerabilities, raising food prices, and intensifying regional food insecurity.

FOOD INSECURITY AND CONFLICT RISK

Rainfall variability and migration have contributed to rising food insecurity across eastern Africa. Between 2022 and 2024, 64.6 per cent of the population faced moderate to severe food insecurity, as seen in Figure 2.8.[32] Moreover, since the 2017 drought, more than 25 per cent of the population has been considered undernourished. Within the Karamoja region, these rates are far higher, especially in South Sudan, which ranks as the second highest risk country in food security score.

TABLE 2.1

Prevalence of irrigation in select East African countries, 2021

There are very low rates of irrigation across East Africa, particularly in Uganda.

	Total cultivated area (thousands of hectares)	Total area irrigated (thousands of hectares)	Percentage of cultivated area that is irrigated
Kenya	6,410	97	1.5%
Uganda	9,100	11	0.1%
Ethiopia	18,595	539*	2.9%*
South Sudan	2,480	12*	0.5%*
Four-country totals	**36,585**	**659**	**1.8%***

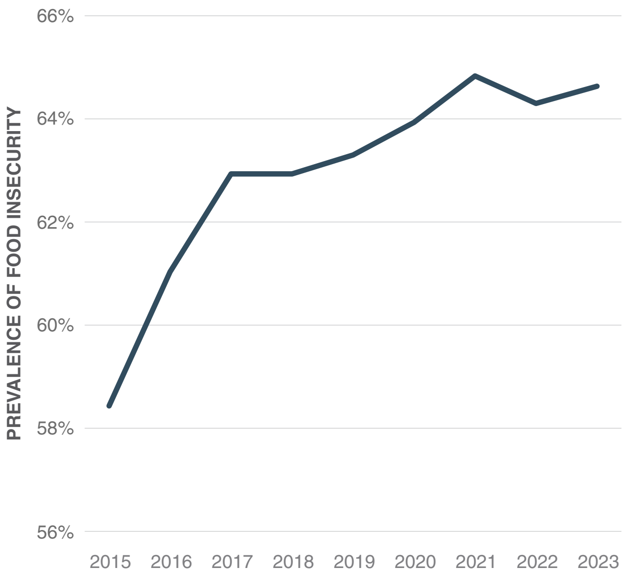
Source: FAO, IEP

Notes: The figures on the cultivated land that is irrigated for Ethiopia and South Sudan are imputed (based on their percentages of cultivated land *equipped* for irrigation and the continental average of the percentage of land equipped for irrigation that is actually irrigated).

FIGURE 2.8

Prevalence of food insecurity in East Africa, three-year averages, 2015–2023

The share of the population experiencing moderate to severe food insecurity has been steadily increasing in East Africa.



Source: FAO

Growing food insecurity in the region has been driven in part by climatic and migratory pressures, which have compounded to drive up regional food prices. From 2015 to 2017, El Niño-driven drought gravely disrupted crop cultivation across the Horn of Africa, with the number of severely food-insecure people increasing by over 20 million.[33] Drought conditions have been found to cut livestock values and raise cereal prices across Africa by 4.4 per cent.[34] In the context of drought in 2017, cattle prices in eastern Africa fell by nearly half, and the value of sheep and goats dropped to one-third of their original price.[35]

Between 2016 and 2020, the poverty rate in Karamoja rose from 60.8 per cent to 65.7 per cent, reflecting the erosion of livestock-based income.[36] Such declines are significant, as improvements in livestock health generally lower the price of staple food commodities and strengthen the purchasing power of pastoral households. This, in turn, can help prevent communities from resorting to violence when food becomes scarce or unaffordable. An evaluation of more than one hundred subnational market areas across Africa over more than a ten-year period, found that a doubling of food prices in a given market was linked with a 13 per cent rise in the number of conflict occurrences in the area one year later.[37]

Purely pastoralist populations are disproportionately affected by below-average rainfall, as their incomes depend almost entirely on livestock. As 50 to 70 per cent of pastoral incomes are put towards their diet, if low rainfall weakens livestock, that can drastically reduce food security for those communities.[38] Additionally, their wealth is generally measured in livestock; it is their form of savings and such groups rarely use traditional monetary banking systems. Specifically, 12 months of below-average rainfall increases the risk of "emergency" food insecurity levels for pastoral regions from 13 per cent to 36 per cent.[39] While agropastoralist communities are also impacted, they are generally better able to adapt to food shortages by diversifying their food sources.

In addition to droughts, external shocks in recent years, including the COVID-19 pandemic and Russia-Ukraine war, have further raised the price of wheat and other staple commodities. From 2017 to 2024, the cost of a healthy diet in eastern Africa rose by about 44 per cent, from US$3.11 to US$4.48 per day, pushing the number of people unable to afford such a diet to 365.5 million, an increase of 57.8 million.[40]

STABILITY AND RESILIENCE THROUGH AGROPASTORALISM

Rural communities across the Karamoja Cluster, particularly purely pastoralist communities, are under growing strain from prolonged droughts, shrinking rangelands, population growth and migration pressures. Influxes of displaced populations across the borders of South Sudan, Kenya, Uganda, and Ethiopia have heightened competition over water and pasture, fuelling localised violence. In some contexts, diversification into agropastoralism offers a potential pathway to greater stability.

By combining seasonal crop cultivation with livestock rearing, households can reduce their dependence on grazing and enhance their resilience to climate shocks. Evidence from Tanzania suggests that by planting during the short rainy seasons, households can increase their lean-season food security and reduce hunger before the next harvest.[41] However, many of the pastoralists are seminomadic and crop cultivation means a sedentary lifestyle, meaning the shift is difficult to achieve.

Short planting seasons can also support the cultivation of cash crops, offering households an economic buffer in times of food insecurity. While cash crops such as sugarcane can provide financial benefits, prioritising staple crop production is necessary for ensuring household food security before expanding commercial agriculture.

Within the pastoralist communities, there is often resistance to sending children to school. Families move semi-nomadically while schools are in fixed locations, and the children who attend schools may not attain vital cattle husbandry skills. This can make them less valuable in the eyes of their communities, less likely to find a partner, and therefore more prone to migrating to cities.[42] In Turkana County, Kenya, only around 20 per cent of the population has ever attended school, and just half of school-age children are enrolled in formal education (53.2 per cent for boys and 46.6 per cent for girls), compared to a national average of 92.5 per cent.[43] Furthermore, in Uganda's Karamoja region, only 25 per cent of the population is literate.[44] Such gaps in education limit economic mobility and heighten vulnerability to food insecurity and undernourishment.

Enabling a sustainable transition from purely pastoral to agropastoral livelihoods faces major challenges. The cultural challenges are significant, with thousand-year traditions of cattle management, group identification and self-worth based around cattle, and a strong distrust of government. Government would need to ensure rural communities have reliable access to freshwater sources, agricultural tools, and arable land, but such investments would be extremely difficult for the resource-constrained governments in the region. International organisations such as the World Bank have channelled more than US$500 million into agricultural development in eastern Africa over the past two decades,[45] but national distribution programs have often fallen short. In 2022, nearly US$4 billion was committed to support rural resilience in East Africa, yet only about US$2.1 billion was disbursed, as seen in Figure 2.9, undermining the potential for lasting change.

Trends Across Countries of the Karamoja Cluster

UGANDA

Uganda's Karamoja sub-region, covering over 11 per cent of the national territory, is home to the largest share of the population of the wider Karamoja Cluster.[46] In Uganda, nearly three-quarters of the population is employed in the agricultural sector, which accounts for 20 per cent of GDP and 48 per cent of the total earnings from exports.[47] Yet, food security indicators remain concerning. More than 22 per cent of the country is undernourished,[48] despite a nine percentage-point improvement since 2020, as seen in Figure 2.10.

Uganda's recent improvements in food security make it an outlier in East Africa.[49] Recent reports have noted upticks in yields and livestock productivity,[50] but its current trajectory also represents a return to its previous levels of food insecurity, prior to the droughts of the late 2010s. Despite recent improvements, substantial vulnerability persists across many districts. Last year, all of Uganda's districts recorded high levels of risk in the ETR's food security indicator.

Such risks are particularly high within the pastoral communities of Uganda's Karamoja region, where every eight in ten households is affected by food insecurity.[51] The ETR's country analysis shows that the districts of Kotido, Moroto, and Nakapiripirit in Karamoja face very high-risk levels of demographic pressure and rank as the three most at-risk districts for food insecurity in Uganda.

Population pressures will further intensify these risks. Uganda ranks second globally for demographic pressure and is projected to add more than 40 million people by 2050. The impacts will be most acute in already-stressed areas such as Karamoja, where subnational districts are expected to grow by roughly three-quarters, representing an increase of more than 700,000 people.

Within Karamoja, Ugandan government initiatives sought to "modernise" by converting Karamojong pastoralist and warriors into farmers. During the 1970s and 1980s, valley tanks were constructed to support crop farming but many of these failed due to siltation, poor maintenance, and the continued reliance on migratory movements which led to overgrazing.[52]

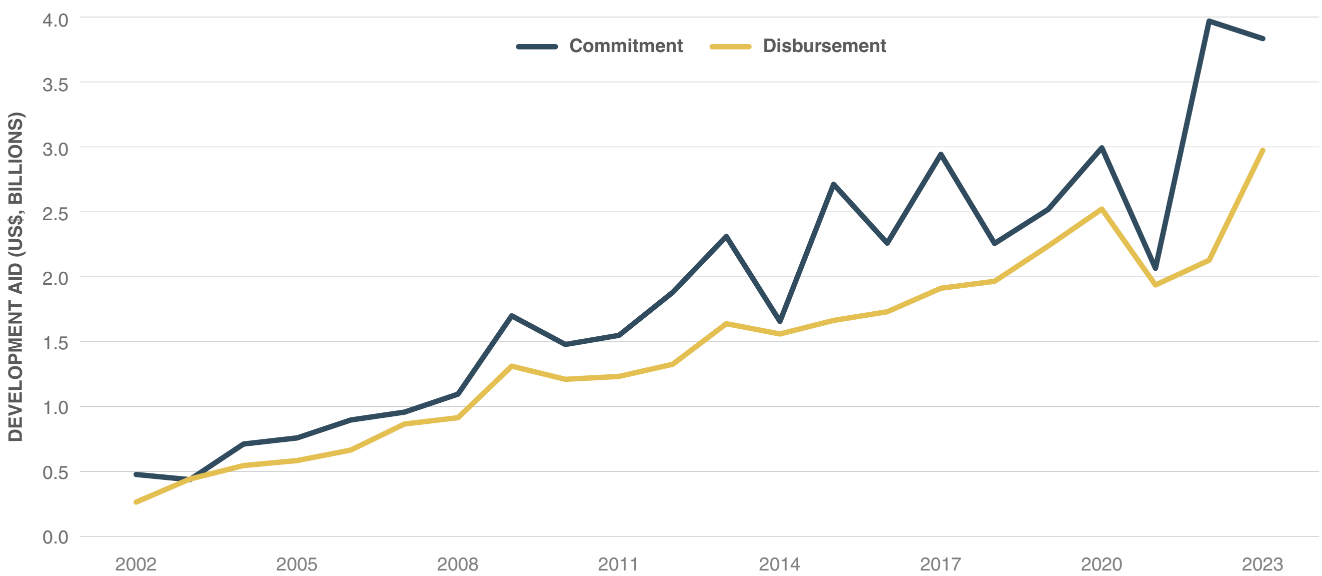
Over time, however, changing climate conditions and new government initiatives further reshaped pastoralist livelihoods and land use. Satellite imagery analysis reveals a 299 per cent increase in cropland area in Karamoja between 2000 and 2011, with Moroto District alone expanding from roughly 700 hectares to over 23,000 hectares under cultivation.[53] This transformation was largely driven by government-led programs promoting sedentary agriculture, which was rooted in the perception that pastoralism was economically unproductive.

While the expansion of cultivated land in the 2000s was rapid, it proved unsustainable. By 2017, over half of the fields opened in Karamoja had been abandoned or left fallow due to poor yields, lack of inputs, and limited market access.[54] Pastoralism continues

FIGURE 2.9

Total development aid to agriculture in East Africa, committed and disbursed, 2002–2023

Disparities between the commitment and disbursement of aid were most severe in 2022.

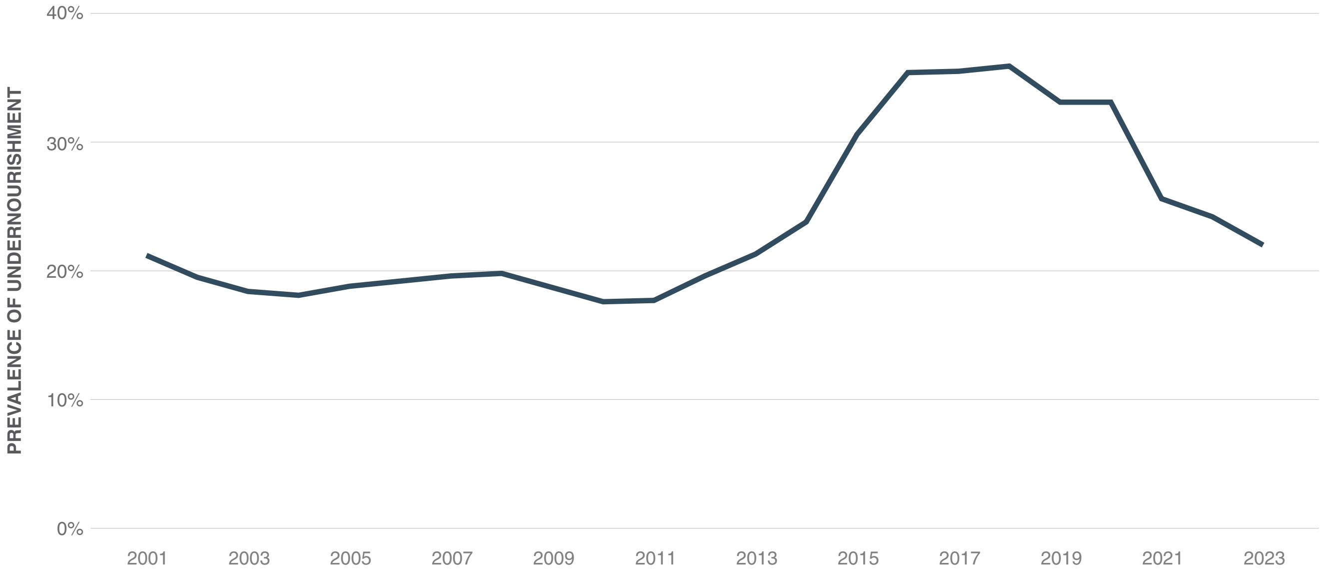


Source: FAO

FIGURE 2.10

Undernourishment in Uganda, three-year averages, 2001–2023

Undernourishment rose substantially in the late 2010s. Though rates have almost returned to their earlier levels, they continue to be high.



Source: FAO

to dominate in the semi-arid zones of Karamoja, where mobility remains essential for accessing pasture and water. However, this mobility has become increasingly constrained, with nearly 62 per cent of the land in Karamoja designated for exploration and mining by government and private actors.[55]

Agropastoralism remains limited in Uganda's Karamoja areas, with only around ten per cent of households in the Napak mountains and 30 per cent region-wide engaged in mixed crop-livestock production.[56] Harsh climate conditions and erratic rainfall limit large-scale agricultural production, with the region contributing only about 2.2 per cent of Uganda's national cereal production.[57] Most seasonal farmers have relocated to the region's "green belt" within the Lake Victoria Basin, where rainfall patterns are more favourable for cultivation.

Current climate conditions in Uganda reflect the country's exposure to thermodynamic shifts that have made rainfall distribution increasingly erratic. Central and western Uganda were particular hotspots of food insecurity, experiencing exceptionally poor rainfall during April and May 2025, likely disrupting yields of key crops such as plantains, cassava, and maize.[58] In contrast, eastern Uganda, including parts of Karamoja, received average to slightly above-average rainfall, partially insulating it from broader national production deficits. Karamoja's strengthened resilience is reflected in notable improvements in its ecological threat score, particularly in water risk, where three of its districts (Kotido, Moroto, and Nakapiripirit) recorded the highest improvements across Uganda. This is expected to support greater sugar cane production in the humid regions of eastern Uganda and raw cow's milk production in Karamoja.

The uneven nature of these outcomes highlights the vulnerability of Uganda's agriculture to shifts in rainfall timing and distribution. This is of particular concern given the influx of migrants into Uganda, which has placed significant strain on refugee-hosting districts. The added migration pressures from neighbouring countries are likely to intensify an already precarious regional food security situation, and in the absence of effective government support, the population in crisis levels of food insecurity is projected to rise from 797,000 to over 950,000.[59]

KENYA

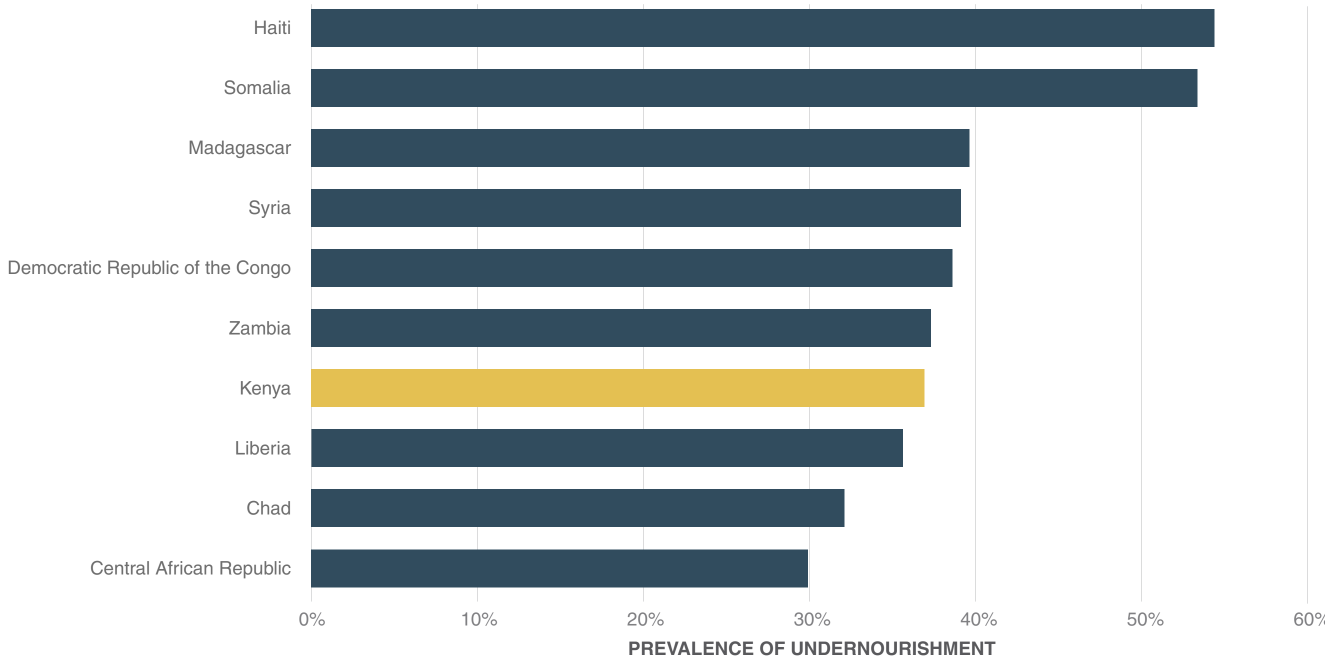
Kenya's arid and semi-arid lands cover 88 per cent of the national territory and sustain roughly 70 per cent of the country's livestock.[60] These areas are often highly food insecure with recurrent droughts undermining both pastoral and agropastoral systems. Kenya is ranked at a high risk of food insecurity in the 2025 ETR, with around 36.8 per cent of the population undernourished, the seventh highest rate globally (as seen in Figure 2.11), up from just 21 per cent in 2015.[61] Affordability has also deteriorated, with around 43 million people now unable to afford a healthy diet.[62] With the majority located in the arid and semi-arid lands of Kenya's lowlands, especially in Turkana County within the Karamoja Cluster, where more than 77 per cent of the population lives below the national poverty line.[63]

Turkana County's population is projected to grow by 42 per cent in the next 25 years, one of Kenya's highest population growth rates and well above the national average. As such, concerns regarding food security are likely to deepen. Driven largely by inflows from South Sudan and Somalia, the Kakuma refugee camp in Turkana has hosted over 200,000 people, ranking among the five largest refugee camps worldwide.[64] Overcrowding in the camp has long strained scarce resources and critical infrastructure in Turkana County, elevating the risk of food insecurity across the region.

FIGURE 2.11

Ten highest undernourishment rates in the world, 2024

The percentage of Kenya's population considered undernourished has increased significantly since 2016, leading to the seventh highest rate globally last year.



Source: FAO

Historically, Kenyan policies have favoured sedentarisation and land privatisation, often at the expense of pastoral mobility. In 2019, Kenya and Uganda signed a reciprocal grazing agreement, allowing Turkana herders legal access to pastures and the Kobebe dam in Uganda's Karamoja region.[65] While this temporarily eased pressure on Turkana rangelands, its implementation has been hindered by governance gaps and shifting security conditions. Specifically, due to a resurgence of violence within Karamoja which has constrained government efforts to sustain the agreement of shared cross-border resources.

In northwest Kenya, recent dry spells have accelerated the cross-border movement of Turkana pastoralists into Karamoja, heightening tensions with the Karamojong over shared water points and pasture. These dry spells have heightened water scarcity in several arid districts of the Karamoja Cluster, including Marsabit, Isiolo, and Turkana, which face some of the highest water risks in Kenya.

This situation is further complicated by the expansion of wildlife conservancies and large-scale infrastructure and energy projects, such as the Lake Turkana Wind Power Park, which have hindered access to essential freshwater sources.[66] Wildlife conservancies now cover 11 per cent of Kenya's landmass, with the largest concentration in the lowlands of the northern districts.[67] Many of these areas prohibit grazing and are patrolled by armed rangers, which, in some cases, have become flashpoints for local disputes. These developments have constrained pastoralist mobility, reduced access to vital grazing corridors, and altered traditional migration routes.

To cope with worsening rainfall variability and government pressure, some Turkana households have shifted toward agropastoralism, settling along the Turkwel and Kerio rivers to cultivate sorghum, maize, and vegetables while maintaining smaller herds of livestock.[68] Many marginalized households have also started to supplement small-scale pastoralism with charcoal burning and selling of firewood, enabling them to meet basic needs when grazing conditions are poor.[69]

This diversification, supported by government-led irrigation projects and urban growth, has allowed some communities to make use of short rainy seasons and natural resources to reduce their reliance on livestock. Importantly, these initiatives demonstrate a wider abandonment of pastoralist livelihoods due to the combined pressures of climate stress, land-use change, and policy interventions.

Despite these challenges, current conditions are relatively favourable. Above-average rainfall across most arid and semiarid counties throughout April and May 2025 have supported strong crop growth and vegetation cover.[70] This is expected to result in favourable yields for two of Kenya's major commodities, sugar cane and maize. Livestock body conditions are also reported to be generally good, particularly in southwestern Kenya, which is likely to sustain the recent gains in raw milk of cattle production.[71]

Nonetheless, the structural vulnerabilities of arid and semi-arid communities, particularly their dependence on seasonal rains, limited irrigation infrastructure, and restricted mobility, mean that favourable conditions remain fragile and could be quickly reversed by the next climatic shock. Currently, an estimated 292,000 people are experiencing emergency levels of food insecurity, with a further 2.5 million in crisis levels.[72] Much of this insecurity is concentrated within four arid counties along Kenya's northern border: Turkana, Mandera, Wajir, and Marsabit. Targeted government investments could help expand viable irrigation systems which would support more diverse income and food sources to help reduce the exposure of these communities to increasingly unpredictable rainfall patterns.

ETHIOPIA

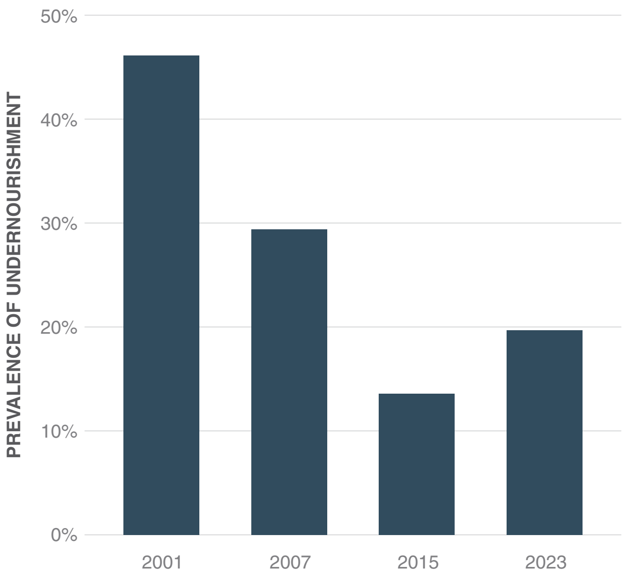
Ethiopia's national food security indicators highlight both progress and ongoing vulnerabilities. While the share of Ethiopia's population that is undernourished has declined from 46 per cent in 2000 to just around 20 per cent in recent years, as seen in Figure 2.12, the country still ranks as the 15th highest globally for food insecurity. Over the past five years, food security has deteriorated significantly, coinciding with the escalation of the Tigray conflict in the north, although its full impact has yet to become fully evident.[73] Affordability remains a significant barrier: between 2019 and 2022, the cost of a healthy diet rose from USD 2.99 to USD 3.72 per day, and in 2022 over half of the population (about 68 million people) could not afford such a diet.[74]

Escalating conflict in Ethiopia's northwestern region has strained the country's limited capacity to accommodate refugees and internally displaced persons. Especially as demographic growth remains high: the Southern Nations federal region of Ethiopia, within the Karamoja Cluster, is projected to record the third-fastest population growth nationally, an increase of more than nine million people by 2050, representing nearly a fifth of Ethiopia's entire projected population growth.

FIGURE 2.12

Undernourishment in Ethiopia, 2001–2023

Ethiopia has more than halved its levels of undernourishment since 2000.



Source: GHI

In Ethiopia's Lower Omo Valley, home to around 200,000 people, pastoral communities such as the Nyangatom, Dassanech, and Mursi have undergone profound livelihood changes in recent years.[75] The completion of the Gibe III Dam on the Omo River in 2016 ended the seasonal flooding that had sustained traditional flood-retreat agriculture for generations.[76] This displaced many communities in the floodplains of southern Ethiopia and affected those dependent upon the annual downstream floods to the Lake Turkana Basin. The loss of this inflow threatens the livelihoods of more than half a million people reliant on the Omo River's natural flood cycle.[77] These displacements and ecological impacts risk worsening existing tensions between neighbouring ethnic groups over scarce natural resources.

For the Nyangatom and Dassanech in particular, the completion of the dam marked a decisive shift away from flood-retreat farming toward greater reliance on flood-based cultivation along the riverbanks. Land-use change has further reduced the resilience of South Omo's pastoral systems. Five national parks have been established on traditional grazing lands, displacing pastoralists and restricting access to pasture.[78] State-led development projects have also hindered pastoral mobility. For example, the Kuraz Sugar Development project in the Omo River Basin, which is one of the largest agricultural development schemes ever to be launched by the Ethiopian government, has displaced Dassanech and Nyangatom families from their floodplain plots to make way for sugar cane plantations.

As mobility and access to key grazing areas is restricted, the timing and distribution of rainfall have become increasingly critical for South Omo's pastoralists. In 2024, the two rainfall seasons, known locally as the Belg rains and the Kiremt rains, in western and southwestern Ethiopia brought close-to-average rainfall, supporting crop and pasture conditions for the South Omo region.

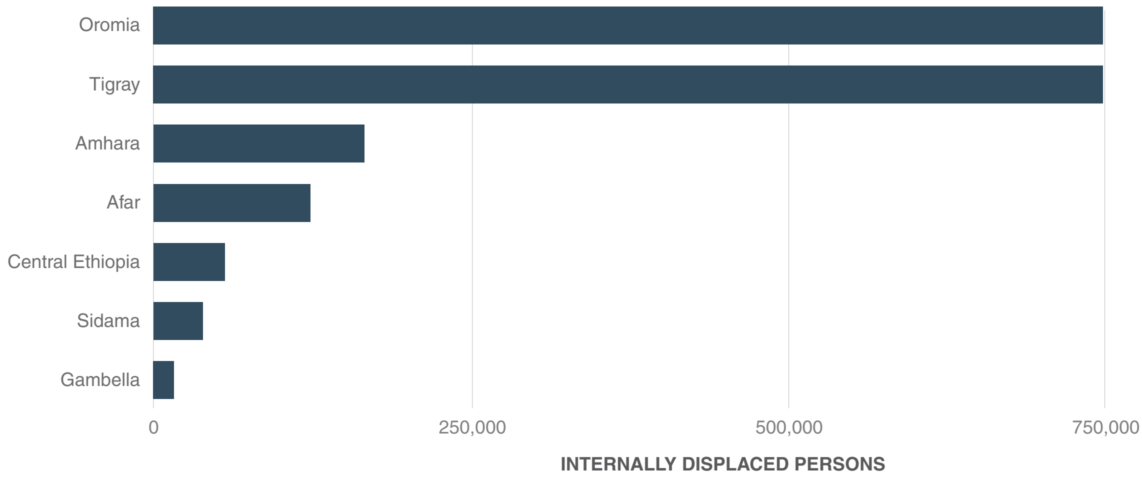
However, in the northwest, rainfall deficits of up to 40 per cent combined with high temperatures to delay crop growth and degrade pastoral vegetation, creating a hotspot of food insecurity.[79] These deficits are particularly concerning in the Amhara district, which faces high food and water threat levels, recording the worst ETR score in the country for food insecurity and the fifth worst score for water risk. Given Ethiopia's high-water stress of 33 per cent, an indicator of the pressure on limited freshwater resources, and its ranking as the fourth highest risk country in impact of natural events, rainfall deficits are likely to exacerbate food insecurity across the country.[80]

Poor rangeland conditions in the northern territories also heighten the risk of displacement, as households are forced to move in search of water and forage. As of 2024, more than 1.9 million people were internally displaced within Ethiopia, with nearly half originating from the northern regions of Amhara and Tigray, as seen in Figure 2.13.[81] Movements in response to these climatic pressures have compounded the displacement crisis already driven by *ongoing conflict*s in Amhara and Tigray. This continued influx is placing additional strain on the security and limited resources of pastoral communities in the Southern Nations federal region of Ethiopia, which already face some of the highest levels of demographic pressure in the country.

FIGURE 2.13

Internally Displaced Persons (IDPs) in Ethiopia, by selected regions of origin, 2024

The largest populations of IDPs were displaced from the states of Oromia and Tigray.



Source: IOM

In South Omo, pastoral vulnerability is shaped by a convergence of climatic and non-climatic factors. The loss of flood-retreat agriculture, expansion of protected areas, and conversion of land for commercial agriculture have all constrained adaptive mobility and reduced livelihood diversity. These pressures amplify the impact of rainfall variability on both food and income security, leaving communities more reliant on short-term relief interventions and increasingly exposed to the risk of displacement and localised conflict. This is especially critical in areas of Ethiopia suffering from acute food insecurity, where more than 400,000 people are experiencing catastrophe and famine level conditions.[82]

SOUTH SUDAN

Amid protracted conflicts and societal instability, South Sudan has consistently ranked among the most food insecure countries in the world. In the 2025 ETR, it is assessed as the second highest-risk country for food security. Between 2022 and 2024, the cost of a healthy diet had its sharpest increase going from US$4.09 to US$8.39 per day.[83] Over this same period, the share of the population unable to afford a healthy diet has jumped from 91.8 to 97.8 per cent, equating to 11.7 million people as of 2024. As a result, child mortality rates are among the highest in the world, at nearly 99 deaths per 1,000 live births (Figure 2.14).[84]

This is particularly concerning in South Sudan's Eastern Equatoria region, which has received much of the population inflow from the conflict in Sudan. The region's population is projected to increase by more than 38 per cent by 2050, the second highest growth rate nationwide, placing significant strain on regional food security, especially among host communities.

In the southeastern Kapoeta region, which forms part of the Karamoja Cluster and is home to the Toposa people, recurring droughts and unpredictable rainfall have reduced pasture availability and heightened vulnerability to food insecurity. The wider Eastern Equatoria region recorded the country's highest overall ETR risk in 2024, as well as its greatest deterioration in score since 2019, driven primarily by rising risks from impact of natural events. In response to this growing hunger crisis, NGOs have introduced school gardens in settlements, providing seeds, tools, and training to diversify food sources. More than 90 per cent of the produce from these gardens was used to support student meals, reducing the proportion of students with inadequate food consumption from around 71 per cent to 32 per cent.[85]

Alongside the FAO, the Dutch government funded US$28 million to the "Food and Nutrition Security Resilience Programme" to address the links between food insecurity and conflict in conflict-affected areas of eastern Africa.[86] In South Sudan, the project focused on distributing agricultural inputs and strengthening local production capacity; however, nearly 85 per cent of all certified seeds in the country are still imported. While these initiatives offer important livelihood diversification opportunities, their long-term impact is limited by the broader security environment, as persistent conflict continues to disrupt agricultural activities, limit mobility, and hinder market access.

Conflict remains a central driver of food insecurity. Violence along the Sudan–South Sudan border, particularly following the eruption of civil war in Sudan in 2022, has prompted an influx of refugees and asylum seekers into southern regions. Food insecurity has been further exacerbated by below-average rainfall in northwestern South Sudan, which has stressed vegetation, reducing forage for livestock and constraining crop growth.[87]

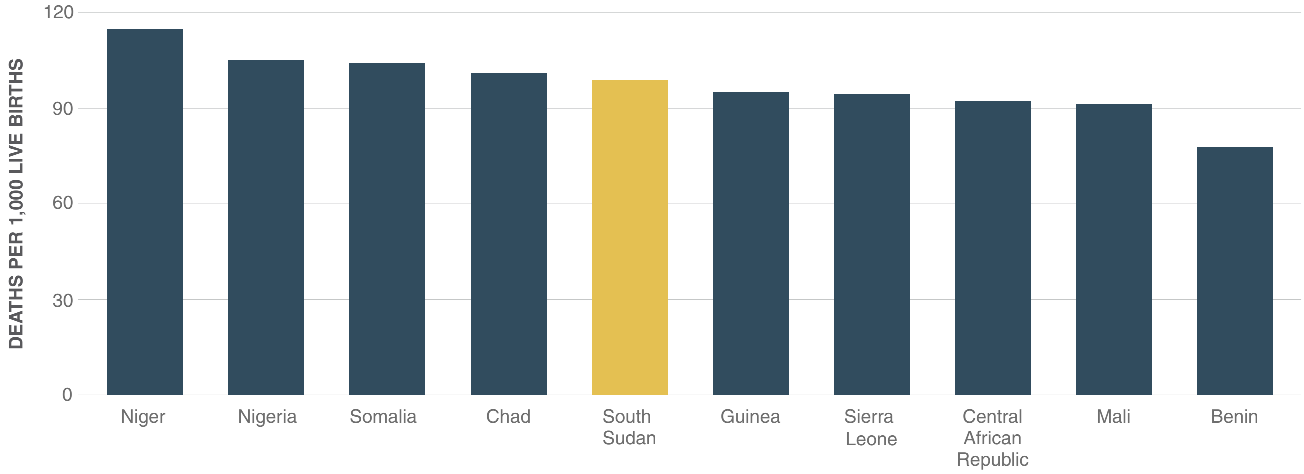
In contrast, the southern parts of the country have maintained near-average vegetation and crop conditions, offering some regionalised stability in production. Between 2021 and 2023, South Sudan recorded increases in the production of raw cow's milk, reaching an annual average of over 2.7 million tonnes, alongside growth in sorghum production from 591,000 to 867,000 kilograms.[88] Moreover, the country remains the world's sixth-largest producer of raw goat's milk, at over 489 million kilograms in 2023.

Still, the region remains a major hotspot for food insecurity as an influx of refugees risks heightening competition over land, water, and humanitarian assistance, particularly where displaced

FIGURE 2.14

Ten highest child mortality rates worldwide, 2022

In South Sudan, one in ten children does not survive past the age of five.



Source: IGME

populations settle in proximity to host communities already facing precarious food and livelihood security. These threats are most acute in the region of Eastern Equatoria, which recorded the largest deterioration in ETR scores nationally and now faces the highest risk levels in South Sudan, driven particularly by worsening exposure to impact of natural events and food insecurity.

At present, approximately 57 per cent of the population is experiencing crisis levels of food insecurity.[89] The scale of intervention remains modest relative to the magnitude of assistance required. Without sustained improvements in security, infrastructure, and market access, adaptive strategies such as community gardens and agropastoral field schools are unlikely to fully offset the systemic risks to livelihoods.

BOX 2.1

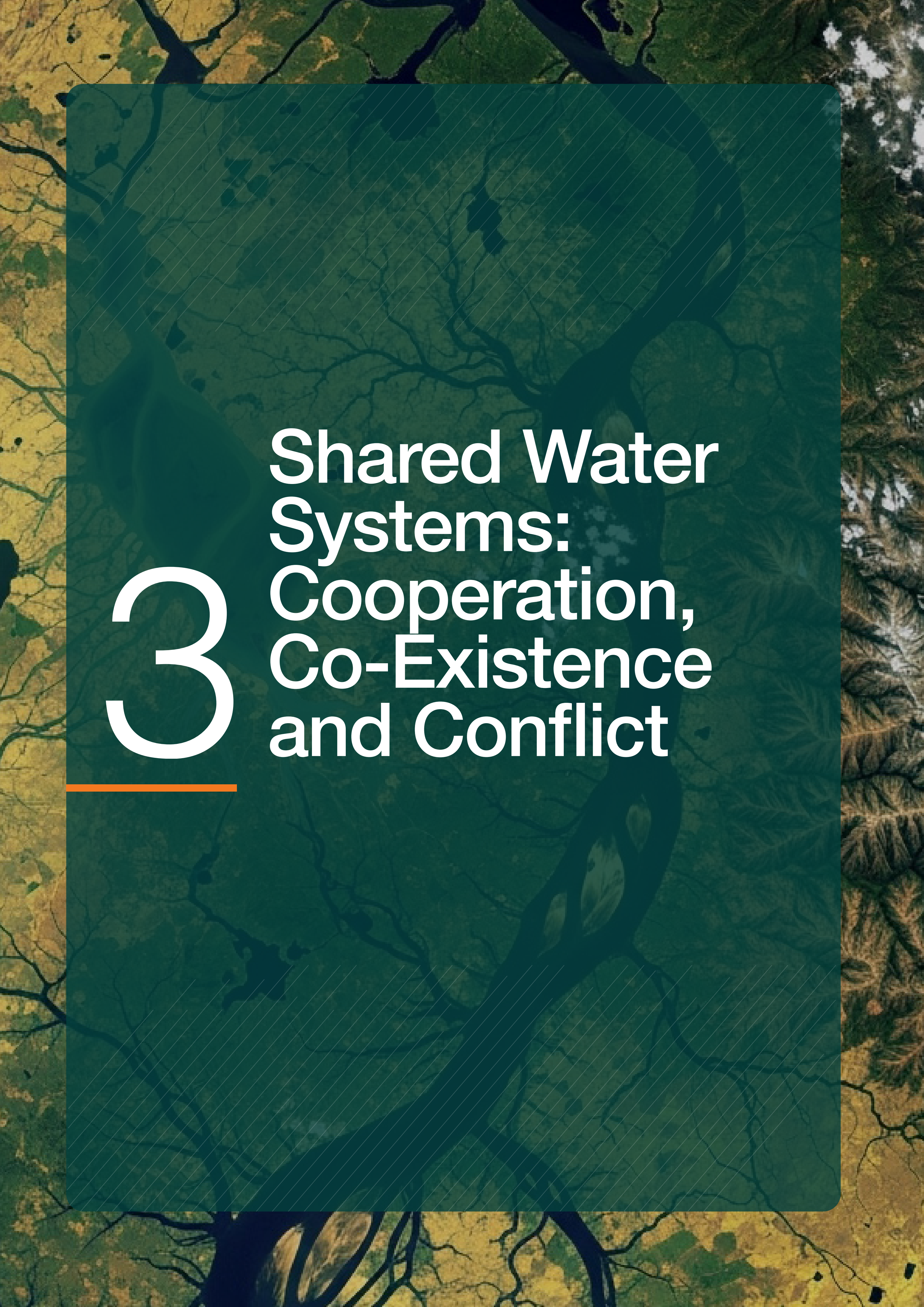
The Charitable Foundation's Work in Karamoja Cluster

Over the past two decades, The Charitable Foundation (TCF), a sister organisation of IEP, has supported initiatives across the Karamoja Cluster, a region long affected by pastoralist conflict, marginalisation, and fragile livelihoods. Working alongside the Danish Demining Group (DDG), a specialised unit within the Danish Refugee Council, TCF has helped implement practical development interventions such as household income support projects and the Northern Uganda Social Action Funds. In these arid and semi-arid areas, such interventions have included general food distribution, village savings and loans associations, income support projects, and public works. These efforts have not only strengthened food security but also enabled households to diversify their sources of income, addressing one of the root causes of cyclical conflict in the region.

Beyond livelihood improvements, TCF's and DDG's collaboration has tackled the drivers of conflict through community safety planning, conflict management education, and inclusive dialogue forums. Beginning in 2010, the Armed Violence Reduction (AVR) program introduced approaches such as community–security provider dialogues, small arms/light weapons (SALW) awareness campaigns, and the establishment of community safety committees.

These activities rebuilt trust between communities and security providers, fostered mechanisms for cooperative problem-solving and reduced reliance on violence. SALW awareness groups reached more than 22,000 people advocating for practical safety measures such as the establishment of a police post in Tapac Subcounty, Uganda.

TCF has also co-organised three Positive Peace workshops in Karamoja, introducing participants to the Pillars of Positive Peace framework. Delivered in a two-day format adapted to the local context, the workshops brought together diverse participants across age, gender, education and community roles. They equipped attendees to apply Positive Peace principles in designing responses such as improving transparency in resource distribution, promoting education and strengthening community accountability. The process not only raised awareness of Positive Peace but also helped participants link them directly to Karamoja's realities, laying the groundwork for community-driven solutions and more sustainable peace initiatives.



3 Shared Water Systems: Cooperation, Co-Existence and Conflict

70%

Global freshwater supply per capita has fallen by 70 per cent since 1950 as global population has tripled, even as the overall volume of annual freshwater flows has remained largely the same.

However, annual per capita withdrawals of freshwater have fallen by 14.4 per cent since a high of 581 cubic metres per person in 2008, owing to improved water management.

The agricultural sector consumes 71.4 per cent of global freshwater withdrawals. Industrial use is around 15.3 per cent and municipal (household and local) use is around 13.2 per cent.

This dominance of agriculture is particularly visible in low- and middle-income countries. In contrast, in high-income countries, industrial and household use make up much larger shares of water withdrawals.

Since 2000, per capita water use across all sectors has declined in high- and low-income countries, though the latter trend is primarily driven by population growth outpacing increased water withdrawals. Middle-income countries have shown more mixed trends.

Industrial water demand has declined in high-income countries but grown rapidly in lower-middle-income economies, highlighting a global shift of water-intensive industries toward developing regions.

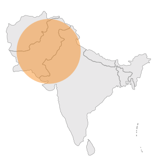
In upper-middle-income countries, household water use has increased sharply in recent decades, reflecting both growing populations and the expansion of infrastructure that allows more people to access piped water for domestic needs.

300
transboundary rivers

There are over 300 transboundary river basins, and 151 countries are part of at least one such system. Increasing dependencies on river systems like the Nile and the Mekong for energy and agriculture are potential drivers of conflict between system-sharing countries.

Shared river systems tend to breed greater cooperation than conflict. Cooperation, including treaties and agreements, are far more common than conflicts over water.

Conflicts within states compared to cooperation is on the rise since 2015. The most conflicts have been recorded in the Middle East, followed by South Asia and sub-Saharan Africa.



The Indus Waters Treaty between India and Pakistan has acted as a core conflict resolution tool and point of cooperation for 60 years. India's 2025 suspension marks a period of heightened tension between the two countries.

Several shared river basins, including those of the Sava River in the Balkans and the Senegal River in West Africa, demonstrate successful cooperative water sharing agreements.

Global Freshwater Availability and Transboundary River Systems

The world's supply of renewable freshwater is finite and unevenly distributed. Pressures on freshwater availability are mounting in the most water-stressed parts of the world as populations grow and rainfall patterns shift. However, in many rich countries, water stress is easing, with falling per capita consumption due to efficiency gains and low population growth.

Global river systems and associated floodplains are home to over 2.7 billion people, with their sustainability and management at the core of economic and individual survival. There are many major river systems that cross multiple states, and their management is critical to maintaining stable interstate relations. Rivers are also critical to global freshwater supply, accounting for much of the renewable surface water that sustains agriculture, industry and households. Pressure on freshwater supply is therefore especially acute in relation to major river systems, which sustain these vast populations and serve as critical ecological lifelines.

This section explores how shared river systems, while sometimes points of interstate tension, can actually help foster peaceful coexistence and exchange, even in regions under severe ecological threat.

Global Pressures on Freshwater

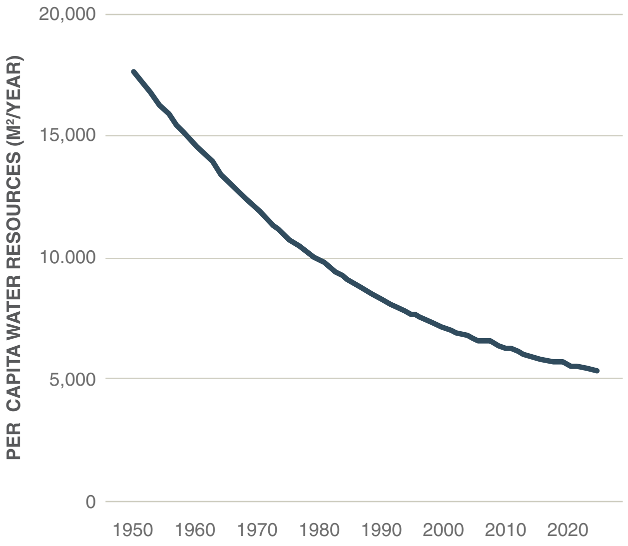
Globally, internal renewable water resources from rivers and aquifers are estimated to amount to 44,211 cubic kilometres per year (equivalent to about 44 quadrillion litres).[1] This figure represents the renewable supply generated each year by rainfall and snowmelt, feeding rivers and replenishing aquifers. It excludes long-term stocks such as glaciers and fossil groundwater, capturing only the water that is naturally renewed and available for use on an annual basis. While the overall volume of global freshwater flows does not meaningfully change from year to year, population growth has meant that on average there is less freshwater per person, as shown in Figure 3.1. Moreover, in many regions, aquifers are being withdrawn faster than they can recharge, meaning that even if global flows remain stable, local availability will decline.

Pressures on global water resources keep increasing, pushing many ecosystems to their limits and impacting food security and nutrition. Annual water withdrawals across all sectors amount to almost 4,000 cubic kilometres – nearly ten per cent of the total available.[2] However, since peaking at 4,049 cubic kilometres in 2019, global withdrawals have seen small but fairly steady declines in recent years, falling by about 1.4 per cent. This trend likely reflects a combination of improved water standards and more efficient management. However, these gains are unevenly distributed, with some regions such as Europe benefiting from greater efficiencies, while others such as South Asia and Africa continue to see net increases in their levels of water extraction.

FIGURE 3.1

Global renewable water resources per person, 1950–2025

The amount of freshwater per person has fallen from nearly 18,000 cubic metres per year in 1950 to just over 5,000 in 2025.



Source: FAO AQUASTAT, IEP calculations

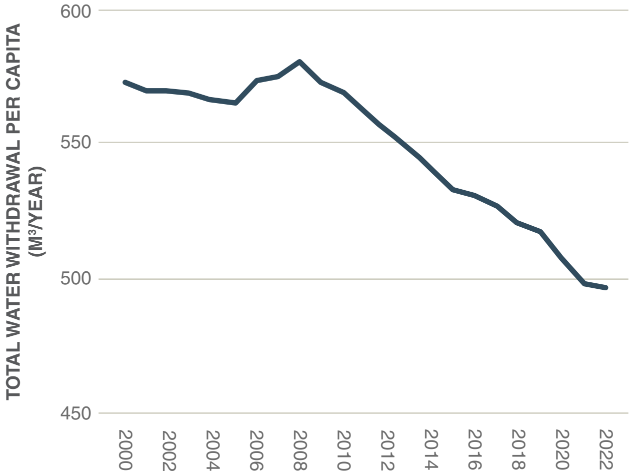
The vast majority of freshwater is used for agriculture, which accounts for 71.4 per cent of all global withdrawals. This reflects the enormous demand for irrigation, livestock and food production systems that sustain a growing population. By comparison, industry consumes 15.3 per cent, largely for energy generation and manufacturing, while municipal use – water supplied to households and services – makes up just 13.2 per cent.

Over the past two decades, annual per capita freshwater withdrawals have declined by 14.4 per cent from a peak of 581 cubic metres per person in 2008, as shown in Figure 3.2. Since 2000, most regions of the world have seen reductions in withdrawals per person, except for Central America and the Caribbean, South America, sub-Saharan Africa, and South Asia. These trends are expected to continue, driven both by gains in water-use efficiency – particularly in agriculture – and by the persistence of water scarcity in densely populated regions facing extended dry conditions.[3]

FIGURE 3.2

Global freshwater withdrawals per person, 2000–2022

Per capita withdrawals of freshwater have fallen since peaking in 2008.



Source: FAO

As shown in Figure 3.3, the decline in global per capita water withdrawals since 2000 has been driven primarily by large reductions in high-income countries. On average, per capita withdrawals in these countries fell by 35 per cent over the period, reflecting both structural economic shifts away from water-intensive industry and improvements in water-use efficiency across agriculture, industry, and households. Smaller declines are also evident in low- and lower-middle-income countries, where per capita withdrawals have fallen by 10.3 per cent and 8.1 per cent respectively. In contrast, upper-middle-income countries saw rising withdrawals until around 2012, after which levels stabilised, leaving a modest overall increase of 4.9 per cent over the two decades.

On a non-per capita basis, however, the picture is quite different. When total volumes of water withdrawn are considered, only high-income countries have registered an absolute decline, with overall withdrawals falling by 16.5 per cent since 2000. In all other income groups, growing populations and expanding economies have driven substantial increases in total demand. Lower-middle-income countries have seen overall withdrawals rise by 27.7 per cent, followed by upper-middle-income countries at 27.4 per cent and low-income countries at 22.3 per cent.

The decline in water use in high-income countries is particularly significant given that these nations have historically, and continue to, withdraw far more water per person than other country groupings. As shown in Figure 3.4, the average person in a high-income country uses around 696 cubic metres of water per year, equivalent to about 1,907 litres per day. This is substantially higher than the 517 cubic metres per year (1,416 litres per day) used in upper-middle-income countries, 468 cubic metres per year (1,282 litres per day) in lower-middle-income countries, and just 168 cubic metres per year (460 litres per day) in low-income countries.

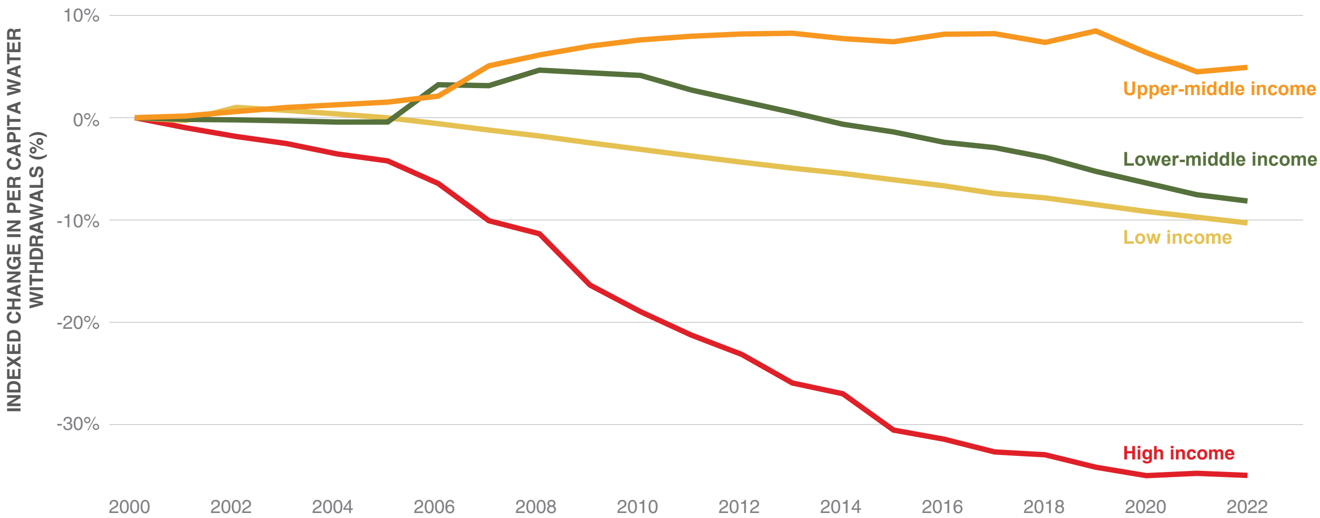
Figure 3.4 also highlights how the purposes of water withdrawals vary considerably across income groups. The FAO distinguishes three main categories of water withdrawals: agricultural use, which includes irrigation, livestock and food production; industrial use, which covers energy generation and manufacturing; and municipal use, which refers to water distributed by utilities to households and public services such as schools, hospitals and firefighting.

In high-income countries, however, the balance looks very different. Agriculture accounts for only 42.7 per cent of withdrawals, while industry consumes 39.6 per cent and municipal uses represent 17.7 per cent. This reflects both higher levels of industrialisation and more extensive provision of piped household water in wealthier countries, in contrast with the overwhelming dominance of agriculture in water use among lower-income economies.

FIGURE 3.3

Indexed change in per capita water withdrawals by country income grouping, 2000–2022

Per capita water withdrawals have fallen fastest in high-income countries. Despite increases in absolute demand, most low- and middle-income countries have also registered per capita declines.

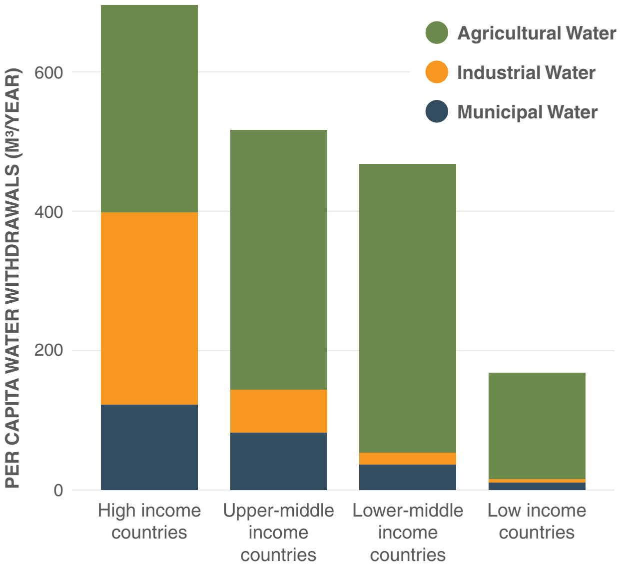


Source: FAO

FIGURE 3.4

Per capita water withdrawals by sector and country income groups, 2022

People in high-income countries use the most water overall, though those in middle-income countries use the most on agriculture.



Source: FAO

The different relative levels of water withdrawal across income groups reflect underlying ecological and economic realities. High-income countries, being more industrialised, devote a far larger share of withdrawals to industry. People in wealthier countries also maintain lifestyles that entail higher levels of municipal or household water use, including piped supply for sanitation, gardening and recreational consumption. By contrast, in middle- and low-income countries, agriculture dominates water use. Although industrial activity has grown substantially in these regions – particularly among upper-middle-income countries – agriculture remains central to their economies and food security. Many of these countries also lie in arid and semi-arid zones, such as the Middle East and North Africa, where irrigation is essential. In wetter regions such as Europe and North America, agriculture is less dependent on irrigation, contributing to the lower share of withdrawals for farming.

Despite using much less water per person than wealthy countries, middle- and low-income countries place greater strain on their available renewable water resources. This is because high-income countries typically enjoy far more abundant supplies of renewable water. For example, high-income countries have nearly 12,000 cubic metres of renewable resources available per person per year. With an average withdrawal of 696 cubic metres per person annually, this represents only about six per cent of their resources.

By comparison, upper-middle-income countries have about 8,300 cubic metres of renewable water per person each year. With average withdrawals of 517 cubic metres, this equates to roughly 6.2 per cent of their available resources. In lower-middle-income countries, renewable resources fall to about 3,700 cubic metres per person annually. Their withdrawals of 468 cubic metres represent around 12.5 per cent of resources, more than double the relative pressure in wealthier states. Low-income countries face a similar challenge: despite withdrawing just 168 cubic metres per person, their renewable supply averages only about 4,300 cubic metres per person per year, meaning their withdrawals account for roughly 3.9 per cent.

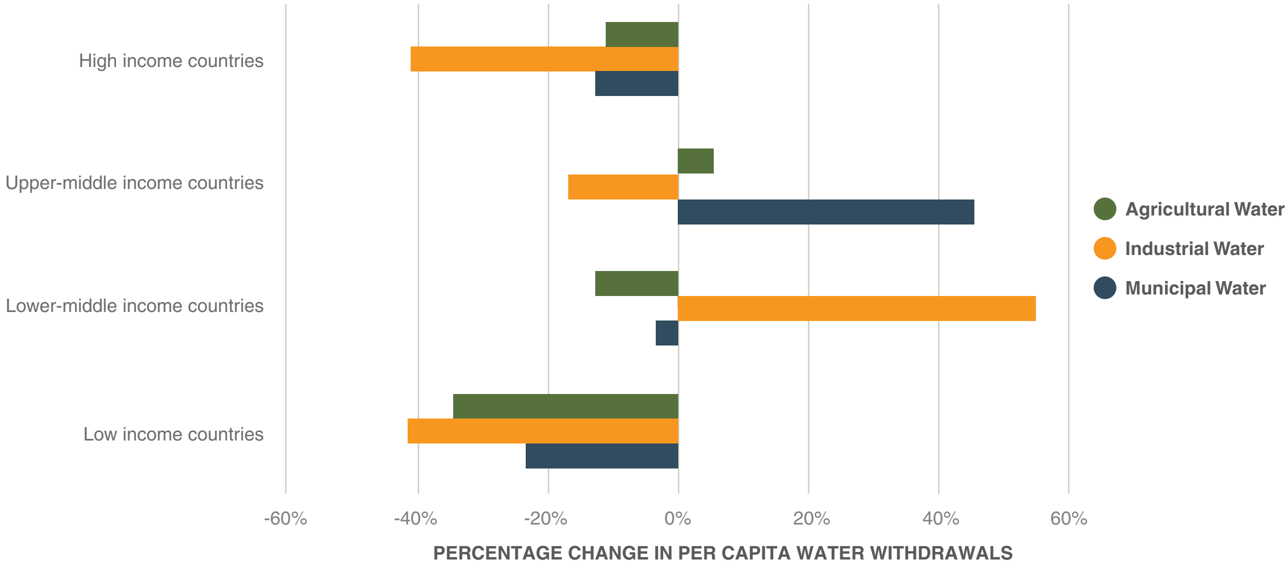
This pattern underscores how absolute levels of water use can be misleading. Even when poorer countries withdraw far less water in per capita terms, their extraction rates can in some cases place much heavier burdens on limited local resources. For example, if people in low-income and lower-middle-income countries were to increase their per capita water use to high-income country levels, they would on average extract 16-19 per cent of their water resources, far more than any other grouping. As many of these countries seek to grow their economies and build their middle classes in the coming decades, such constraints make them more vulnerable to scarcity, climate variability, and conflict over access.

Since 2000, the drivers of change in per capita water withdrawals have differed substantially across income groups. Figure 3.5 shows the percentage change in withdrawals by sector and income group between 2000 and 2022. High-income and low-income countries both recorded relative declines across all three categories – agricultural, industrial, and municipal use – though for different reasons. In high-income countries, these declines also corresponded to absolute reductions, while in low-income countries total withdrawals increased slightly but failed to keep pace with rapid population growth, resulting in per capita decreases.

FIGURE 3.5

Percentage change in per capita water withdrawals by sector and country income groups, 2000–2022

Per capita water withdrawals show declines in high- and low-income countries, with mixed trends across middle-income groups.



Source: FAO

The largest absolute decline has been in industrial water use in high-income countries, which fell by 188.3 billion cubic metres per year. This reflects long-term economic transitions, as high-income countries continue to shift from industrial to service-based economies that are less water-intensive, and as many industries have relocated to lower-cost regions.

This relocation trend is visible in the sharp rise in industrial water use in lower-middle-income countries. In these settings, industrial withdrawals recorded the largest relative increase of any sector or income group, rising by 55.1 per cent per capita, equivalent to an additional 28 billion cubic metres annually. This expansion underscores the growing role of industrialisation in lower-middle-income economies, with water use rising in parallel.

In contrast, upper-middle-income countries have seen industrial water use decline since 2000. On a per capita basis, withdrawals dropped by 16.5 per cent, equivalent to a modest decline of 1.2 billion cubic metres per year. At the same time, these countries have experienced striking growth in municipal water use, which rose by 45.9 per cent per capita, or 30.8 billion cubic metres annually. This surge likely reflects the growth of middle classes and expanded infrastructure, which has enabled greater household water consumption.

While declines in per capita water withdrawal generally signal environmental relief, the substantial reductions observed in low-income settings likely reflect mounting scarcity. Withdrawals in these countries fell by 34.1 per cent in agriculture, 22.8 per cent in municipal use, and 41.3 per cent in industry between 2000 and 2022 – the steepest relative declines of any income group – and these reductions come off an already extremely low baseline. As of 2022, the average person in a low-income country uses 16 times less water than the average person in a high-income country. In practice, households in low-income settings are not using less water because of efficiency gains, but rather because of rising water stress and deteriorating access in places already operating close to subsistence levels.

As such, the greatest future pressures on global water resources are likely to come from low- and middle-income countries as they continue to industrialise, urbanise and expand their middle classes. Rising living standards are typically accompanied by higher municipal demand, while shifts in consumption patterns – particularly the adoption of more water-intensive diets such as greater meat and dairy intake – add further stress. At the same time, continued industrial growth will increase withdrawals in regions where renewable water resources are already limited, amplifying risks of scarcity and competition. These dynamics suggest that without major advances in efficiency, governance and sustainable food systems, the combination of population growth, industrial expansion, and changing lifestyles could create mounting pressure points in the decades ahead.

Transboundary Waterways

Cooperation between states over transborder water systems has historically been high, but contention over water resources is on the rise. Increasing pressures on both inland and oceanic systems are giving rise in some regions to increasing social instability, violence, food insecurity, economic disruption and ecological degradation. Competition over access to water resources is no longer just an environmental concern; it is an important geopolitical issue. Water scarcity is driving geopolitical tensions across multiple river basins in the Middle East, South Asia, East Africa, Central Asia and Southeast Asia. There are important feedback loops between shared water systems, and how they intersect with peace, conflict and ecological threats like food security.

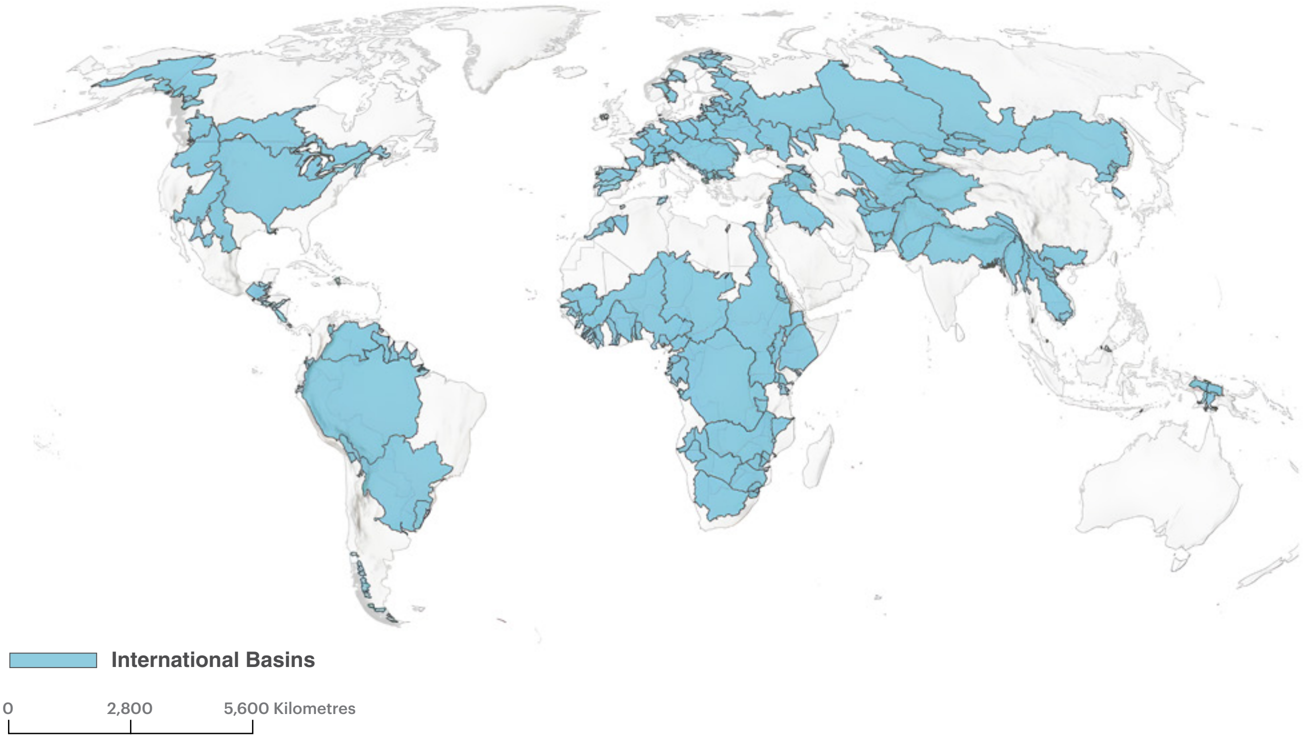
There are over 300 transboundary river basins spanning 151 countries, shown in the map in Figure 3.6. Transboundary rivers – watercourses shared by two or more sovereign states – have long been seen as potential flashpoints for international conflict. More than 40 per cent of the global population live in areas where their main rivers or lakes flow across international borders.

One of the biggest issues for transboundary water management are the twinned impacts of population growth and increased demand on freshwater. An effective governance mechanism is key to managing these pressures into the future. As Table 3.1 shows, in six of the river systems relations are improving, even though tense, while deteriorating in only three.

FIGURE 3.6

Global map of shared river basins

There are over 300 transboundary river, lake or basin systems around the world, with 151 states sharing a riparian system with at least one other state.



Source: Transboundary Freshwater Dispute Database

TABLE 3.1

Ten largest transboundary river basin systems by population

The trends around transboundary basin governance are mixed across regions, with dependent populations expected to grow from 1.8 billion to 2.3 billion by 2050.

Rank	River Basin System	Countries Included	Population (millions)	2050 Projection (millions)	Area (km²)	Status of Agreements	Cooperation Trend (2015–2025)
1	Ganges–Brahmaputra–Meghna (GBM)	India, Bangladesh, China, Nepal, Bhutan, Myanmar	~630	~700	~1,700,000	Limited multilateralisation; bilateral India–Bangladesh Ganges Treaty (1996); China mainly data-sharing	Deteriorating / stressed
2	Nile	Egypt, Sudan, Ethiopia, Uganda, Kenya, Tanzania, Rwanda, Burundi, DRC, South Sudan, Eritrea	~270	~450	~3,200,000	Nile Basin Initiative (1999), Cooperative Framework Agreement (not all ratified)	Improving but tense
3	Indus	Pakistan, India, China, Afghanistan	~230	~320	~1,120,000	Indus Waters Treaty (1960) India–Pakistan; no basin-wide pact	Deteriorating
4	Niger	Guinea, Mali, Niger, Nigeria, Burkina Faso, Côte d'Ivoire, Benin, Chad, Cameroon	~130	~180	~2,130,000	Niger Basin Authority (1980; strengthened in 2000s)	Improving
5	La Plata (Paraná–Paraguay)	Brazil, Argentina, Paraguay, Uruguay, Bolivia	~120	~140	~3,170,000	La Plata Basin Treaty (1969), various bilateral agreements	Mostly static
6	Danube	Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova, Ukraine, Czechia, Slovenia, Bosnia and Herzegovina, Montenegro, Albania	~80	~75	~801,000	International Commission for Protection of the Danube River (ICPDR, 1998)	Improving
7	Congo	Democratic Republic of the Congo, Central African Republic, Angola, Republic of Congo, Cameroon, Tanzania, Rwanda, Burundi, Zambia	~120	~200	~3,700,000	CICOS cooperation expanding; basin-wide integration partial	Static to improving
8	Mekong	China, Myanmar, Laos, Thailand, Cambodia, Vietnam	~70	~85	~795,000	Mekong River Commission (1995) covers lower basin; China/Myanmar not members	Static to deteriorating
9	Zambezi	Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe	~50	~60	~1,400,000	Zambezi Watercourse Commission (ZAMCOM, 2004; operational 2014)	Improving
10	Rhine	Switzerland, Austria, Germany, France, Luxembourg, Netherlands, Belgium, Liechtenstein, Italy	~60	~58	~198,000	International Commission for Protection of the Rhine (since 1950s)	Improving / model

Source: IEP

The ten largest transboundary river systems by population collectively support approximately 1.8 billion people, with a conservative projection of 2.3 billion by 2050. These basins are geographically diverse, spanning Asia, Africa, Europe and South America, and they present a mix of governance structures, levels of cooperation and future challenges. Population growth will increase usage and potentially water stress. Therefore, the management of these relationships and treaties is important for peaceful coexistence.

The major river basins and the status of their treaties are:

- The Ganges-Brahmaputra-Meghna basin is the most populous, home to around 630 million people today, with growth expected to reach 700 million. It lacks a comprehensive multilateral framework, with governance limited to bilateral treaties, most notably between India and Bangladesh.
- The Nile Basin supports about 270 million people, projected to rise to 450 million, and while the Nile Basin Initiative provides a cooperative structure, significant tensions remain over the construction of the Grand Renaissance Dam in Ethiopia and its effect on downstream flows to Egypt.
- The Indus Basin, shared primarily by Pakistan and India, supports roughly 230 million people and is projected to grow to 320 million. It is governed by the Indus Waters Treaty of 1960, which has survived two wars and recent clashes between India and Pakistan.
- The Niger Basin, with 130 million residents today and a projection of 180 million by 2050, benefits from the Niger Basin Authority, which has strengthened regional coordination in recent decades.
- The La Plata Basin in South America supports about 120 million people, with moderate population growth projected. Cooperation has been occurring since the 1969 basin treaty, but day-to-day, modern basin management is not well coordinated across countries.
- The Danube Basin sustains about 80 million people, with stable or slightly declining numbers expected due to demographic trends; it is governed comprehensively by the International Commission for the Protection of the Danube River (ICPDR) within a European regulatory framework.

Other large systems include the Congo Basin with 120 million population today, projected 200 million by 2050, the Mekong Basin with 70 million population today, projected 85 million by 2050, the Zambezi Basin with 50 million population today, projected 60 million, by 2050, and the Rhine Basin with 60 million today, stable to slightly declining population, by 2050. Each demonstrates varying levels of institutionalisation, with cooperation trends ranging from improving to static or deteriorating.

The historical record of transboundary water management demonstrates that shared rivers have overwhelmingly been sources of cooperation rather than conflict. Of the hundreds of transboundary river and lake basins worldwide, the vast majority operate under some form of cooperative arrangement, with over 680 water-related treaties negotiated since 1820.[4]

The Rhine Basin exemplifies this success, transforming from a heavily polluted industrial waterway in the mid-20th century into one of the world's most effectively managed transboundary systems, with comprehensive cooperation among eight riparian states through the International Commission for Protection of the Rhine. Similarly, the Niger Basin Authority has strengthened regional coordination across nine West African nations since 1980, facilitating not only water sharing but broader economic integration. The Danube Basin offers another model, with 14 countries cooperating through the ICPDR within a robust European regulatory framework that has improved water quality and ecosystem health across the basin.

These success stories reflect a fundamental reality: nations sharing water resources have strong incentives to cooperate, as unilateral action often proves counterproductive and downstream states retain leverage through various means. Water agreements create predictable frameworks that reduce uncertainty, establish monitoring mechanisms that build trust, and provide neutral venues for dialogue that can survive broader diplomatic breakdowns and also provide a platform for discussing other bilateral issues. The institutional capacity developed through water cooperation often spills over into other areas of regional integration, as seen in Southern Africa where the Zambezi Watercourse Commission (ZAMCOM) has strengthened ties among eight nations.

However, despite this broadly positive global picture, significant areas of concern remain. Population growth, changing climatic conditions and rapid development are placing unprecedented stress on several major transboundary systems where governance frameworks have not kept pace with emerging challenges. While some basins like the Niger, Danube and Zambezi show improving cooperation, others including the Ganges-Brahmaputra-Meghna, Indus and Mekong systems face deteriorating or stressed relationships at precisely the moment when stronger coordination is most needed. These at-risk systems share common characteristics that distinguish them from more successfully managed basins. The at-risk river basin systems often involve regional rivals or powers with deep geopolitical tensions, lack comprehensive multilateral frameworks despite affecting hundreds of millions of people, and face compounding pressures from rapid population growth and climate variability that existing bilateral arrangements appear ill-equipped to address.

To understand the importance of shared river basins as a critical issue for peace it is necessary to recognise the diversity in how major transboundary river systems are managed, as well as the scale of agreements and the number of people affected. As Table 3.2 shows, there are at least ten major transboundary river systems that could lead to conflict.

While the focus on high-risk transboundary river systems reveals significant governance gaps, it is important to recognise that water cooperation often demonstrates remarkable resilience even amid political tensions. Many bilateral and regional water agreements have survived wars, regime changes and diplomatic breakdowns. The Indus Waters Treaty between India and Pakistan has held through multiple armed conflicts. Even limited frameworks, like those governing the Okavango River in southwestern Africa, have enabled peaceful cooperation among nations with divergent interests.

The existence of partial coverage or basic bilateral arrangements, though falling short of ideal multilateral frameworks, often represents pragmatic progress rather than failure. These modest agreements can prevent disputes from escalating and establish channels for dialogue that persist when other diplomatic ties fray. However, the ten major transboundary river systems examined here represent cases where current arrangements – whether absent, partial, or functionally limited – appear insufficient for the future given the scale of population dependency, intensity of water stress, and complexity of geopolitical dynamics expected in the next 50 years. Understanding the governance structures helps identify what makes these ten systems particularly vulnerable to future conflict.

TABLE 3.2

Ten transboundary river systems with high conflict risk and inadequate management

River systems in South Asia, MENA, Central Asia and sub-Saharan Africa all have limited transboundary management and are subject to conflict risk. More than one billion people collectively depend on these rivers.

Rank	River System	Countries	Basin Population (millions)	Transboundary Governance Level	Water Conflicts
1	Ganges-Brahmaputra-Meghna	India, Bangladesh, China, Nepal, Bhutan, Myanmar	~630	Partial Coverage	Yes
2	Congo	Democratic Republic of the Congo, Central African Republic, Angola, Republic of Congo, Cameroon, Tanzania, Rwanda, Burundi, Zambia	~120	Partial Coverage	Yes
3	Tigris-Euphrates	Turkey, Syria, Iraq, Iran	~60	No Basin-Wide Agreement	Yes
4	Amu Darya/Syr Darya	Afghanistan, Tajikistan, Uzbekistan, Turkmenistan, Kazakhstan, Kyrgyzstan	~60	Partial Coverage	Yes
5	Irrawaddy	China, Myanmar	~35	No Agreement	Yes
6	Zambezi	Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe	~50	Functional but Limited	Yes
7	Lake Chad Basin	Nigeria, Niger, Chad, Cameroon, CAR, Libya	~45	Functional but Limited	Yes
8	Jordan River	Israel, Palestine, Jordan, Lebanon, Syria	~15	Partial Coverage	Yes
9	Salween	China, Myanmar, Thailand	~10	No Agreement	Yes
10	Okavango	Angola, Namibia, Botswana	~1.5	Functional but Limited	No

Source: IEP

When looking at the water systems with conflict and poor governance the data reveals a challenging pattern across a number of important transboundary river systems, which range from having minimal agreements to no agreement. There is seemingly a higher potential for water conflict risk in basins with high population density and geopolitical complexity. The Ganges-Brahmaputra-Meghna system has a dependent population of around 630 million people, with regional rivals and nuclear powers China and India managing its use.

While robust water management systems prevail around the world, the prevalence of partial or absent governance frameworks in these major river systems shows that substantial risks remain. Only three of the ten systems have functional river basin organisations, and even these face significant limitations. China remains outside the Ganges-Brahmaputra frameworks, Afghanistan is excluded from Central Asian water agreements, and Palestinians lack representation in Jordan River management. These exclusions create institutional blind spots that raise the risk of future conflict.

Bilateral approaches dominate where multilateral frameworks are needed. The Tigris-Euphrates system relies on bilateral agreements while excluding Iran entirely, creating a patchwork of arrangements inadequate for basin-wide challenges. Developing agreements have been complicated by the wars in the region and at times the lack of functioning governments.

There is also a tendency to address transboundary issues through easier bilateral negotiations rather than more complex but necessary multilateral institutions. Implementation capacity consistently lags behind institutional ambitions. Even where there are organisations like the Zambezi Watercourse Commission (ZAMCOM) or the Permanent Okavango River Basin Water Commission (OKACOM), both in Southern Africa, they often struggle with enforcement powers and resource constraints. This suggests that creating institutions alone is insufficient without sustained political commitment and adequate funding.

Several systems demonstrate how water stress both triggers and results from broader conflicts. Myanmar's patchwork of civil wars stretching back to independence has prevented any meaningful transboundary cooperation over the Salween, and the 2021 military coup has similarly disrupted any prospects for Irrawaddy cooperation with China. The Tigris-Euphrates has seen water deliberately weaponised during the period that ISIS controlled large amounts of territory during which they threatened to blow up the Mosul Dam. This conflict-water nexus creates vicious cycles where poor governance leads to resource competition, which fuels conflict, which further undermines governance capacity. Breaking these cycles requires addressing both immediate water management needs and underlying political instabilities simultaneously.

River systems that cross national borders have attracted considerable interest due to their complexity and potential for conflict. The Nile River in Northeast Africa and Mekong River in Southeast Asia, for example, pose significant challenges, especially as nearly half a billion people depend on these two systems. Egypt is highly reliant on its historical 85 per cent allocation of Nile water to support its population of over 100 million.

As shown in the map in Figure 3.7, Ethiopia completed the Grand Ethiopian Renaissance Dam (GERD) to fuel its economic growth. The risk of violent conflict involving Egypt and Ethiopia has been considered high in recent years. The GERD was opened in September 2025 without broader water sharing arrangements resolved. Sudan, previously an opponent of the dam, is now in favour of the project as it hopes the GERD will aid management of Nile flooding.

While the likelihood of armed attacks from Egypt is low, any major reduction in water flow to Egypt could result in retaliatory measures. However, the destruction of the dam would result in catastrophic levels of ecological damage. Even without reductions in water flows, it remains a key source of tension between countries in the region.[5]

FIGURE 3.7

Nile River dams

Water-sharing arrangements between states remain a source of tension in the Nile River Basin in the context of the construction of the Grand Ethiopian Renaissance Dam.

Source:IEP

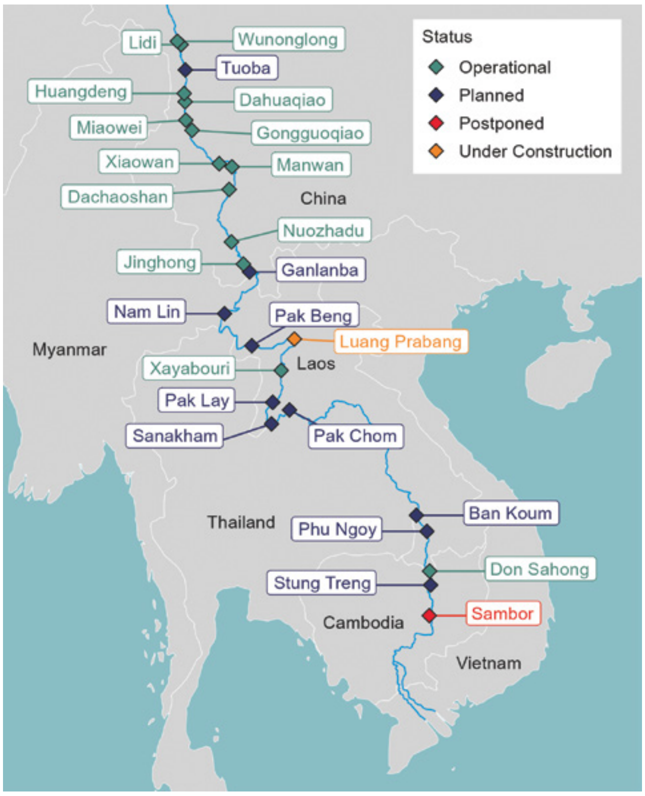
Many other countries around the world rely on large, shared rivers, and over exploitation by upstream countries of the shared resources could lead to conflict in the future, though current shared management processes appear to be working. Another example is the construction of dams on the Mekong River, as shown in the map in Figure 3.8.

Six countries share the Mekong River in Southeast Asia, which begins in China. Over 360 million people depend on the Mekong River, including for energy generated by hydroelectric dams. Building dams has required moving communities, and there are major concerns about their environmental and social effects. Cambodia had paused some dam projects because of these concerns but restarted one in 2022. Dam plans near the Thai-Laos border face opposition from neighbouring countries, locals and NGOs. While the Mekong is one of the best managed rivers in regard to cooperative resource management and sharing, it remains a challenging and precarious system. China continues to operate outside the Mekong River Commission despite controlling the river's headwaters, and demand for water use within the basin

FIGURE 3.8

Mekong River dams

Planned Mekong River dams in Thailand, Laos, and Cambodia have been delayed by cross-border contestation and concerns about their environmental and social impact.



Source: IEP

continues to rise. The withholding of water from upstream dams in China, Cambodia, Laos and Thailand has the potential to be used to leverage favourable political, security and business agreement for China.

The concept of "water security" encompasses both conflict risk and cooperative resilience – that is, the capacity of institutions to absorb hydrological shocks. Environmental and climatic changes are important contextual factors. Climate change is expected to alter precipitation patterns, increase water variability and potentially intensify scarcity in many regions. This has raised concern that hydro-political tensions could worsen in the future, particularly in hotspot basins with rapid population growth and weak governance. Recent research identifies certain basins, including the Nile, the Ganges-Brahmaputra, the Indus and the Tigris-Euphrates, as having a confluence of high-water stress, projected climate impacts, and political fragility that could heighten conflict risks.

One study found that, dependent on the rate of climate change, between 536 million (under the best-case scenario) and 920 million people (under a business-as-usual climate action approach) are projected to live in high or very high conflict risk shared river basins by the year 2050.[6] However, research suggests that climate pressures do not doom river relationships to conflict. Instead, they amplify the importance of adaptive cooperation. In regions with robust treaties and communication, such as the Mekong or the Southern African basins, states have so far managed variability through cooperative adjustments.

Historically, water has been more a source of cooperation than conflict**.** According to a global dataset of water-related conflict and cooperation events, cooperation – such as treaties, joint management frameworks and data-sharing agreements – has long been far more common than conflict across regions and climates.[7] As shown in Figure 3.9, cooperative engagements were dominant through much of the second half of the 20th century, even during periods of heightened geopolitical tension. In the 1990s, an era of heightened multilateralism, the total number of recorded water-related engagements increased substantially. However, over the next several decades, the number of water-related conflicts rose, while cooperation gradually declined.

This shift is further illustrated in Figure 3.10, which tracks the proportion of conflict events over time. The trendline shows relative stability through much of the 20th century, but in the 21st century, the share of conflict events has climbed. By the late 2010s, water conflicts accounted for more than 50 per cent of total recorded events, driven largely by drought-related disputes in Africa and irrigation and dam-related tensions in Asia.[8]

According to the Pacific Institute, which maintains a complementary dataset on exclusively conflict-related engagements , the annual number of conflicts remained relatively low from the early 1990s through the 2000s. However, from around 2015 onward, there has been a notable escalation. By 2018, the dataset recorded about 130 events, which rose to around 230 in 2022, and peaked at nearly 350 incidents in 2023.

These records show that water conflicts are not evenly distributed across the globe. Instead, they have been concentrated in regions where scarcity overlaps with political instability and competing water demands. Since 2015, the Middle East is the region to have recorded the most incidents, with more than 440 incidents, more than one-third of the global total. This includes chronic disputes tied to transboundary rivers, drought-driven tensions, and urban water shortages. South Asia follows with more than 230 recorded conflicts, highlighting persistent struggles in India, Pakistan, and surrounding countries where agricultural demand and climate variability create flashpoints. Sub-Saharan Africa, with at least 220 incidents, has also seen regular water-related clashes, often tied to pastoralist groups competing with farming communities. Other notable regions include Latin America and the Caribbean (about 140 conflicts) and Northern Africa (about 70 conflicts), reflecting both rural-urban water pressures and disputes linked to large river systems such as the Nile and Amazon tributaries. This geographical spread suggests that water conflict is both a local governance issue and a transboundary concern, with fragile political contexts amplifying the risks of violence.

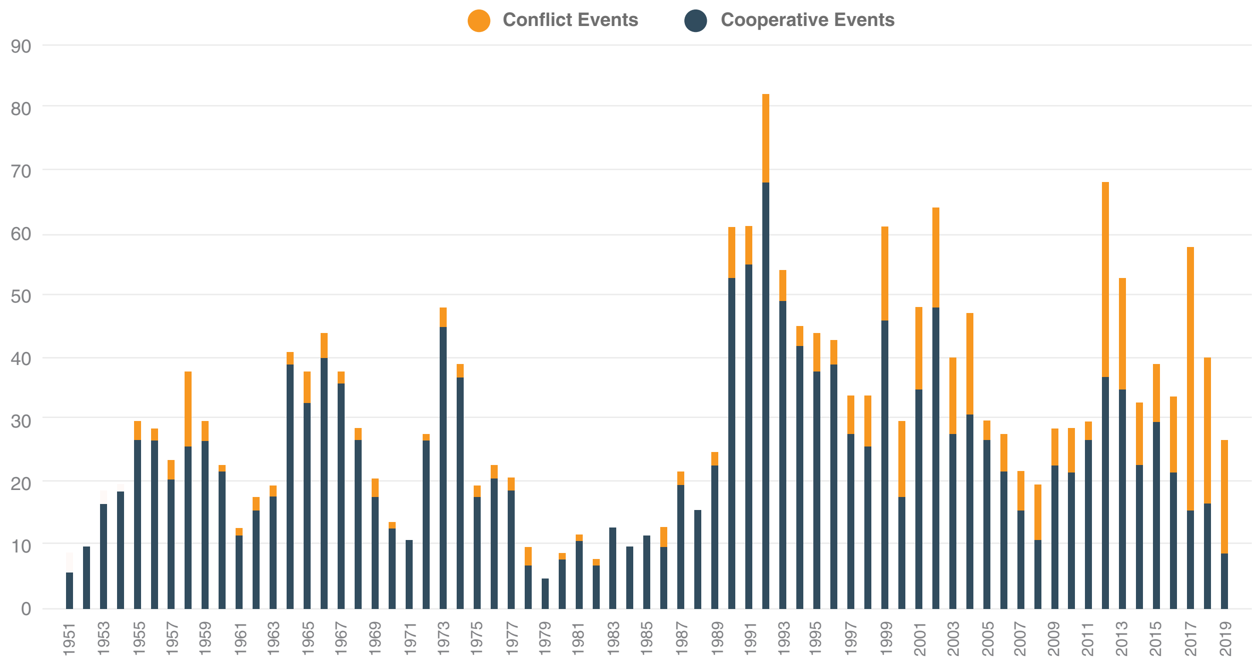
Across these regions, certain countries emerge as repeated flashpoints:

- **Israel and Palestine (~170 conflicts)** – Water has long been a central element in broader geopolitical disputes, with access to aquifers and shared watercourses frequently contested.
- **Yemen (~165 conflicts)** – Chronic shortages, exacerbated by war, have turned water into a driver of both social unrest and survival struggles.
- **India (~110 conflicts) and Pakistan (85 conflicts)** – Longstanding disputes over river-sharing agreements and local scarcity have created both domestic and cross-border flashpoints.
- **Russia and Ukraine (~85 conflicts)** – Conflicts in these

FIGURE 3.9

Total water-related conflict and cooperation events, 1951–2019

Over the past seven decades, recorded cooperation events related to water have been far more common than conflict events, but since 2013 conflict events have been on the rise.

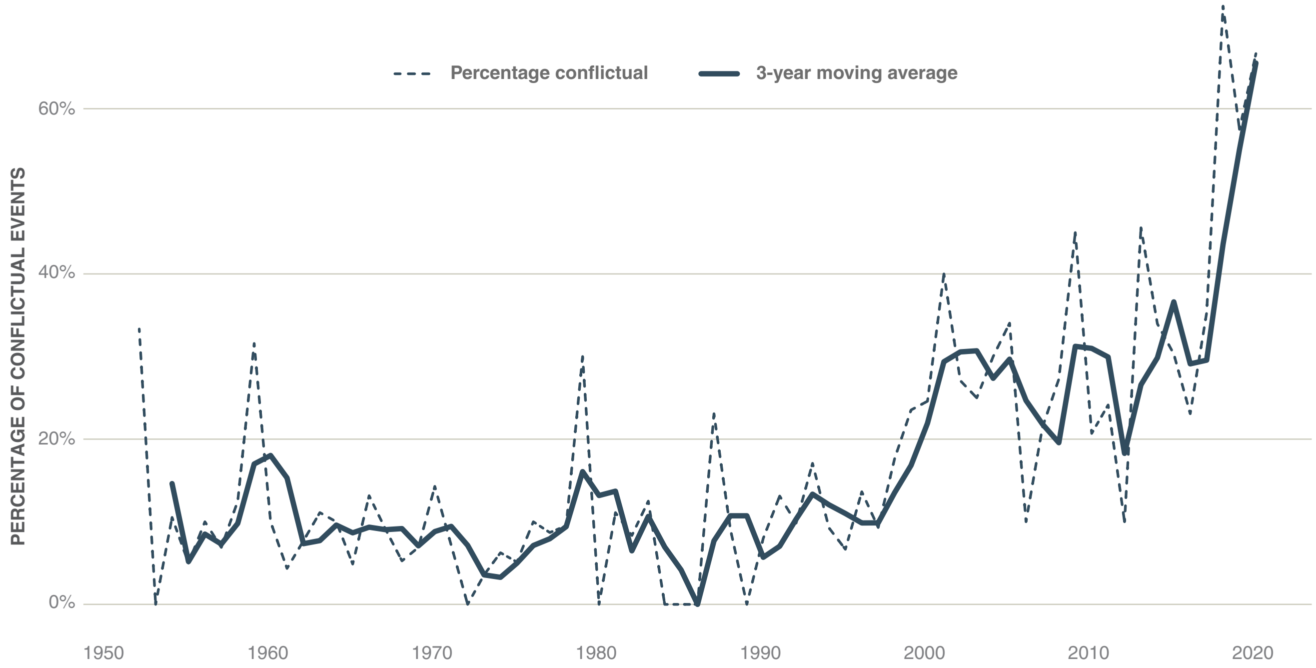


Source: Kåresdotter, E., et al. (2022)

FIGURE 3.10

Prevalence of conflict in water-related events, 1951–2019

As of the late 2010s, conflict has become more common than cooperation in water-related engagements. These events are nearly exclusively internal conflict events rather than cross-border conflicts.



Source: Kåresdotter, E., et al. (2022)

countries often intersect with broader political and military struggles, where water infrastructure becomes both a target and a casualty.

- **Somalia (~40 conflicts), South Africa (~35 conflicts), and Kenya (~30 conflicts)** – These African states reflect a mix of communal violence, pastoralist-farmer disputes and urban protests linked to unreliable supplies.
- **Mexico (~40 conflicts)** – Although lower in absolute numbers, conflicts reflect tensions between rural users, industry and city demand.

Actors vary from local communities and pastoralists clashing over shared resources, to states and armed groups leveraging water for strategic advantage. Urban protests, especially in recent years, reflect growing dissatisfaction with failing infrastructure and governance.

The sharp increase in water-related conflicts from 2015 to 2019, when recorded incidents more than doubled from relatively low levels to around 130 events annually, reflects a convergence of climatic, demographic and political pressures during this period, though caution is warranted as improved reporting mechanisms may account for some of the apparent rise. This escalation correlates closely with a series of severe and prolonged droughts that struck multiple regions simultaneously: South Asia experienced significant monsoon failures and heat waves between 2015 and 2016, the Middle East and North Africa faced intensifying water scarcity amid the Syrian civil war and the rise of ISIS, which weaponised water infrastructure, the Sahel region endured successive drought years that displaced pastoralist communities and heightened farmer-herder conflicts, and Southern Africa confronted severe drought conditions that peaked around 2015-2016, straining both urban water supplies and agricultural systems.

These climate shocks intersected with rapid urbanisation and population growth in water-stressed regions, creating acute competition for diminishing supplies. The period also saw the proliferation of non-state armed groups in fragile states, particularly in the Middle East and sub-Saharan Africa, who recognised water infrastructure as both a strategic asset and a tool of control over civilian populations. Additionally, increased smartphone penetration and social media usage during this period may have improved documentation of local water disputes that previously went unrecorded, suggesting the actual increase in conflicts, while real, may be somewhat less dramatic than the data indicates. Nonetheless, the geographic concentration of incidents in regions experiencing both drought and political instability – with the Middle East, South Asia, and sub-Saharan Africa accounting for the vast majority of conflicts – points to genuine escalation rather than purely a reporting artifact.

The recent surge in conflicts suggests that water is becoming an increasingly contested resource as pressures mount from population growth, climate change and ecological stress. While cooperation has not disappeared, the balance has tilted toward conflict, highlighting the urgency of learning the lessons of successful transboundary water governance and resilience mechanisms.

Transboundary Waterway Cooperation

Early predictions anticipated the possibility of "water wars" in the 21st century, suggesting that nations might come into conflict over scarce water resources as populations grew and climates changed. While disputes over shared rivers do occur and have become more common, outright warfare between countries over water is exceedingly rare.

Early empirical studies systematically examined whether sharing a river increases the likelihood of inter-state conflict. One study found that countries which share a river do show a higher probability of militarised disputes, even after accounting for the fact that neighbouring states are generally more prone to conflict.[9] Subsequent analyses confirmed a statistical correlation between shared river basins and low-level interstate conflicts (e.g. threats or skirmishes), lending some credence to the idea that water can be a contributing factor to tensions.

Studies assessing the mechanisms behind this correlation, asked whether conflicts were driven by resource scarcity (competition for water quantity) or ill-defined boundaries (disputes arising when a river forms an unclear border). Their findings were mixed: shared basins did correlate with more frequent militarised disputes, but there was little support that ambiguous river boundaries were the main culprit. For example, extremely dry countries did exhibit slightly more water-related disputes, but other measures of scarcity, such as drought frequency or upstream water dominance, were not significant predictors. These results imply that shared rivers alone rarely trigger serious conflict in the absence of other aggravating factors, although they may contribute to diplomatic frictions or rivalry under certain conditions.[10]

In contrast to the popular "water wars" narrative, no case of an outright war between nations over water has been documented in modern history. An analysis of 263 international river basins found no wars between countries were fought exclusively over water in the second half of the 20th century. Instead, states typically found non-violent ways to address their water disagreements. The same research uncovered 157 freshwater treaties signed during the same period, vastly outnumbering instances of acute conflict.[11]

This broad empirical pattern, repeated across multiple datasets and studies, shows that cooperation is the prevailing response to shared water challenges. Only a small fraction of recorded events escalated to violence, and those tended to be limited skirmishes rather than full-scale warfare.

Most often, states with shared waterways engaged in negotiations, information-sharing, and joint management initiatives, or at worst, heated rhetoric and political disputes. Even basins that are the source of strong tensions usually see a mix of conflict and cooperation. For example, rivals might still cooperate on technical data exchange even as they argue over a new dam, highlighting that interstate relationships over water are not one-dimensional.[12]

More recent quantitative studies reinforce this picture while adding nuance. They have found that cooperative events significantly outnumbered conflictive events in international basins. Notably, most recorded disputes and agreements alike centred on issues of water quantity allocation and infrastructure (e.g. dam building).[13]

Research also finds that water stress is far more likely to induce diplomatic and cooperative responses than military ones.[14] In fact, quantitative analyses show a positive correlation between water scarcity and the signing of water treaties: basins facing recurrent droughts or variability often see neighbouring states come to the negotiating table to formalise water-sharing arrangements. Basins under high water stress are significantly more likely to enter into cooperative agreements than those with abundant water.[15] As water variability increases, states tend to respond by strengthening institutional cooperation, up to a point. These findings support an "inverted-U" model whereby moderate scarcity incentivises cooperation (by making the resource precious enough to require joint management) while extremely severe scarcity can overwhelm institutions and potentially provoke disputes.[16]

Institutional mechanisms are frequently highlighted as key in preventing conflict. The presence of treaties, river basin organisations, or other cooperative regimes can significantly mitigate the risk of disputes escalating. The existence of a water-sharing treaty or commission was found to be a strong indicator of peaceful cooperation, even in basins under high stress.[17] Building on this, analysis of dozens of international river disputes found that when states enter formal negotiations or mediation over a river claim, the process often leads to a peaceful settlement or improved cooperation rather than militarised conflict.[18] In general, riparians with a history of institutionalised cooperation (such as information-sharing protocols or joint management bodies) experience fewer and less intense conflicts over water. This said, other research has found that riparian basins with water conflicts are also subject to higher overall risk around interstate conflicts as water conflicts often create general mistrust or conflict between states meaning that tensions over non-water related issues may be more likely to escalate to become conflictual.[19]

Power dynamics also factor into the conflict-cooperation equation. Theoretical frameworks like the "hydro-hegemony" model suggest that when there is a large power asymmetry in a basin (e.g. an upstream actor with much greater economic or military power than downstream states), the dominant state can often secure its interests without open conflict. In these situations, cooperation may take on an asymmetrical character: the weaker side may acquiesce to terms set by the stronger, resulting in a form of coerced cooperation rather than a truly equitable partnership.

When factors other than water allocations can be included in the agreements this can broaden the breadth of the cooperation leading to more durable agreements. Countries can broaden the scope of negotiations to include hydropower, irrigation benefits, or economic development. This approach is grounded in frameworks like Integrated Water Resources Management (IWRM), which has been successfully applied in several agreements. For instance, in the 1964 Columbia River Treaty, Canada (the upstream country) was compensated by the United States (the downstream country) for both flood control services and a share of the additional power revenues generated downstream. Quantitative studies suggest that basins where states have discovered benefit-sharing opportunities (such as joint infrastructure projects) tend to enjoy more stable cooperation.

Lessons from Shared River Systems

Indus River Basin

FIGURE 3.11

Map of the Indus River

The Indus and its tributaries span Pakistan and India, as well as parts of China and Afghanistan.

The Indus River and its tributaries are a critical waterway for both India and Pakistan, supplying, in the case of Pakistan, most of the water required for its agriculture. Yet the waterway boundary spanning two sometimes hostile neighbours has required consistent cooperation and diplomacy, even in times of high tension.

The Indus Waters Treaty (IWT) of 1960 is often hailed as a landmark in India-Pakistan relations, an excellent example of successful cooperation between two hostile neighbours. It has functioned as a cornerstone for water-sharing in the Indus River basin for over six decades. Yet the treaty has both fostered peacemaking, by providing a stable framework to resolve water disputes, and been a source of friction, especially over the past 15 years.

The partition of British India in 1947 created two new states – India and Pakistan – with borders that cut across the Indus River system. The headwaters of the Indus and its tributaries (Jhelum, Chenab, Ravi, Beas, Sutlej) lay mostly in India (including the disputed region of Kashmir), while the rivers flowed downstream into Pakistan's plains. This geographical reality set the stage for a serious water dispute soon after independence.

In April 1948, just months after partition, Indian engineers in East Punjab abruptly shut off water from canals that supplied Pakistan's agriculturally rich Punjab, sparking the first Indo-Pakistan water crisis. An interim Inter-Dominion Accord in May 1948 restored flows in exchange for annual payments by Pakistan, but it was only a temporary fix. Pakistan, an agrarian economy heavily dependent on Indus basin irrigation, felt its "national survival" was at stake if India controlled the rivers. India, for its part, insisted on sovereign rights to use waters within its territory and viewed Pakistan's appeals for international arbitration as infringements on its sovereignty.[20]

Amid this stalemate, the World Bank entered as a mediator, proposing that India and Pakistan cooperate to develop the Indus basin, leaving contentious politics aside. Eugene Black, World Bank president, adopted this "functional approach", convening a working group of Indian, Pakistani, and World Bank engineers to negotiate water sharing purely on technical merits. After nearly a decade of arduous talks (1952–1960), punctuated by Cold War geopolitics and extensive World Bank diplomacy, the Indus Waters Treaty (IWT) was finally signed in Karachi on 19 September 1960 by Indian Prime Minister Jawaharlal Nehru and Pakistani President Ayub Khan, with the World Bank as a signatory guarantor.[21]

The IWT essentially partitioned the Indus basin rivers between the two countries. The three "Eastern Rivers" – the Ravi, Beas, and Sutlej – were allotted to India for unrestricted use, while the three "Western Rivers" – the Indus mainstem, Jhelum, and Chenab – were allocated to Pakistan. This gave Pakistan rights to about 80 per cent of the total Indus waters (including the larger downstream flows), and India about 20 per cent. India, as the upper riparian on the western rivers, agreed to strict limits on its use of those rivers: India can use the western rivers for nonconsumptive needs like hydropower generation, navigation and limited irrigation, but cannot divert or store their waters beyond specified limits. Pakistan, in turn, was to allow India exclusive use of the eastern rivers, which required building new canals and storage on Pakistan's side to replace the water from eastern rivers that would be diverted by India. The ten-year transition phase of the treaty coincided with the 1965 Indo-Pakistani war, yet India honoured its treaty obligations even during active conflict, continuing to supply water and payments as agreed.[22]

The IWT established a permanent cooperative mechanism: the Permanent Indus Commission (PIC), comprising one commissioner from each country, which meets regularly to exchange data, discuss issues, and resolve disputes bilaterally. If the commissioners cannot resolve a question, the treaty sets out a graded dispute resolution process: technical disagreements can be referred to a neutral expert, and legal disputes to an arbitration tribunal or other adjudication, with the World Bank playing a facilitating role in appointing experts or court chairs. This mechanism was designed to handle future conflicts within the treaty framework and avoid unilateral action.

A FRAMEWORK FOR PEACEFUL COOPERATION

From 1960 through the end of the 20th century, the Indus Waters Treaty functioned as a remarkably successful water-sharing regime, especially given the animosity of its signatories. It is often cited as one of the world's most enduring and effective transboundary water treaties. The IWT has survived three wars between India and Pakistan, in 1965, 1971, and 1999, and remained in force even when broader diplomatic relations collapsed. Both countries largely abided by the treaty's terms. Indeed, the IWT is regarded as a rare high point in an otherwise fraught relationship.

TREATY DISPUTES

Despite its overall success, the Indus Waters Treaty has not been without disputes, as shown in Table 3.3. The treaty's detailed rules for project design and a binding arbitration mechanism means that disagreements were channelled into legal/technical forums rather than open conflict.

There was no armed conflict over water in these instances. In fact, the IWT often served as a safety valve, providing legal and diplomatic processes to address grievances that might otherwise provoke unilateral retaliation. However, these arbitrated conflicts have accumulated over time to reduce trust even as cooperation continued.

POST-2000 DYNAMICS: FROM COOPERATION TO COERCION

Entering the 21st century, the Indus Waters Treaty's role began to shift from purely cooperative to increasingly contentious, reflecting the broader downturn in India-Pakistan relations. Several trends after 2000 sharpened the Indus waters issue.

For decades India has not fully exploited the water allocated to it under the treaty, notably, much of the flow of the Ravi and Sutlej (eastern rivers) still flowed unused into Pakistan. Under the government of Narendra Modi (since 2014), India made a concerted effort to stop this wastage and utilise its full share. New projects like the Shahpurkandi Dam (on Ravi, completed 2024) and the Ujh Dam (on a tributary of Ravi) were launched to divert remaining waters for Indian use. India also fast-tracked hydropower on the western rivers within treaty limits.

TABLE 3.3

Major Indus Waters Treaty disputes

Dispute Name	River	Years	Problem	Outcome
Salal Dam	Chenab River	1970s–1987	Pakistan raised concerns over India's dam height and storage volume.	Dispute resolved via bilateral talks; India lowered the dam height; project completed with Pakistan's consent in 1987.
Wular/Tulbul Project	Jhelum River (Wular Lake)	1980s–1991; post-2016	India proposed a navigation dam; Pakistan objected due to treaty restrictions on storage on western rivers.	India suspended the project in 1991; remained frozen until revived post-2016 under a more assertive Indian policy.
Baglihar Dam	Chenab River	Late 1990s–2008	Pakistan claimed India's design violated treaty limits; bilateral talks failed.	Neutral Expert appointed in 2005; ruled largely in India's favour in 2007 with minor design changes; dam commissioned in 2008.
Kishanganga/Neelum Project	Kishanganga (Jhelum tributary)	2010–2018	India's dam diverted water affecting Pakistan's downstream project; Pakistan claimed treaty violation.	Court of Arbitration (2013) allowed diversion with minimum flow to Pakistan; India completed project in 2018; Pakistan accelerated its own dam development.
Ratle & Other Projects	Chenab & Jhelum Rivers	2016–ongoing	Pakistan challenged several Indian projects (e.g. Ratle Dam) for treaty violations; India insisted issues were technical.	Procedural deadlock: World Bank initiated both arbitration and Neutral Expert in parallel; India refused to cooperate; dispute remains unresolved.

Following a rise in cross-border terrorism, Prime Minister Modi signalled a tougher stance: India also began leveraging water in international forums. And in January 2023, India formally invoked Article XII (governing treaty amendments) via the Permanent Indus Commission to demand modifications to the treaty.

2025 CRISIS: SUSPENSION AND CONFLICT

Matters came to a head in early 2025. On April 22, 2025, a terrorist attack by gunmen in Indian-administered Kashmir (near Pahalgam) killed 26 civilians, most of them tourists. India blamed Pakistan-based militant groups for the massacre, which Pakistan denied.[23] In response, the Indian government announced it was suspending the IWT with Pakistan. Pakistan's National Security Committee rejected the unilateral suspension and warned that "any diversion of Pakistan's water is to be treated as an act of war." The Pakistani foreign minister even alluded that if India permanently cut off flows, it could provoke a conflict with nuclear dimensions. Such rhetoric underscored how existential the Indus waters issue is for Pakistan, interruption of Indus flows threatens its food security directly, and thus its national survival. Indeed, about 80 per cent of Pakistan's irrigated agriculture depends on Indus basin rivers.

In the weeks after the suspension, tensions spiked. For the first time, India began operating its dams outside the treaty constraints: in May 2025, Indian authorities carried out **"**reservoir flushing" on the Chenab River's Salal and Baglihar dams without notifying Pakistan. This operation, which involves emptying reservoirs to flush out silt, had been forbidden under the treaty (or at least tightly regulated) because it causes sudden downstream flow changes. India proceeded unilaterally, aiming to boost its dams' storage and power generation capacity now that it considered itself unbound by IWT limits. The immediate impact was dramatic: sections of the Chenab in Pakistan's Punjab ran dry for a few days, as India's dam gates were shut, then released sediment-laden torrents when opened.[24]

In May 2025, a brief military skirmish erupted, with a four-day exchange of drone strikes and artillery across the Kashmir border, raising fears of a wider war. It took urgent mediation by external powers (the US, China, and others) to calm the situation. A ceasefire was brokered after a flurry of behind-the-scenes diplomacy. On June 21, 2025, India's Home Minister Amit Shah stated emphatically that the treaty would remain "suspended permanently". He argued that the IWT's very preamble, promoting peace and friendship, had been violated by Pakistan, thus nullifying the treaty's rationale.[25]

For Pakistan, the danger is acute. If India were truly to cut off or significantly reduce Indus flows, Pakistan's densely populated plains would face severe water shortages, especially in winter and dry seasons.

At present, however, India's ability to "turn off" the rivers is limited by its infrastructure. All of India's dams on the western rivers are run-of-the-river projects with minimal storage. India cannot overnight stop the Indus or divert the rivers entirely. In the near term, the greater threat to Pakistan is more subtle: India could time its dam operations to manipulate flows within the range of its technical capacity. Even small disruptions at critical moments could hurt Pakistani agriculture since Pakistan lacks sufficient storage to buffer variations. Pakistan's own dam capacity can hold only about 30 days of Indus flow; any prolonged cut would be disastrous if not managed.[26] While the implications are unclear, the rising tensions in South Asia and the Middle East are potentially linked to the future of water diplomacy for the Indus. In September 2025, Pakistan and Saudi Arabia signed a mutual defence treaty, in effect building shared obligations to respond to an attack on the other. While this has mainly been subject of discussion for its effect in providing Saudi Arabia with the nuclear umbrella from Pakistan, it also means that Saudi Arabia would most likely support Pakistan in any conflict with India. This is likely to be supportive of the continuation of the Indus agreement as India is more likely to think carefully before creating a pretext for war.

Internationally, India's suspension of the IWT raised concerns about precedent. China, a close ally of Pakistan and an upstream riparian, also took interest. In May 2025, China's state media announced an acceleration of the Mohmand Dam project in Pakistan – a hydropower dam China was financing, framing it as support to Pakistan amid India's water "threats".[27] The implication was clear: China signalled solidarity with Pakistan, effectively cautioning India against pushing Pakistan too far on water. China has its own tensions with India over transboundary rivers like the Brahmaputra, so it watches Indus developments closely as part of the regional water geopolitics. Additionally, parts of the Indus basin run through disputed Kashmir regions under Chinese control (e.g., the Shyok tributary in Aksai Chin), though those contribute minimally to Indus flows. If the Indus treaty unravels, involvement of other players like China or even Afghanistan could complicate matters further. For now, the IWT remains officially bilateral, but the 2025 episode showed that global powers have a stake in preventing water conflicts.

Sava River Basin

FIGURE 3.12

Map of the Sava River

The Sava River basin spans Slovenia, Croatia, Bosnia and Herzegovina, Serbia, and Montenegro.

The dissolution of the Socialist Federal Republic of Yugoslavia (SFRY) in 1991–95 created seven independent states and left deep political and ethnic rifts. The conflicts in Croatia (1991–95), Bosnia and Herzegovina (1992–95), and later Kosovo (1998–99) were the deadliest in Europe since World War II. Besides human devastation, the wars wreaked havoc on infrastructure and the environment.

In the Sava River Basin, industrial facilities were destroyed and over a million landmines were planted, contaminating land and waterways. The Sava River, once Yugoslavia's vital inland shipping route and a backbone of its economy, suffered neglect and damage. Navigation halted due to wrecked bridges, sunken vessels, and unexploded ordnance littering the riverbed. Each new state initially turned inward to rebuild, but it soon became clear that effective management of shared rivers like the Sava was beyond any one country's capacity. Transboundary water issues: floods, pollution, navigation, and hydropower development, demanded cross-border cooperation.

By the late 1990s, the international community recognised water cooperation was a potential tool for peacebuilding in the Balkans. In 1999, the EU-led Stability Pact for Southeastern Europe was launched to promote regional cooperation after the conflicts. Under its auspices, representatives of Slovenia, Croatia, Bosnia and Herzegovina, and the Federal Republic of Yugoslavia (Serbia and Montenegro) convened in 2001 to discuss joint management of the Sava River. In November 2001, they signed a Letter of Intent signalling their commitment to a Sava River Basin Initiative.

This political will for cooperation was striking given the recent hostilities. Leaders and water experts from the four countries, despite divergent post-war circumstances, found common ground in rehabilitating the Sava. Each country had strong cultural and economic ties to the river, and all shared a history of Yugoslav-era water management that provided a foundation for dialogue. Still, differences were evident: Slovenia had largely escaped war damage and was already on the path to European Union membership, while Croatia, Bosnia and Herzegovina, and Serbia lagged in development and faced internal challenges. These asymmetries influenced their priorities for the river. Upstream Slovenia emphasised environmental protection and recreation, whereas downstream Serbia stressed navigation and water usage for industry. Nonetheless, the Sava River's importance as a shared lifeline helped persuade the parties that cooperation was preferable to conflict.[28]

The groundwork laid in 2001 set the stage for formal negotiations on a basin-wide treaty. With support from external facilitators, including the Office of the High Representative in Bosnia, the OSCE, the EU, and the Regional Environmental Center (REC), two working groups drafted a framework agreement and an accompanying action plan in 2002. This culminated in the initialling of the Framework Agreement on the Sava River Basin later that year.

In December 2002, the foreign ministers of Bosnia and Herzegovina, Croatia, Serbia and Montenegro, and Slovenia signed the Framework Agreement on the Sava River Basin (FASRB) in Kranjska Gora, Slovenia. The FASRB entered into force two years later, in December 2004, after the countries completed ratification.[29] As the first multilateral agreement among all these former Yugoslav republics (aside from the Dayton Peace Accords of 1995), the FASRB was a landmark in regional relations.

In the agreement the countries pledged to manage the Sava jointly for both economic development (e.g. reviving trade navigation) and environmental safety (e.g. flood control and pollution prevention). To guide cooperation, the FASRB also enshrined fundamental principles of sovereign equality and territorial integrity of states, the obligation of mutual benefit and good faith, and respect for national laws and institutions.

Crucially, the FASRB created a permanent institutional framework to implement its provisions. Article 3 established the International Sava River Basin Commission (ISRBC) as the coordinating body for the agreement. The Sava Commission is composed of representatives (typically high-level water officials or diplomats) from each party, with each country having an equal vote. The Commission's mandate is broad: it is responsible for developing plans and programs to achieve the FASRB's objectives, adopting binding decisions on navigation issues, and making recommendations on all other aspects of water management in the basin. This structure allows continuous, technical-level collaboration insulated from day-to-day politics. Notably, the FASRB also envisaged the development of additional protocols to address specific areas in more detail.[30]

Over the past two decades, the FASRB and the Sava Commission have provided a neutral platform where the former adversaries regularly interact, negotiate, and solve practical problems. This sustained engagement has incrementally rebuilt trust and normalised relations among the four countries through the "backdoor" of technical cooperation. Sava Commission members have emphasised that the trust built in the water sector has spilled over into broader inter-governmental relations, creating a virtuous cycle of communication. This trust was tested and affirmed during crises such as the massive floods of May 2014, when the Sava Commission swiftly convened emergency high-level meetings and helped coordinate international assistance to hardest-hit areas in Bosnia and Serbia.[31]

The Sava Commission's convening power also enabled joint diplomatic initiatives that bolster trust. A prominent example is the Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube Basin, signed in 2008–2010. The ISRBC, alongside the Danube Commission and International Commission for the Protection of the Danube (ICPDR), led a year-long negotiation with over 50 stakeholders to balance navigation development with ecological protection on the Danube and Sava Rivers. The very fact that the Sava countries co-initiated and spoke with one voice in this complex international dialogue signals enhanced diplomatic confidence.

The FASRB's implementation has yielded tangible socio-economic benefits that reinforce peace by improving everyday life, a core goal of post-conflict recovery. For instance, under the agreement, the countries have worked to rehabilitate navigation on the Sava, which in Yugoslav times carried substantial cargo traffic. In 2009, a jointly commissioned feasibility study and project plan was developed to provide a comprehensive roadmap for restoring navigability along the Sava River. As a result, sections of the Sava that were unnavigable after the war have gradually reopened. By 2010, large vessels could again reach the Croatian river port of Slavonski. Restoring navigation has clear peace dividends: it stimulates cross-border trade, generates jobs, and incentivises maintenance of stability for continued economic gain. Likewise, cooperation in flood management under the FASRB has directly benefited communities.

The Sava River Basin Framework Agreement exemplifies how shared environmental management can facilitate peacebuilding by creating common ground and interdependence among countries with a recent history of conflict. The agreement turned a river that flowed through divided lands into a connector of communities and governments.[32] It helped the countries of the Western Balkans to transition from confrontation to cooperation, at least in the water sector, and this cooperation has had positive spillover effects on regional stability.

Syr Darya and Amu Darya River Basins

FIGURE 3.13

Map of the Syr Darya River and the Amu Darya River

These river basins span Kyrgyzstan, Tajikistan, Uzbekistan, Turkmenistan, Kazakhstan, and Afghanistan.

Shared water resources in Central Asia's Syr Darya and Amu Darya river basins have long been a double-edged sword, serving as both a source of interstate tension and a catalyst for cooperation. These two rivers, which feed the Aral Sea, are lifelines for five post-Soviet republics: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan (as well as Afghanistan), whose divergent needs and unequal geography (water-rich upstream vs water-scarce downstream) have created a complex security dilemma. In recent decades, climate change, population growth and ageing infrastructure have intensified water stress, compounding the legacy of Soviet-era mismanagement and making effective transboundary water governance both more difficult and more urgent.

SOVIET-ERA WATER MANAGEMENT AND POST-1991 BREAKDOWN

Under the Soviet Union, Central Asia's water resources were managed through a highly centralised system designed to serve Moscow's economic priorities. From the 1950s onward, Soviet planners constructed an extensive network of dams, reservoirs, and canals across the Syr Darya and Amu Darya basins to expand irrigated agriculture (especially cotton cultivation) in the downstream republics. The central government controlled inter-republican allocations: upstream water infrastructure in Kyrgyzstan and Tajikistan was operated primarily to ensure summertime irrigation flows for downstream Uzbekistan, Kazakhstan and Turkmenistan, with little regard for upstream energy needs.

This integrated system achieved the Soviet goal of massive cotton output (by the 1980s the Central Asian republics grew 90 per cent of Soviet cotton) but at devastating ecological cost, most infamously the Aral Sea's near disappearance due to over-extraction of river water. By 1991, river diversions had caused the Aral Sea to lose two-thirds of its volume and split into shrinking remnants, precipitating an environmental and public health crisis in the region.[33]

The collapse of the Soviet Union in 1991 also brought about the collapse of centralised water management. The newly independent states inherited a web of interdependent water infrastructure without the top-down authority or legal framework to govern. Downstream Uzbekistan discovered that 91 per cent of the water sustaining its agriculture originated in Kyrgyzstan and Tajikistan, leaving it highly vulnerable. Turkmenistan faced a similar plight, with 98 per cent of its water coming from upstream countries. By contrast, upstream Kyrgyzstan and Tajikistan now controlled headwaters but lacked the fossil fuels that powered their Soviet-era winter heating; their incentive was to use water for domestic hydropower generation in winter, even if that reduced summer flows downstream.[34]

Each state began pursuing its own water-energy priorities, exposing a fundamental asymmetry: the agrarian economies of downstream states required steady summer irrigation, whereas upstream states prioritised energy and development needs that implied altering the timing and quantity of releases. These new realities set the stage for conflict, as downstream countries suddenly found themselves in a weaker physical position and feared their water lifelines could be curtailed.

Yet, despite dire predictions in the early 1990s that "water wars" would erupt among the Central Asian states, outright conflict was averted through emergent cooperation and institution-building. The Central Asian leaders moved quickly to preserve Soviet-era arrangements in the immediate post-independence period. In February 1992, the five states signed an agreement on the joint management, use, and protection of interstate water resources, effectively pledging to respect the previous quota system and treat the waters of the Aral Sea basin as a common resource.[35] This agreement established an Interstate Commission for Water Coordination (ICWC) to set annual allocations for each republic, with two basin-specific management organisations – BVO Syr Darya and BVO Amu Darya – to implement these quotas based on Soviet-era norms.

WATER-ENERGY CONFLICTS AND ATTEMPTS AT COOPERATION IN THE 2000S

By the late 1990s and into the 2000s, cooperation began to deteriorate as each state's short-term needs often overrode regional promises. The Syr Darya basin became an early flashpoint. Kyrgyzstan, impoverished and fuel-poor, asserted its upstream prerogatives by reorienting its Toktogul Reservoir operations to generate winter hydroelectric power for domestic use, which required retaining water in summer (when downstream farms needed it most) and releasing extra water in winter.

In 1997, the Kyrgyz government declared that water was an economic commodity under its sovereignty rather than a free common good, demanding that downstream Uzbekistan and Kazakhstan compensate Kyrgyzstan for the service of water storage and regulation.[36] Uzbekistan, for its part, responded by cutting off or sharply raising prices for natural gas supplies to Kyrgyzstan in winter, effectively using energy to punish or pressure Kyrgyz over water release disagreements.[37]

Tensions reached their peak in the late 2000s and early 2010s, revolving around ambitious new dam projects. Tajikistan announced the revival of the Rogun Dam on the Vakhsh River (Amu Darya basin), a Soviet-era project that had stalled during civil war, which would give Tajikistan control over a vast portion of Amu Darya's flow and the ability to generate abundant power. Downstream Uzbekistan viewed Rogun, as well as Kyrgyzstan's similar plans for a dam on the Naryn/Syr Darya, as a threat to its water security.[38] Uzbekistan lobbied international financial institutions to withhold funding, refused to buy Tajik electricity, and between 2010–2012 imposed a de facto rail blockade on Tajikistan by stopping freight cars.[39]

In 2016, Uzbekistan's new leadership reversed its posture and actively sought rapprochement with its neighbours. Uzbekistan ended its opposition to Tajikistan's dam projects, expanding bilateral energy trade and reopening land transit routes. Similarly, Uzbekistan improved relations with Kyrgyzstan, settling border disputes and reviving water-sharing dialogues. Striking a deal over the long-disputed Kempir-Abad (Andijan) Reservoir, which lies in Kyrgyzstan but supplies Uzbekistan. In 2022, Uzbekistan and Kyrgyzstan agreed on a border delineation that granted Uzbekistan use of the reservoir's water (critical for Uzbek agriculture) while compensating Kyrgyzstan with land.[40]

Building on this momentum, recent years have seen breakthroughs in multilateral water cooperation that would have been unthinkable a decade prior. In 2023, Kazakhstan, Uzbekistan and Kyrgyzstan signed an agreement to jointly construct and operate the giant Kambar-Ata-1 Hydropower Plant on the Naryn/Syr Darya in Kyrgyzstan.[41] The three governments agreed to form a joint company and share the costs and benefits of the dam, with guarantees to purchase the electricity generated.

Not only will the Kambar-Ata-1 hydropower plant increase regional power supply; it is also explicitly intended to ensure a sustainable water supply for the Syr Darya basin by coordinating releases for downstream needs. This tripartite partnership signals a shift: rather than fight over dams, states are now co-investing in them. It also underscores Uzbekistan's transformation into an active participant in upstream infrastructure development.

Not all problems have been resolved in this new cooperative climate. Some bilateral frictions remain, and new ones have arisen. Kyrgyzstan and Tajikistan, for example, have had lethal clashes along their border in 2021–2022, in part sparked by disputes over small-scale irrigation channels and access to water in the densely populated Ferghana Valley enclave areas.[42] These incidents, which killed dozens, show that local competition for water can inflame ethnic and territorial tensions even when governments achieve cooperative interstate relations.

The water-energy trade-off remains another unresolved challenge. The creation of joint energy projects is promising, but the region could benefit from a multilateral energy-water nexus agreement. Global heating is perhaps the factor that exacerbates all other challenges. Central Asia is already experiencing more frequent droughts, heatwaves and irregular precipitation. A severe regional drought in 2021, for example, sharply reduced river flows, damaged crops and pasture, and even contributed to unrest.[43]

Projections indicate that by 2050, average annual flow of the Amu Darya and Syr Darya could decline due to the melting and shrinking of the glaciers that feed them, after an initial surge of glacial melt-water in the coming years.[44] The unpredictability of climate impacts, glacier loss, altered snowmelt timing, more intense spring floods and summer droughts, will make the current water management regime even harder to maintain.

One estimate warns that climate change-related droughts and floods could impose economic damages equal to 1.3 per cent of regional GDP annually, and crop yields could drop by 30 per cent by 2050, potentially creating over five million internal climate migrants in Central Asia.[45] Such stresses, if not addressed cooperatively, carry obvious conflict potential: poorer communities and farmers may compete fiercely for shrinking water, and states may feel pressure to secure additional water by any means.

Senegal River Basin

FIGURE 3.14

Senegal River Basin

The Senegal River and its tributaries span Guinea, Mali, Mauritania, and Senegal.

The Senegal River Basin in West Africa, shared by Senegal, Mauritania, Mali and Guinea, is often cited as a model of transboundary water cooperation and peacebuilding. Stretching over 1,800 kilometres from Guinea's highlands through Mali and along the Senegal–Mauritania border to the Atlantic, the river is a lifeline for roughly 12 million people in the region. In the wake of droughts and the Sahel's harsh climate, these four countries have forged diplomatic agreements and joint institutions to manage the river's resources cooperatively.

After gaining independence in the 1960s, Senegal, Mauritania, Mali and Guinea all recognised the Senegal River as a critical resource linking their nations. Early efforts at cooperation struggled, though the desire for cooperative development of the river remained. In 1972, Mali, Mauritania and Senegal came together to sign the Nouakchott Convention, formally creating the Organisation pour la Mise en Valeur du fleuve Sénégal (OMVS). This tripartite organisation explicitly reaffirmed the Senegal River's status as an international watercourse and committed the states to pursue joint development objectives. The OMVS emerged from a shared recognition of vulnerability: the devastating droughts of the late 1960s and early 1970s convinced the countries that only by pooling efforts could they secure water, food, and energy for their people.[46]

Since its inception, the OMVS has established a strong institutional framework based on equitable decision-making and benefit-sharing. Formalised in 1975, all major decisions requiring unanimous consent. Two foundational treaties, the 1978 Convention on the Legal Status of Jointly Owned Structures and the 1982 Convention on their Financing, enshrined co-ownership of infrastructure and proportional cost-sharing, replacing water allocation disputes with shared benefit generation.[47] Agencies manage hydropower assets collectively, while unilateral projects are prohibited to prevent tensions. In 2002, OMVS members adopted a Water Charter that strengthened environmental safeguards and expanded participation to include local water users, modernising governance and fostering inclusive, cooperative river basin management.

Several features of the OMVS diplomatic architecture have explicitly contributed to conflict prevention. First, regular high-level meetings (summits of heads of state and frequent ministerial council sessions) have institutionalised dialogue. These meetings provide a forum to voice concerns and manage disputes before they escalate. Second, each state has an equal vote and veto power, meaning no country can be dominated by another's agenda, thereby averting upstream-downstream power struggles. Third, the sharing of costs and benefits has built a dense web of interdependence. Each country now needs the others to keep the system running: for instance, Mauritania's capital would go dry without Senegal releasing water at Diama, Senegal's electricity grid relies on Mali's dam, and Mali's dam itself needed financing from the wealthier downstream partners. This mutual reliance serves as a powerful deterrent against conflict.

It is also noteworthy that OMVS has broadened the scope of cooperation beyond water alone, extending to areas like public health and regional integration. Joint programs to combat malaria and other water-related diseases in the basin have been carried out under OMVS auspices. Such collaborations have humanitarian benefits and also reinforce a sense of community among the countries. Likewise, the OMVS power grid and improvements to navigation (plans to make the river navigable year-round) facilitate trade and the free movement of people and goods, further interlinking the countries economically and culturally.

The Diama and Manantali dams represent the OMVS's flagship joint infrastructure projects, designed to serve all member states through multipurpose development. The Diama Dam, completed in 1986 near the Senegal–Mauritania border, prevents saltwater intrusion from the Atlantic, enabling year-round irrigation and securing drinking water for cities such as Nouakchott and Saint-Louis. The Manantali Dam, completed in 1988 in Mali, regulates dry-season flows, supports recession agriculture, and powers a 200 MW hydroelectric facility that began operations in 2002. Electricity and irrigation benefits from these dams are shared through a regional grid and cost-sharing agreements, reflecting deliberate interdependence. As a result, hundreds of thousands of hectares have been irrigated, urban water security has improved, and clean energy has expanded access and reduced fossil fuel reliance.[48]

In the 2010s and beyond, the OMVS has deepened regional cooperation through second-generation joint infrastructure projects, including the Félou and Gouina hydroelectric plants in Mali, expanding the shared energy grid and demonstrating continued commitment to collective development. These initiatives have significantly boosted electricity supply across Senegal, Mali, and Mauritania, with future integration planned for Guinea. Alongside power generation, the OMVS has facilitated improvements in irrigation and inland navigation, leading to enhancements in trade and livelihoods. International partners such as the World Bank and Global Environment Facility have supported this progress through environmental management programs which have created jobs, restored ecosystems and improved health outcomes.[49]

Even during periods of geopolitical turmoil, such as coups in member states or bilateral disputes, the OMVS mechanisms have helped keep communication channels open. During the 1989–91 Senegal–Mauritania border conflict, for example, formal diplomatic ties were cut, yet the multilateral engagement over the river was maintained.[50] As tensions eased, the OMVS countries not only resumed cooperation but also sought to broaden it, inviting Guinea to participate as an observer in OMVS meetings. Guinea eventually formally joined the OMVS in 2006, which transformed the organisation into a four-member body encompassing the entire basin.

Looking ahead, the Senegal River Basin faces new challenges that will test the strength of its cooperative regime. The Sahel region is projected to experience greater rainfall variability and more frequent droughts in coming years, which could put additional strain on water resources. However, the OMVS countries have proactively framed climate adaptation as a shared task. The Water Charter of 2002 provides mechanisms to adjust water allocations in low-flow periods based on agreed priorities, drinking water and essential ecological flows taking precedence. Moreover, joint infrastructure like the Manantali Dam increases resilience by storing water in wet years for use in dry years – a buffer that no single state could realistically achieve alone. In essence, the basin's cooperative apparatus is a form of climate insurance: it prevents "water grabs" during droughts and encourages multilateral responses. All states share hydrological data with one another, reducing uncertainty and fear – a critical factor in preventing unilateral action during climate extremes.

Over the past half-century, the Senegal River's riparian states have progressively built one of Africa's most successful transboundary water institutions. The OMVS experience demonstrates how deliberate institution-building, characterised by equity, joint ownership and inclusive decision-making, can prevent water wars and even mitigate unrelated conflicts by keeping lines of communication open.

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 half the standard deviation) across the four scores. This creates a weighted average, which is represented in the following equation:

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

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.

All indicator scores are classified from "very low" to "very high" levels of threat based on the following bands:

Very Low Threat	Low Threat	Medium Threat	High Threat	Very High Threat
<1.6	1.6-2.2	2.2-3	3-3.8	>3.8

ETR INDICATOR SOURCES, DEFINITIONS AND SCORING CRITERIA

Water Risk	
Indicator type	Quantitative
Data Sources	World Resources Institute (WRI), Standardized Precipitation Evapotranspiration Index (SPEI-03)
Measurement period	2019–2024

Definition: How hard it is for people to get reliable access to clean, safe water – as potentially aggravated by unpredictable dynamics in precipitation and evaporation.

Calculation: The water risk indicator has two subcomponents. The first is the WRI's "unimproved/no drinking water" measure, which reflects 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 (WHO and UNICEF 2017). Specifically, the indicator aligns with the unimproved and surface water categories of the Joint Monitoring Programme (JMP) – the lowest tiers of drinking water services.

The second component is based on the Standardized Precipitation Evapotranspiration Index (SPEI-03) originally developed by Vicente-Serrano, et al. (2010). SPEI-03 measures the deviation of the three-month water balance (precipitation minus potential evapotranspiration) from its long-term mean. For the ETR water risk measure, the SPEI-based subcomponent is based on the count of the number of months in a given year in which a subnational area's SPEI value was lower than -1.5, indicating exceptionally dry conditions for the area relative to its long-term averages.

These two subcomponents are banded on a 1–5 scale and then combined using a weighted average, with the WRI subcomponent accounting for two-thirds of the overall score and the SPEI subcomponent accounting for one-third.

Food Insecurity	
Indicator type	Quantitative
Data Sources	Global Food Security Index (Economist Intelligence Unit), Proteus Index (World Food Programme), Armed Conflict Location & Event Data (ACLED), UN Development Programme (UNDP)
Measurement period	2019–2024

Definition: How likely people are to not have enough food, taking into account food supplies and accessibility, affordability, and the violent threats to supply chains.

Calculation: The food insecurity indicator is a composite measure that incorporates both national and subnational components. At the national level, it combines the Economist Intelligence Unit's Global Food Security Index and the Proteus Index developed by the World Food Programme. After normalising both indices, an aggregate national score is calculated.

At the subnational level, two indicators are used: an inequality-adjusted income index (from the Subnational Human Development Index produced by UNDP) and a conflict index based on the per capita rate of civilian casualties from conflict (based on ACLED data).

Each subnational unit's overall food insecurity score is a weighted average of the aggregate national indicator (80 per cent), the income index (10 per cent), and the conflict index (10 per cent).

Impact of Natural Events	
Indicator type	Quantitative
Data Sources	Climate–Conflict–Vulnerability Index (CCVI)
Measurement period	2019–2024

Definition: How dangerous climate-related disasters like floods, storms, or heatwaves could be for people – especially in places that are more crowded and have less developed infrastructure.

Calculation: The impact of natural events indicator is based on three components taken from Climate–Conflict–Vulnerability Index (CCVI). The first component is the Climate Index (or Climate Hazard Exposure pillar), which measures a region's exposure and sensitivity to climate-related hazards, including temperature anomalies, drought frequency, flood occurrence, vegetation stress, and similar metrics. The second two are population density and poverty level measures from the CCVI's Vulnerability pillar.

The overall indicator is calculated as a weighted geometric mean of the three factors, with the Climate Index component weighted twice as heavily as the other two population density and poverty.

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	2025 and 2050

Definition: How fast population is projected to grow over the next several decades, as measured by the percentage difference between the 2025 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 subnational unit is aggregated for both 2025 and 2050. Percentage differences between projected future populations and current populations are then normalised on a 1–5 scale, with all areas expected to experience no growth or negative growth assigned a score of 1.

APPENDIX B

ETR Country Scores, 2024

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	Water Risk	Food Insecurity	Impact of Natural Events	Demographic Pressure
Afghanistan	4.228	4.216	4.078	3.506	4.179
Albania	2.100	1.939	2.268	2.025	1.011
Algeria	2.677	2.458	2.351	2.971	2.095
Angola	3.727	3.694	3.492	3.060	3.892
Argentina	2.053	1.633	1.971	2.266	1.689
Armenia	2.076	1.836	2.094	2.175	1
Australia	2.097	1.428	1.503	1.154	2.813
Austria	1.351	1.057	1.190	1.421	1.345
Azerbaijan	2.568	2.970	2.463	2.084	1.438
Bahamas	2.022	1.445	2.195	1	2.234
Bahrain	2.985	1.907	1.585	2.504	3.898
Bangladesh	3.203	2.019	3.065	3.919	1.873
Belarus	1.907	1.705	1.883	2.078	1
Belgium	1.481	1.114	1.181	1.493	1.636
Belize	2.694	2.897	2.757	2.123	2.163
Benin	3.894	3.445	3.302	4.153	3.725
Bhutan	2.669	2.165	3.099	1.591	2.456
Bolivia	3.126	3.295	2.798	3.140	2.248
Bosnia & Herzegovina	1.954	1	2.230	2.187	1.000
Botswana	2.602	2.563	2.921	1.745	2.121
Brazil	2.693	2.788	2.295	2.878	1.493
Brunei	2.127	1.752	1.786	1.013	2.608
Bulgaria	1.728	1.444	1.795	1.863	1
Burkina Faso	4.066	4.169	3.471	3.781	4.050
Burundi	4.271	3.645	3.769	4.929	3.325
Cambodia	3.262	3.232	3.156	3.353	1.615
Cameroon	3.631	3.615	3.327	3.714	2.846
Canada	1.825	1.301	1.399	1.238	2.326
Central African Republic	3.848	3.984	4.177	2.919	2.871
Chad	3.850	3.792	3.808	3.159	3.874
Chile	1.828	1.577	1.863	1.909	1.519
China	2.298	1.949	1.854	2.852	1.009
Colombia	2.735	2.661	2.595	2.824	2.109
Comoros	3.296	3.028	3.422	3.198	2.980
Costa Rica	2.105	1.683	1.818	2.007	2.305
Côte d'Ivoire	3.690	3.702	3.163	3.948	2.558
Croatia	1.574	1	1.718	1.735	1
Cuba	2.493	2.504	2.607	2.320	1
Cyprus	1.969	1.152	1.844	1.483	2.357
Czechia	1.469	1.189	1.354	1.593	1.365
Democratic Republic of the Congo	4.211	3.729	3.813	4.633	3.768
Denmark	1.479	1.326	1.271	1	1.721

Country	Overall Score	Water Risk	Food Insecurity	Impact of Natural Events	Demographic Pressure
Djibouti	3.485	4.075	3.462	2.007	2.541
Dominican Republic	2.817	3.446	2.300	2.252	1.922
Ecuador	2.896	3.236	2.450	2.626	2.137
Egypt	2.649	1.688	2.261	2.993	2.525
El Salvador	2.780	2.356	2.497	3.318	1.108
Equatorial Guinea	3.553	4.030	2.819	2.436	3.482
Eritrea	3.880	3.760	4.069	3.245	3.730
Estonia	1.644	1.531	1.887	1.382	1
Eswatini	3.046	3.284	3.274	2.327	1.800
Ethiopia	4.194	3.864	3.789	4.631	3.281
Fiji	2.449	2.736	2.669	1.645	1.284
Finland	1.450	1.435	1.288	1.251	1.535
France	1.587	1.248	1.197	1.511	1.794
Gabon	3.221	3.782	3.003	2.130	2.484
Gambia	3.985	3.707	3.330	4.485	3.214
Georgia	2.271	1.986	2.657	2.010	1
Germany	1.347	1.208	1.235	1.502	1.022
Ghana	3.677	3.156	3.031	4.074	3.304
Greece	1.684	1.730	1.560	1.684	1.176
Guatemala	2.965	2.753	2.733	3.078	2.877
Guinea	3.865	4.132	3.440	3.903	2.508
Guinea-Bissau	3.912	4.396	3.613	3.505	2.807
Guyana	2.371	2.879	2.494	1.274	1
Haiti	4.021	4.065	3.963	4.000	1.741
Honduras	3.104	2.874	2.827	3.396	2.456
Hungary	1.578	1	1.618	1.829	1.013
Iceland	1.917	1	1.488	1.002	2.635
India	3.109	2.752	2.860	3.513	2.255
Indonesia	3.167	3.182	2.576	3.568	1.491
Iran	2.579	2.796	2.169	2.622	1.676
Iraq	3.463	3.326	2.945	3.224	3.671
Ireland	1.695	1	1.148	1	2.337
Israel	2.349	1.399	1.465	1.059	3.371
Italy	1.369	1.213	1.338	1.426	1.073
Jamaica	2.788	2.689	2.661	2.990	1.081
Japan	1.532	1.292	1.547	1.664	1
Jordan	2.822	1.693	2.088	2.066	3.642
Kazakhstan	2.364	2.955	1.709	1.848	1.743
Kenya	3.648	3.705	3.339	3.640	3.312
Kosovo	1.919	1.110	1.701	2.489	1.014
Kuwait	2.581	1.874	1.703	1	3.565
Kyrgyzstan	2.762	2.881	2.550	2.806	1.481
Laos	3.158	3.394	3.093	2.853	1.995
Latvia	1.846	2.161	1.632	1.630	1
Lebanon	2.184	1.039	2.542	2.251	1.518
Lesotho	3.223	3.300	3.551	2.674	1.616
Liberia	4.129	3.906	3.820	3.747	4.311
Libya	2.559	2.526	2.296	2.434	2.485
Lithuania	2.123	2.669	1.879	1.540	1
Luxembourg	1.939	1.242	1.067	1	2.768
Madagascar	4.085	3.936	3.829	4.285	3.726
Malawi	4.089	3.152	3.525	3.936	4.512
Malaysia	2.379	2.142	1.840	2.316	2.481
Mali	4.143	4.065	3.342	4.249	3.960
Mauritania	3.688	4.208	3.352	2.685	3.055

Country	Overall Score	Water Risk	Food Insecurity	Impact of Natural Events	Demographic Pressure
Mauritius	2.844	3.945	1.849	1.885	1.417
Mexico	2.449	2.431	2.126	2.608	1.886
Moldova	2.629	2.833	2.612	2.397	1
Mongolia	3.141	3.650	3.112	2.127	1.970
Montenegro	1.559	1.037	1.732	1.670	1.003
Morocco	3.308	3.974	2.339	3.268	1.399
Mozambique	3.805	3.985	3.623	3.688	3.119
Myanmar (Burma)	3.346	3.349	3.074	3.569	1.057
Namibia	3.261	3.505	3.530	2.166	2.320
Nepal	3.266	2.702	3.113	3.613	2.776
Netherlands	1.312	1.180	1.253	1	1.413
New Zealand	1.751	1.008	1.535	1.312	2.164
Nicaragua	3.309	3.443	2.905	3.405	1.507
Niger	4.420	3.609	3.703	4.075	4.979
Nigeria	4.112	3.445	3.438	4.210	4.252
North Korea	2.481	1.566	3.237	2.197	1.001
North Macedonia	2.008	1.178	2.317	2.001	1.481
Norway	1.808	1.070	1.230	1.003	2.505
Oman	2.493	2.081	1.880	1.566	3.107
Pakistan	3.570	2.985	3	4.180	2.815
Palestinian Territories	2.791	1.945	2.682	3.221	2.182
Panama	2.670	3.215	2.121	1.777	2.316
Papua New Guinea	3.601	3.734	3.884	2.756	2.782
Paraguay	2.472	1.779	2.616	2.221	2.425
Peru	3.075	3.839	2.450	2.590	1.390
Philippines	3.125	2.487	2.837	3.536	2.677
Poland	1.766	1.838	1.519	1.853	1
Portugal	1.632	1.760	1.364	1.590	1.304
Qatar	2.309	1.984	1.319	1	3.089
Republic of the Congo	3.662	3.677	3.826	2.600	3.289
Romania	1.674	1.346	1.887	1.641	1
Russia	2.121	2.491	1.960	1.713	1.040
Rwanda	4.100	3.482	3.319	4.662	3.721
Saudi Arabia	2.556	1.949	1.775	1.348	3.380
Senegal	3.771	4.096	3.120	3.593	3.377
Serbia	1.920	1.023	2.299	2.000	1.027
Sierra Leone	4.105	3.919	3.673	4.491	3.321
Singapore	2.010	1.306	1.253	2.523	1.783
Slovakia	1.658	1.022	1.663	1.961	1.035
Slovenia	1.526	1	1.463	1.707	1.290
Solomon Islands	3.426	3.384	3.643	2.749	3.052
Somalia	4.160	4.038	4.356	3.840	2.936
South Africa	2.775	2.629	2.571	2.953	1.760
South Korea	1.512	1.347	1.589	1.541	1
South Sudan	3.998	3.261	4.323	4.044	3.182
Spain	1.621	1.777	1.404	1.300	1.485
Sri Lanka	2.783	2.601	2.742	2.960	1.408
Sudan	3.724	3.167	3.680	3.930	3.171
Suriname	2.795	3.136	2.793	2.072	1.815
Sweden	1.783	1.320	1.456	1.276	2.206
Switzerland	1.439	1.263	1.179	1	1.688
Syria	3.229	1.824	3.481	3.316	2.759
Taiwan	1.299	1	1.597	1	1
Tajikistan	3.376	3.819	2.836	3.331	1.357
Tanzania	3.898	3.798	3.424	3.776	3.962

Country	Overall Score	Water Risk	Food Insecurity	Impact of Natural Events	Demographic Pressure
Thailand	2.208	1.605	2.318	2.457	1.161
Timor-Leste	3.539	3.664	3.716	2.701	3.071
Togo	3.946	3.657	3.416	4.416	2.917
Trinidad & Tobago	2.232	2.424	2.248	1.969	1.003
Tunisia	2.604	2.754	2.194	2.730	1.533
Turkey	1.847	1.694	1.763	1.702	1.921
Turkmenistan	2.305	2.284	2.272	2.333	1.712
Uganda	4.225	3.455	3.530	4.236	4.535
Ukraine	2.281	1.232	2.464	2.691	1
United Arab Emirates	2.414	2.019	1.476	1.030	3.228
United Kingdom	1.611	1.095	1.259	1.568	1.852
United States	1.726	1.613	1.323	1.053	2.035
Uruguay	1.806	1.912	1.893	1.530	1
Uzbekistan	2.593	2.302	2.467	2.883	1.539
Vanuatu	3.056	2.528	3.413	1.320	3.112
Venezuela	3.207	2.578	3.069	3.645	2.262
Vietnam	2.708	2.449	2.411	3.098	1.408
Yemen	4.075	2.996	3.829	4.161	4.007
Zambia	3.765	3.666	3.402	3.218	4.019
Zimbabwe	3.528	3.524	3.833	3.123	1.180

ENDNOTES

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